FEDERAL RESERVE BANK OF SAN FRANCISCO

WORKING PAPER SERIES

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Market Imperfections and Asia's Growth Experience

John Fernald
Federal Reserve Bank of San Francisco

and

Brent Neiman
Harvard University

May 2006

Working Paper 2006-17
http://www.frbsf.org/publications/economics/papers/2006/wp06-17bk.pdf

Measuring the Miracle: Market Imperfections and Asia's Growth Experience

John Fernald and Brent Neiman*

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Abstract: The newly industrialized economies (NIEs) of Asia are the fastest-growing economies in the world since 1960. A clear understanding of their rapid development remains elusive, with continuing disputes over the roles of technology growth, capital accumulation, and international trade and investment. We reconcile seemingly contradictory explanations by accounting for imperfections in output and capital markets. For instance, in Singapore, growth-accounting studies using quantities (the primal approach) find rising capital-output ratios and a constant labor share; but studies using real factor prices (the dual approach) find a constant user cost. We provide evidence that "favored" firms reaped economic profits and received preferential tax treatment, subsidies, and access to capital—market imperfections that are difficult to capture when implementing the dual approach. Further, declining pure profits can reconcile the constant or rising labor shares in *revenue* in the NIEs with theories of international trade that predict falling labor shares in *cost.* We provide empirical support for the quantitative importance of profits and heterogeneous user costs, describe the two-sector dynamics, and derive measures of technology growth, corrected for the imperfections that we quantify. We then discuss implications for broader disputes about Asian development.

Keywords: Growth accounting, development, market imperfections, trade and factor shares
JEL Codes: D24, E23, E43, F43

* John Fernald: Federal Reserve Bank of San Francisco. Brent Neiman: Harvard University. We thank Jonathan Anderson, Robert Barro, Susanto Basu, Jeff Campbell, Davin Chor, Erwin Diewert, Dan Fineman, Chang-Tai Hsieh, Boyan Jovanovic, Greg Mankiw, Justin Wolfers, Alwyn Young, several anonymous referees, and seminar participants at several institutions for helpful discussions or comments. We thank David Thipphavong for very helpful research assistance. An earlier version of this paper circulated under the title, "Measuring Productivity Growth in Asia: Do Market Imperfections Matter?" The views are our own and do not necessarily reflect those of anyone else affiliated with the Federal Reserve System.

In studies of economic growth and development, East Asia's experience looms large. The newly industrialized economies (NIEs) of Singapore, Taiwan, Korea, and Hong Kong are the four fastest-growing economies in the Penn World Tables, with per capita output rising 7 to 8 percent per year from 1960-1996 (see Table 1). Sala-i-Martin et al. (2004) show in cross-country growth regressions that an East Asian dummy is the single most robust explanatory variable. Lucas (1993) and Ventura (1997) argue that this East Asian "Miracle" is one of the most interesting facts of the post-war international growth experience.

A consensus explanation for Asia's growth path, however, remains elusive. How important was technological progress versus factor accumulation? Did international trade allow capital to accumulate rapidly without an equally rapid decline in returns? More generally, what was the role of the public sector?

We address these broad questions by identifying growth-accounting issues that arise with government intervention and market distortions. We assess implications of heterogeneous user costs of capital in the NIEs and, in the case of Singapore, large but declining pure economic profits. Heterogeneity reflected tax incentives and subsidies to direct resources and solicit foreign direct investment (FDI). Unfavored firms faced a higher cost of capital while favored firms earned large economic profits.

This two-sector perspective allows us to reconcile prominent, yet mutually exclusive, descriptions of Asia's development. First, growth-accounting studies reach conflicting results depending on whether one looks at "primal" (quantity-based) or "dual" (factor-price-based) measures of total factor productivity (TFP). Second, the growth accounting studies (and the national accounts) report constant or rising labor shares, which are inconsistent with explanations that emphasize export-oriented growth in capital-intensive sectors.

Young's (1992, 1994, 1995) careful primal growth accounting established the new conventional wisdom that, though several of the NIEs had modest TFP growth, others had little or none (see also Kim and Lau, 1994). Growth reflected accumulation of capital and labor. Hsieh (2002), however, challenges this view using the dual. He finds that in the NIEs, especially in Singapore, TFP grew more quickly (see Table 1). These apparently contradictory results reflect the following puzzle. Labor-income shares were generally stable or rising. Hence, the rising capital-output ratios behind the weak primal TFP growth imply sharp declines in returns to capital; but, especially in Singapore, reasonable user-cost measures are flat.

Pure profits and heterogeneous user costs resolve this puzzle. Suppose the user cost of capital is observed for only part of the economy. It misses pure profits, preferential tax treatment, and investment subsidies to targeted firms. Observed dual TFP then applies to unfavored firms only. Primal TFP, however, takes payments to capital as a residual. Hence, it incorporates profits and heterogenous user costs. If the profit rate falls and favoritism rises, then dual TFP growth exceeds primal TFP growth.

Unlike the growth accounting studies, several description of Asia's growth specifically focus on the role of international trade. Ventura (1997) emphasizes that small open economies can accumulate capital without rapidly diminishing returns. As production shifts to support the export of capital-intensive goods, rapid growth in capital and output can occur even with constant technology. Romalis (2004) shows that trade data are consistent with this shift—an application of the Rybczynski theorem. These appealing explanations of the importance of trade for growth, however, imply increasing capital shares and declining labor shares; but in the data, only Hong Kong shows a decline in labor's share of income over the 1970-90 period.

Declining profits reconcile flat or rising labor shares with a shift towards capital-intensive production because profits drive a wedge between factor shares in revenue and in cost. We estimate factor shares in cost using data on the industry composition of output in each country, combined with international data on industry factor shares. In most cases, the industry composition of output did, indeed, shift steadily towards capital-intensive sectors as Romalis' results and Ventura's theory predict, implying a rise in capital's share of costs. Hence, in contrast to a face-value interpretation of the original growth-accounting results, our explanation allows an important role for trade in the NIEs' sustained rapid growth.

More generally, we derive aggregate growth-accounting implications in a two-sector economy and show the link between standard TFP growth and technology change. For Singapore, we combine primal and dual results to shed light on sectoral and aggregate dynamics. For firms receiving preferential treatment, even the primal results were insufficiently pessimistic: Output grew nearly 10 percent per year for two decades, with sharply negative technology growth. The unfavored sector had annual output growth of about 6 percent with positive technology growth. Overall, technology growth was slightly negative.

Our interpretation of the dual-primal divergence is more plausible than the main alternatives. First, Hsieh suggests, with little evidence, that there were massive national accounting errors. We discuss this hypothesis (and its difficulties) in an appendix. Second, Young dismisses the dual calculations, in part because they ignore key tax benefits and are not appropriate for all firms. We agree that these issues are central, but find the pattern of mismeasurement economically important. The two methods differ because a subset of the economy earned very large profits and received government favoritism that grew over time.[1]

In sum, we provide a two-sector re-interpretation of the growth-accounting results. Output and capital intensity rose in the favored sector, where technology growth was abysmal. Since this sector received large quantities of foreign direct investment, our results suggest that policies designed to lure FDI did not, in fact, raise overall TFP through technology transfer.

I. Primal and Dual Measures of Productivity

With consistent accounting data, primal and dual TFP are identical. With independent quantity and price data for the NIEs, however, they look substantially different. This section discusses the identities as well as a simple economic environment, with market distortions, in which the two measures might differ.

A. Manipulating Accounting Identities

The national accounts identity states that nominal output *PY* equals nominal factor income. One can force the identity to hold by defining payments to capital as a residual, $PY - WL$. *P* is the price deflator, *Y* is real output, *W* is the nominal wage, and *L* is total labor input. Conceptually, measured payments to capital include required payments *RK*—where *R* is the implicit rental cost (or user cost) and *K* is capital input—plus any pure profits (or losses) Π. We provide economic definitions of *R* and Π below. Thus:

$$PY = WL + (R + \Pi/K)K. \quad (1)$$

For any variable *J*, let $\hat{j}$ be the percent change, d*J*/*J*. $\widehat{(r + \pi / k)}$ is growth in residual payments to capital; we combine *R* and Π /K because, with only accounting data, we cannot distinguish them. s_L is labor's share in output, WL / PY. The residual capital share is then (1-s_L). Totally differentiating (1) yields $\hat{y} + \hat{p} = \left[s_L \hat{l} + (1 - s_L)\hat{k} \right] + \left[s_L \hat{w} + (1 - s_L)\widehat{(r + \pi / k)} \right]$. Rearranging shows that "primal" TFP growth—output growth less share-weighted input growth—equals a "dual" weighted average of real factor price growth:[2]

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[1] Can we be sure that neither Young nor Hsieh made large errors in their calculations? Young's primal data match up well with the "official" data on output and labor input; capital input growth recomputed from the underlying investment data also line up well. We re-examined Hsieh's sources and calculations and are not aware of major errors (though we interpret his results differently). In particular, the national accounts show a rapid increase in the capital-output ratio of about three percent per year, whereas reasonable user-cost estimates are flat. Feenstra and Reinsdorf (2003) consider whether stochastic tastes or technologies could lead to large standard errors in the dual. They conclude that if one compares Young and Hsieh's results for periods of 15 years or longer, the differences are statistically significant. This is consistent with our explanation that Hsieh correctly measured capital costs for the subset of the economy that he observed. Barro (1999) also discusses possible interpretations of the dual-primal discrepancy for the national accounts.

[2] Henceforth, for convenience we often use TFP to refer to its *growth* rate. When possible, we omit time subscripts.

$$TFP_{\text{Primal}} \equiv \hat{y} - \left[s_L \hat{l} + (1-s_L)\hat{k} \right] = \left[s_L(\hat{w}-\hat{p}) + (1-s_L)(\widehat{r+\pi/k} - \hat{p}) \right] \quad (2)$$

Thus, if identity (1) holds, then primal and dual TFP are identical. But one can estimate the dual with independent factor-price data. Hsieh (2002), in particular, finds measures of real interest rates i_t for the NIEs and calculates Hall-Jorgenson (1967) user costs of capital, R_{Dual}, as $(i_t + \delta)q_t$, where q_t is the investment deflator, i_t is the real interest rate (defined in terms of asset inflation $\hat{q}_t$), and δ is the depreciation rate. He also estimates nominal wages. He deflates with the GDP deflator,[3] assumes zero economic profits, and uses Young's estimated factor shares to calculate:[4] $TFP_{\text{Dual}} \equiv s_L(\hat{w}_{\text{Dual}} - \hat{p}_{\text{Dual}}) + (1-s_L)(\hat{r}_{\text{Dual}} - \hat{p}_{\text{Dual}})$. Hence, the primal and dual differ if growth in either estimated wages or capital-payments differ:

$$TFP_{\text{Dual}} - TFP_{\text{Primal}} = s_L(\hat{w}_{\text{Dual}} - \hat{w}) + (1-s_L)\left(\hat{r}_{\text{Dual}} - \widehat{(r+\pi/k)}\right) . \quad (3)$$

Table 2 shows this decomposition with data from Young (1995, 1998) and Hsieh (2002). Lines 1 to 3 show the items on the right side of equation (3); lines 4a and 4b show primal and dual TFP growth. Lines 5 and 6, respectively, show the contribution of wages and capital payments to the dual-primal difference.

Tables 1 and 2 show that the primal and dual differ markedly only in Singapore and Taiwan. Wages play a sizeable role in Singapore and account for the bulk of the difference in Taiwan. Hsieh (2002) has little discussion of the role of wages.[5] We view the wage discrepancies as largely a measurement issue; in what

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Discrete-time Tornquist indices approximate the continuous time identity. In BLS data for U.S. TFP (1948-2002), the approximation error between the primal and the dual is negligible, so we continue to treat equation (2) as an identity.

[3] Hsieh (2002) and Young (1995, 1998) provide estimates of real factor price growth only. For notational simplicity, we assume the primal and dual use the same output deflator, so that differences are the same in real or nominal terms.

[4] Hsieh allows for multiple types of capital and labor (see Hsieh 2002, pp505-506), as does Young. Nominal wage growth is then $\hat{w} + \hat{l} \equiv \sum s_j \hat{w}_j + \sum s_j \hat{l}_j$, where s_j is the labor-income share for workers of characteristic j (e.g., education). One can write $\hat{l} = \widehat{\sum L_j} + (\sum s_j \hat{l}_j - \widehat{\sum L_j}) = \widehat{emp} + \widehat{qual}$, i.e., the sum of employment growth and labor quality growth. Thus, measured wage growth is reduced by the amount of the labor-quality correction.

[5] The two use slightly different source data on wages and employment. Young measures $\hat{l} = \sum s_j \hat{l}_j$. He benchmarks to total labor compensation, which imposes the identity that $WL = \sum W_j L_j$. Hence, his estimate of implicit wage growth, $\hat{w}_{\text{Primal}} = (\hat{w} + \hat{l}) - \sum s_j \hat{l}_j$, is necessarily consistent with the aggregate compensation figures. Hsieh measures $\hat{w}_{\text{Dual}} = \sum s_j \hat{l}_j$ directly, so he doesn't need to benchmark to aggregate compensation. Implicitly, two factors "explain" the wage differences. First, Hsieh's survey data have less growth in employment than the official tabulations and he implicitly has less labor quality growth than Young (1995); for given growth in nominal compensation, these factors imply faster wage growth. Second, Hsieh's figures on total labor compensation rises from 25 percent of GDP in 1973 to 37 percent of GDP in 1990. Hence, his show larger growth in nominal labor compensation.. Young (1998) questions the reliability of Hsieh's wage data.

follows, we focus on economic or conceptual issues raised by capital's contribution, line 6.

In Singapore, capital account for most (1.6 percentage points) of the dual-primal gap. The puzzle is that weak primal TFP performance implies sharp declines in capital returns, but estimated user-costs are flat.

B. A two-sector economic framework with profits and user-cost heterogeneity

We now discuss a simple economic environment in which, because of pure profits and capital-cost heterogeneity, the primal and dual might yield different results. We consider a partial equilibrium environment with two firms, indexed by *i* = *F* or *U* (ultimately, "favored" and "unfavored") that seek to maximize shareholder wealth. We abstract from uncertainty or factor adjustment costs.

Capital *K* and labor *L* are homogeneous, with $K_t = K_{F,t} + K_{U,t}$ and $L_t = L_{F,t} + L_{U,t}$. Each firm has a Cobb-Douglas production function, $Y_{i,t} = A_{i,t} K_{i,t}^{\alpha_i} L_{i,t}^{1-\alpha_i}$, where $A_{i,t}$ is the firm's technology. Equity-financed firms seek to maximize the present discounted value of cash flow. Cash flow each period is revenue net of wages, capital expenditures, and net taxes paid: $P_{i,t}Y_{i,t} - W_t L_{i,t} - (1-\kappa_{i,t} - \tau_{i,t}D_{i,t})I_{i,t} - \tau_{i,t}\left(P_{i,t}Y_{i,t} - W_t L_{i,t}\right)$. The capital goods price (q) is the numeraire. Firms take the wage, W_t, as given. Firms deduct wage payments before paying taxes at rate $\tau_{i,t}$. $D_{i,t}$ is the present value of allowances for depreciation in the tax code per dollar of investment; the tax authorities issue a credit of $\tau_{i,t}D_{i,t}$ when the firm undertakes the investment.[6] $\kappa_{i,t}$ is an investment subsidy, so that $(1-\kappa_{i,t} - \tau_{i,t}D_{i,t})I_{i,t}$ is the firm's effective net expenditure on capital. If the firm has market power, then price $P_{i,t}$ (relative to the capital goods price) depends on its choice of output: $P_t^i(Y_{i,t})$. Capital accumulation depends on investment $I_{i,t}$ and depreciation: $K_{i,t+1} = (1-\delta)K_{i,t} + I_{i,t}$. i_t is the real interest rate between *t*-1 and *t* (with $i_0 \equiv 0$), again defined in terms of the numeraire *q*, so that $\prod_{j=0}^{t}\left(1+i_t\right)^{-1}$ is the firm's discount rate from period 0 to period *t*. We assume perfect foresight and write the problem:

$$\text{Max } \mathrm{W}_0 = \sum_{t=0}^{\infty}\left(\prod_{j=0}^{t}(1+i_t)^{-1}\right)\left[(1-\tau_{i,t})(P_t^i\left(Y_{i,t}\right)Y_{i,t} - W_t L_{i,t}) - (1-\kappa_{i,t} - \tau_{i,t}D_{i,t})I_{i,t}\right]$$

$$\begin{aligned} \text{s.t.} \quad & Y_{i,t} = A_{i,t}K_{i,t}^{\alpha_i}L_{i,t}^{1-\alpha_i} \\ & K_{i,t+1} = (1-\delta)K_{i,t} + I_{i,t}, \text{ and } K_{i,0} \text{ given} \end{aligned} \quad (5)$$

[6] With constant tax rates, this formulation is equivalent to allowing firms to deduct depreciation each period against

The first-order condition for labor yields the standard condition that the output elasticity is a markup $\mu_{i,t}$ over the share of payments to labor in total revenue, $s_{Li.t}$ (see, e.g., Hall 1990):

$$1-\alpha_i = \mu_{i,t}\left(W_t L_{i,t}/P_{i,t}Y_{i,t}\right) \equiv \mu_{i,t}s_{Li,t}, \text{ where } \mu_{i,t} = \left(1+(\partial P_t^i/\partial Y_{i,t})(Y_{i,t}/P_{i,t})\right)^{-1} \quad (6)$$

With perfect competition, price is not affected by the firm's output, so $\mu_{i,t}=1$. Similarly, the Euler equation for capital implies that the output elasticity is a markup over the share of payments to capital in total revenue, $s_{K.t}$, where capital's nominal cost is calculated with an implied rental rate or user cost of capital, $R_{i,t}$:

$$\alpha_i = \mu_{i,t}\left(R_{i,t}K_{i,t}/P_{i,t}Y_{i,t}\right) \equiv \mu_{i,t}s_{Ki,t},$$
$$\text{where } R_{i,t} = \frac{1}{(1-\tau_{i,t})}\left[(1+i_t)(1-\kappa_{i,t-1}-\tau_{i,t-1}D_{i,t-1})-(1-\delta)(1-\kappa_{i,t}-\tau_{i,t}D_{i,t})\right] \quad (7)$$

If $\kappa_{i,t-1}=\kappa_{i,t}$ and $\tau_{i,t-1}D_{i,t-1}=\tau_{i,t}D_{i,t}$, then the user cost takes the familiar Hall-Jorgenson (1967) form:[7]

$$R_{i,t} = \left(i_t+\delta\right)\left(\frac{1-\kappa_{i,t}-\tau_{i,t}D_{i,t}}{1-\tau_{i,t}}\right) \quad (8)$$

The user cost is the implicit rental cost of using a dollar of capital for one period. It is thus capital's counterpart to the wage. The firm must earn an after-tax return to cover interest plus depreciation. All else equal, with a higher tax rate firms must earn a higher pre-tax return to compensate shareholders, raising the user cost. The purchase price of capital is effectively $1-\kappa_{i,t}-\tau_{i,t}D_{i,t}$; hence, reducing investment subsidies or depreciation allowances also raises the user cost. With perfect competition, the user cost equals the marginal product of capital. With no taxes or capital subsidies, $\mathrm{R}_{i,t}=\left(i_t+\delta\right)$, as in Hsieh.

As before, we define primal TFP as: $\widehat{tfp}_i = \hat{y}_i - s_{L,i}\hat{l}_i - (1-s_{L,i})\hat{k}_i$, where labor's share is observed and capital's share is a residual (we now omit time subscripts for simplicity). If firms have market power, with markup $\mu_i > 1$ then, as is well known, TFP growth need not equal technology change $\hat{a}_i$. Differentiating the production function and substituting from the first-order conditions, $\hat{a}_i$ is given by:

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income before paying taxes. $D_{i,t}$ is the present value of these deductions.

[7] We abstract here from many of the rich considerations facing firms in their optimization decisions. Auerbach (1983) and Hassett and Hubbard (2002) survey the voluminous literature on the user cost. Personal taxes are also a source of capital taxes but do not directly impact growth-accounting as long as firms take the interest rate as given. We have abstracted from property taxes. These were unimportant in Korea and Hong Kong, and appear to have moved over time with corporate tax rates in Singapore and Taiwan; see Asher (1989) and Tanzi and Shome (1992).

$$\begin{aligned}\hat{a}_i &= \hat{y}_i - \alpha_i \hat{k}_i - (1-\alpha_i)\hat{l}_i = \hat{y}_i - \mu_i s_{K,i}\hat{k}_i - \mu_i s_{L,i}\hat{l}_i \\ &= \widehat{tfp}_i + (\mu_i - 1)s_{L,i}(\hat{k}_i - \hat{l}_i)\end{aligned} \tag{9}$$

Equations (6) and (7) imply that $\mu_i(s_{L,i} + s_{K,i}) = 1$, so that $\mu_i = P_i Y_i / (WL_i + RK_i)$. Hence, $\alpha_i = RK_i / (WL_i + RK_i)$ and $1 - \alpha_i = WL_i / (WL_i + RK_i)$. As in Hall (1990), equation (9) shows at an industry level that using factor shares in cost would correctly give output elasticities; but shares in revenue do not.

We define instantaneous profits as any revenue that remains after paying for labor and capital: $\Pi_i = P_i Y_i - R_i K_i - W\, L_i$. Then the profit share in revenue, $\Pi_i / P_i Y_i$, is $s_{\Pi,i} = 1 - s_{L,i} - s_{K,i} = (\mu_i - 1)/\mu_i$. It follows that the last term in (9) is $(\mu_i - 1)s_{L,i}(\hat{k}_i - \hat{l}_i) = s_{\Pi,i}(1-\alpha_i)(\hat{k}_i - \hat{l}_i)$. If there are profits (reflecting markups), then the weights on capital and labor do not properly capture marginal products. If capital grows faster than labor, then this mismeasurement implies that technology growth exceeds measured TFP growth because, in constructing TFP, one overweights the productive contribution of faster-growing capital.

If the value of the firm's output equals the value of the firm's inputs (with capital payments as a residual), then the derivation of equation (2) applies, so that primal and dual firm-level TFP are equal. Thus, if primal TFP does not measure technology change, then neither does dual TFP.

To relate technology to the dual, we can, as before, differentiate $P_i Y_i = W_i L_i + R_i K_i + \Pi_i$ to find that $\hat{y}_i - s_{L,i}\hat{l}_i - s_{K,i}\hat{k}_i = s_{L,i}(\hat{w}_i - \hat{p}_i) + s_{K,i}(\hat{r}_i - \hat{p}_i) + s_{\Pi,i}(\hat{\pi}_i - \hat{p}_i)$. If we divide through by $1 - s_{\Pi,i} = s_{L,i} + s_{K,i}$ (to convert revenue shares to cost-shares) and rearrange, we find:

$$\hat{a}_i = (1-\alpha_i)(\hat{w}_i - \hat{p}_i) + \alpha_i(\hat{r}_i - \hat{p}_i) + \left(s_{\Pi,i}/(1-s_{\Pi,i})\right)\widehat{s_{\Pi,\,i}} \tag{10}$$

where $\widehat{s_{\Pi,\,i}} = \hat{\pi}_i - \hat{p}_i - \hat{y}_i$ is the profit-share growth rate. Technology change is a weighted sum of real-factor-price growth (with elasticities as weights) and profit-share growth. Hence, a cost-share-weighted dual alone would not equal technology change unless either the profit share or profit-share growth equals zero.

C. Implications for Measurement

Hsieh (2002) recognizes that taxes, subsidies, and profits might matter but assumes they do not. He also assumes that all firms face the same user cost. In our model, these factors are potentially important.

First, to assess the role of taxes, one needs both tax rates and depreciation allowances. If tax rates fall or depreciation allowances become more generous, then the user cost falls even if $\left(i_t + \delta\right)$ is constant. Hsieh suggests that taxes probably rose, not fell, in Singapore, since corporate tax revenues rose relative to GDP. This need not be the case. Suppose tax depreciation is γK. Then corporate taxes to GDP equals $\tau(P^{Corp}Y^{Corp} - WL^{Corp} - \gamma K^{Corp})/PY$. Corporate net income is $NI^{Corp} = P^{Corp}Y^{Corp} - WL^{Corp} - \delta K^{Corp}$, assuming economic depreciation δK. Thus, the tax-GDP ratio is $\tau(NI^{Corp}/PY)(1+(\delta-\gamma)K^{Corp}/NI^{Corp})$. If NI^{Corp}/PY and K^{Corp}/NI^{Corp} are constant, then the tax-GDP ratio rises if τ rises or γ falls. But it also fluctuates with corporate net income relative to GDP.

Second, anecdotal evidence for the NIEs suggests heterogeneity and, in the case of Singapore, large profits. Some firms received favorable treatment which, in some cases, included monopoly power. Suppose the favored firm *F* has a markup greater than one (implying positive profits) and receives investment subsidies and/or favorable tax treatment that lower its user cost. In contrast, the unfavored firm behaves competitively and has a higher user cost. It receives no subsidies or favorable treatment.

What would a statistician find if he compared primal and dual TFP? Suppose interest and depreciation rates are constant. He does not adjust for taxes, let alone for the potentially different, and time-varying, tax and subsidy parameters for the two firms; he does not observe any pure economic profits. Then he would observe a constant user cost. Assuming the unfavored tax and depreciation rates are constant over time, then its user cost , $(i+\delta)(1-\tau_U D_U)/(1-\tau_U)$, would in fact be constant. Hence, the dual correctly estimates growth in the unfavored-firm's user cost: $\hat{r}_{\text{Dual}} = \hat{r}_U = 0$. If we use firm-specific $\hat{p}_i$ and α_i—which need not equal their aggregate values—we can measure unfavored technology from equation (10), with $s_{\Pi,U}$ =0.

But aggregate payments to capital, $(R_t + \Pi_t/K_t) = (K_{F,t}R_{F,t} + K_{U,t}R_{U,t})/K_t + \Pi_t/K_t$, need not be constant, since neither R_F, nor the weights $K_{i,t}/K_t$, nor Π_t/K_t need be constant. From (3), noting that $\widehat{(r+\pi/k)} = (s_K\hat{r} + s_\Pi(\hat{\pi}-\hat{k}))/(1-s_L)$ and that $(1-s_{L,t}) = s_{K,t} + s_{\Pi,t}$, we find:

$$\begin{aligned} TFP_{\text{Dual}} - TFP_{\text{Primal}} &= (1-s_L)\left(\hat{r}_{\text{Dual}} - \widehat{(r+\pi/k)}\right) \\ &= s_K(\hat{r}_U - \hat{r}) + s_\Pi\left[\hat{r}_U + \hat{k} - \hat{\pi}\right] \\ &= s_K(\hat{r}_U - \hat{r}) + s_\Pi\left[(\hat{r}_U - \hat{p}) + (\hat{k} - \hat{y}) - \widehat{s_\Pi}\right] \end{aligned} \tag{11}$$

The first term captures the representativeness of $\hat{r}_U$. The second term captures the effects of economic profits. If $s_\Pi > 0$, then this term tends to be positive if the capital-output ratio rises or if the profit rate falls.

. One need not get a wedge from equation (11). For example, in steady state, $\hat{r}_U = \hat{r}_F = \hat{r} = 0$; and $\widehat{s_\Pi} = \widehat{s_K} = 0$. The second term then becomes $s_\Pi \left[\hat{s}_K - \hat{s}_\Pi\right] = 0$. Even out of steady-state, $\hat{r}_U$ and $\hat{r}_F$ might grow at the same rate; and the profit and capital shares might both be constant. Nevertheless, during the transition to a new steady state, these terms can very plausibly be positive.

Later, we argue that this model captures Singapore's reality and quantify the terms in (11).

D. Linking Sectoral and Aggregate Technology

In general, neither the aggregate primal nor dual measures technology. We now relate aggregate TFP and technology. We measure aggregate output as a Divisia index: $\hat{y} \equiv \omega_F \hat{y}_F + \omega_U \hat{y}_U$, where the nominal output share of sector *i* is $\omega_i \equiv P_i Y_i / (P_F Y_F + P_U Y_U) \equiv P_i Y_i / PY$. This is the continuous-time analogue to discrete-time chain-weighting. Since the two firms have Cobb-Douglas production functions, we find:

$$\begin{aligned}\hat{y} &\equiv \omega_F \left(\hat{a}_F + \alpha_F \hat{k}_F + (1-\alpha_F)\hat{l}_F\right) + \omega_U \left(\hat{a}_U + \alpha_U \hat{k}_U + (1-\alpha_U)\hat{l}_U\right) \\ &= \left[\omega_F \hat{a}_F + \omega_U \hat{a}_U\right] + \left[\omega_F \alpha_F \hat{k}_F + \omega_U \alpha_U \hat{k}_U\right] + \left[\omega_F (1-\alpha_F)\hat{l}_F + \omega_U (1-\alpha_U)\hat{l}_U\right]\end{aligned}$$

The first term, $\hat{a} \equiv \omega_F \hat{a}_F + \omega_U \hat{a}_U$ tells us how much aggregate output rises because of technological change, holding labor and capital in the two sectors fixed (so that the second and third terms are zero). Given this property, we define this term to be aggregate (i.e., average) technology change. With some algebraic manipulation (see appendix), we can write aggregate TFP growth, $\widehat{tfp} = \hat{y} - s_L \hat{l} - (1-s_L)\hat{k}$, as:

$$\widehat{tfp} = \hat{a} + s_\Pi (\hat{x}_F - \hat{k}) + \Sigma_K , \qquad (12)$$

where $\hat{x}_F = \alpha_F \hat{k}_F + (1-\alpha_F)\hat{l}_F$ and $\Sigma_K = \left(K_F K_U / PY \cdot K\right)\left(R_F - R_U\right)\left(\hat{k}_F - \hat{k}_U\right)$. The second term captures the combined effects of economic profits. In the favored sector, TFP doesn't equal technology because the weights on inputs are shares in revenue rather than in cost, so that profits are not properly accounted for. At the same time, by taking capital's share as a residual, the full profit share is allocated to capital (in all sectors, not just in the favored sector). If $\hat{x}_F = \hat{k}$, these effects perfectly offset one another. The third term, Σ_K, reflects reallocations of capital. Other things equal, a higher user cost implies a higher marginal product of capital; shifting capital to where it's more valuable raises output and TFP.

Thus, with significant and different distortions across sectors, estimating technology as distinct from TFP requires building from the bottom up. For example, using aggregate cost rather than revenue shares would not, in general, yield technology. (The appendix discusses this further.)

II. Singapore: Taxes, Pure profits, and heterogeneous user costs

The model above suggests features that cause the dual-primal gap. Singapore, where the dual-primal gap is largest, offers ample qualitative evidence that these features matter. Virtually every description of Singapore's transition from a poor country in the 1960s to a rich, modern economy cites the government's active intervention and enticement of vast inflows of FDI. "Favored" firms—primarily government-linked corporations (GLCs), statutory boards (SBs), and multinationals—appeared to earn large profits, reflecting market power and favorable factor prices.[8] Incentives (favoritism) increased over time.

GLCs (where the government is a substantial shareholder) and wholly-government-controlled SBs contributed as much as 25 percent of Singapore's GDP by the late 1980's.[9] Ermisch and Huff (1999) claim that government SBs charged artificially high prices for public utilities and telecom to earn monopoly profits. The Singapore Economic Committee (1986) indicates that monopoly pricing by SBs raised the cost of doing business and makes the policy recommendation that SB tariffs be reduced. Consistent with this monopoly-pricing view, the current surpluses of commercially-oriented SBs (included in national accounting profits) averaged 13 percent of GDP from 1975-1984 and 10 percent from 1985-1988. Ramirez and Tan (2004) report that listed GLCs have statistically significantly higher q-ratios than other listed firms.

Singapore's active enticement of FDI also led to large profits. From 1972 to 1990, Singapore generated FDI inflows averaging almost ¼ of gross fixed capital formation by offering a wide range of incentives that reduced production costs. Singapore figures prominently in the literature on tax havens: "low-tax jurisdictions that provide investors opportunities for tax avoidance" (Desai, Foley, and Hines, 2006). Firms might locate intangible assets in Singapore or else adjust internal transfer prices to realize high profits there. Indeed, the average tax rate for U.S. multinationals in Singapore is consistently among the lowest in the world —about 30 percentage points below the unweighted mean in 1983, for example. Such profit shifting, as well

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[8] SBs are created by acts of Parliament and are accountable to particular ministries. For example, SBs provided utility services, telecom, and port operations. GLCs are incorporated under the Companies Act. Several state holding companies (e.g., Temasek) hold equity on behalf of the government; Singapore's Economic Development Board sometimes takes equity stakes, as well. See Ramirez and Tan (2004, fn 3) and Economist Intelligence Unit (2004).

[9] Late 1980s share is from IMF (1995). Department of Statistics (2001) argues that by the mid-90s, the GLC share of GDP was only a bit over 10 percent, though calculation explicitly excludes widespread holdings in companies where the government owns less than 20 percent of the company. Ramirez and Tan (2004, p514) point out that Singapore Statistics' definition of GLCs exclude many companies in which the government has effective control.

as other subsidies that reduced operating costs, would lead to large economic profits.

GLCs, SBs, and multinationals also had user costs of capital that likely differed from other firms. Special treatment (investment subsidies in our model) included direct government financing, artificially high credit worthiness (creditors assumed the government would bail out bad performers), and political connections.[10] A major benefit was subsidized land access. Under the Land Acquisition Act, the government had authority to purchase land at its 1973 market price, which it leased to industrialists at rates that reflected the low acquisition price. As land prices rose, the value of the land subsidy grew more valuable.[11]

Many preferences are firm-specific and unquantifiable.[12] But changes in tax law are observable. Major, legislative changes took place under the Economic Expansion Incentives (Relief from Income Tax) Act. The 1967 Act (as amended in 1970) gave so-called "pioneer firms" a five-year tax holiday, i.e., a tax rate of zero. In 1975, the tax-holiday period was extended to 10 years. In 1984, pioneer status was extended to selected service firms. In 1987, Singapore reduced the tax rate for firms ending their tax-holiday period from 40 percent to 10 percent. The share of manufacturing value added accounted for by pioneer firms rose from an average of 53 percent in the first half of the 1970s to about 64 percent in the second half of the 1980s. More generally, depreciation provisions became more generous after 1979, and the statutory corporate tax rate fell from 40 percent to 33 percent in 1986 and to 32 percent in 1989.[13] We quantify the tax effects below.

Finally, the government directed substantial credit to favored firms. In the 1970s, government loans to foreign investors, GLCs, and commercially-oriented SBs amounted to about 20 percent of the total stock of bank loans to the private sector (these figures exclude sizeable housing loans). The average interest rate on these government-directed commercial loans was about 3 percent less than the bank-lending rate used by Hsieh. (In the 1980s, the government stopped publishing the interest rate information.)

Inflows of FDI were the same order of magnitude as bank loans, and rose markedly over the 1970s and

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[10] The Economist Intelligence Unit (1993) states: "Singapore's government relies heavily on incentives to attract foreign investment…. Investment incentives include tax holidays and concessions, accelerated depreciation schemes, favourable loan conditions, equity participation and high-quality industrial estates…" Burton (1995) claims that GLCs' "costs of capital are usually lower than for companies in the private sector." U.S. Embassy (2001) claims that "GLCs were given preferential rates by DBS Bank, itself a GLC."

[11] Ermisch and Huff (1999) and Tan (2001) discuss the implicit land subsidy. In Schein's (1996) case studies, negotiations between the government and foreign investors over leases for favorable land parcels figure prominently.

[12] Negotiated terms are not public, so one cannot easily quantify these incentives. Even if foreign companies faced competition in export markets, the measures likely reduced production costs and allowed for economic profits.

[13] Sources for this paragraph are Fordham (1992), Commerce Clearing House (various dates), Low *et al* (1993, p355),

1980s. As a financing source, FDI inflows plus the change in government loans amounted to about 80 percent of the change in bank loans to the private sector in the 1970s; this ratio rose to nearly 120 percent in the 1980s. The increase reflected FDI, since the quantity of government loans declined over the 1980s.

III. Adjusting for Corporate Taxes

Before quantifying the role of profits and heterogeneity in explaining the dual-primal gap, we assess whether capital taxes are quantitatively important. Hsieh recognizes that taxes might matter, but he was unable to obtain reliable tax information. He suggests that abstracting from taxes probably does not drive results, since Singapore's corporate-tax assessments rose relative to GDP. This rising ratio is not surprising, however, since corporate net income rose rapidly relative to GDP. For example, net income as reported by corporations rose from 11 percent of GDP in 1970 to 28 percent by 1980.

Tax rates tell a different story. Figure 1.A shows the statutory rate (marked with an x) and two measures of averages taxes paid (i.e., taxes relative to income): from Inland Revenue Authority Reports (filled squares) and from financial reports of corporations (triangles). The three measures all decline in the 1980s.

Were tax preferences for targeted firms quantitatively important? The corporate reports allow us to calculate average taxes paid for local- versus foreign-owned firms and by major sector.[14] Figure 1.B shows that foreign manufacturing firms, who were major recipients of "pioneer" status, paid lower rates, which fell from about 40 percent to under 10 percent by 1990. Other firms' rates fell only to about 30 percent. Foreign manufacturing accounted for about 1/3 of total corporate profits in the 1980s and 2/3 of foreign profits. We thus calculate two tax wedges: for foreign manufacturing, and for everyone else. (Note that some favored firms (e.g., GLCs) received other, non-tax forms of preferential treatment.)

To measure tax wedges, we also need the present value of depreciation allowances, D_i. We use the tax code to calculate D for each major type of business capital. For regular firms, the capital-income weighted present value of depreciation allowances rose from about 0.6 before 1977 to about 0.75 after 1979. The major changes over the 1970-90 period are (i) in 1978, initial and annual allowances for industrial buildings become more generous; and (ii) in 1980, allowances for transport and machinery become more generous. The tax code has numerous other special provisions for targeted activities, though most are quantitatively modest.

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and http://www.iras.gov.sg/ESVPortal/ct/ct_b.2.2_what+are+the+tax+rates.asp (downloaded May 17, 2006).

The one significant difference for favored firms was a 50 percent investment allowance introduced in 1980 for non-pioneer-manufacturing, which was in *addition* to other, regular allowances. We assume that 40 percent of foreign manufacturing firms received the investment allowance, based on the roughly 60 percent share of manufacturing production accounted for by pioneer firms.

We use the average tax rate for foreign manufacturing, assume that other firms paid the statutory tax rate, and calculate the tax wedges $T_i = (1-\tau_i D_i)/(1-\tau_i)$. For foreign manufacturing, the wedge fell 1.3 percent per year; for other firms, it fell by 0.7 percent per year.[15] Although the decline in statutory rates was smaller than the decline in foreign manufacturing rates, the decline in T_i was still large for non-foreign manufacturing because of the increase in *D*. The overall tax wedge is the capital-weighted average of the two wedges.. Based on net fixed asset data in Singapore Statistics (1992b), we use ¼ as our benchmark for the weight of foreign manufacturing and find that *T* falls at 0.9 percent per year.[16]

Thus, the effect on the dual is large for both unfavored as well as favored firms. Nevertheless, it accounts for only about a quarter of capital's 1.6 percentage point contribution to the dual-primal gap, as Table 3 shows. Hence, Hsieh is correct that the tax correction alone cannot explain the full dual-primal gap. For unfavored firms (a subset of non-foreign-manufacturing), we incorporate the tax-adjustment of -0.7 percent per year into the estimate of $\hat{r}_U$ in the rest of the paper. The 0.6 percentage point difference between $\hat{t}_F$ and $\hat{t}_U$ provides some quantitative evidence of user-cost heterogeneity.[17]

Table 3 shows that the tax adjustments for the other NIEs appear small, albeit consistent with the dual-primal gaps from Table 2. For Taiwan, the contribution is about 0.2 percentage point per year, largely reflecting increases in investment tax credits (κ) in the 1980s. In Korea, the tax wedge contributes about 0.1 percentage point. Tax rates for large companies fell over time, and depreciation allowances became somewhat more generous. But κ (for selected investments) also became less generous. In Hong Kong, the change in the tax wedge contributes nothing to the dual-primal gap: Depreciation allowances became slightly more

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[14] The appendix details our construction of these series.
[15] We estimate the trend in the tax wedge for each type of capital, and then weight by average capital-income shares. Following Hsieh (2002), we fit a time trend to the data and divide by the mean. One can apply this procedure to data that might occasionally take on negative values, so that one cannot use logs. But taking logs first gives similar results.
[16] This calculation is fairly robust to alternative paths for the capital weight. We also confirmed that qualitative results were robust to a wide range of assumptions about depreciation allowances. Note that the declining tax wedge is consistent with a rising corporate tax-to-GDP ratio because (corporate profits/GDP) was rising.

generous over time, but the corporate tax rate also rose slightly.

IV. Measuring the Economic Distortions and Structural Transformation

We now use equation (11) to assess the empirical importance of profits and user-cost heterogeneity for the dual-primal gap. We use international factor share data to estimate cost shares for the NIEs. In contrast with labor's share of revenue, these cost-shares show the structural transformation predicted by theories of trade and Asian development. We then use these figures to estimate profit shares and profits' contribution to the gap. We back out, as a residual, the heterogeneous-cost-of-capital term. Together, profits and user-cost heterogeneity explain much more of the gap than taxes do.

A. Increasing Capital Intensity in the NIEs

Theories that stress the role of international trade in Asian growth predict rising capital shares and falling labor shares.[18] The Rybczynski theorem states that an increase in the stock of a given factor causes increased production and exports of goods intensive in that factor. Romalis (2004) finds that as the NIEs accumulated human and physical capital, their share of world production and exports of capital-intensive goods rose and their share of unskilled-labor-intensive production fell, implying capital's share of costs rose.

Ventura (1997) applies a form of the factor price equalization theorem. If two countries with identical technologies (and no factor intensity reversals) produce goods that differ sufficiently in factor intensities, then trade equalizes factor prices. The capital-intensive country exports capital-intensive goods and imports labor-intensive ones. In essence, trade in goods is an indirect way to trade factors of production; return differentials are arbitraged away.[19] Factors have diminishing returns only globally, so small open economies can sustain rapid growth by accumulating factors and shifting production without factor returns changing.

Since the NIEs accumulated capital far faster than skill-adjusted labor, Ventura's explanation also implies rising capital shares and falling labor shares.[20] As Table 4, line 1, shows, however, ($1\text{-}s_L$) fell over time in Singapore, Korea, and Taiwan—inconsistent with Ventura's predictions and Romalis's results.

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[17] Unobserved subsidies and other sources of user-cost heterogeneity are also likely to be important, of course.
[18] See Feenstra (2004) for a detailed presentation of the Heckscher-Ohlin model, the Rybczynski theorem, factor price equalization, and other related theorems in international trade.
[19] Under certain conditions, Ventura's application of factor-price equalization results implies truly constant factor prices. His explanation remains valid, however, as long as factor prices decline at slower rates than factors accumulated. Romalis (2004), however, emphasizes the empirical failure of the factor price equalization theorem.
[20] Ventura's predictions for factor shares are relative to the rest of the world. In BLS or Jorgenson data for the United States, there is little evidence of a trend in factor shares over this period.

Of course, residual capital payments ($1\text{-}s_L$) include any pure profits. To control for these, we combine international data on industry capital-cost shares from Sarel (1997) with data on the industry mix of output to estimate "true" capital shares in *cost, α*. Table 4, line 3, shows *α.* Capital shares in cost generally increased over time (line 4), albeit minimally in Korea, in line with trade theories.

Why might these calculations be misleading? First, the NIEs might produce a different product mix within one-digit industries than the world norm. For Singapore, we obtained two-digit-manufacturing value-added data for 1990 and applied factor shares (averaged 1980-1996) from Jorgenson's U.S. data. The implied manufacturing capital share was 0.32, compared with 0.31 in Sarel. Product mix thus cannot explain much of a gap between ($1\text{-}s_L$) and *α.* Second, we assume constant one-digit factor shares. Jones (2003) argues that shares are not constant. But deviations from strict Cobb-Douglas appear small relative to mean differences across industries. This is true in Jorgenson's U.S. data, for example.

B. Accounting for the Dual-Primal Gap

We now use the implied cost shares to calibrate the role of profits. Section II argued qualitatively that in Singapore, government policy gave some firms market power, low average factor prices, and large profits. Indeed, Singapore's strikingly low labor share is consistent with this anecdotal evidence.

Table 4 quantifies profit shares s_Π by comparing ($1\text{-}s_L$) (line 1) with estimated cost shares (line 3). If capital's share in total cost is *α* and labor's share is (1- *α*), then the profit rate is $s_\Pi = ((1-s_L)-\alpha)/(1-\alpha)$.[21] Singapore is the only country with substantial profits. The residual revenue share ($1\text{-}s_L$) is about ½ but our estimated capital cost share is only a bit above 1/3 (line 3), implying a profit share s_Π of about ¼ (line 7). As line 8 shows, this large profit share declined about 1.2 percent per year from 1970-1990.

Estimated profits in Taiwan, though small, were negative. The high labor share estimate (¾) drives the negative estimate. Young (2003) argues that a labor share of ¾ overstates the true share: Young (1995) inadvertently overcorrects for (imputed) proprietor's wage income. Thus, we interpret these results for Taiwan (as well as for Korea and Hong Kong) as indicating small pure profits.

Table 5 uses equation (11) to decompose Singapore's dual-primal gap. Capital contributed 1.6

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[21] This calculation assumes an even distribution of profits across sectors. In Section V, we will assume profits exist only in the relatively capital-intensive favored sector, and this will slightly increase the profit share, Table 4 indicates that even after making any such adjustments, profits will only be large in Singapore.

percentage-points per year to the gap (line 4). The tax adjustment from Section III accounts for about ¼ of this (line 3). The profit term, $s_\Pi\left[(\hat{r}_U - \hat{p}) + (\hat{k} - \hat{y}) - \widehat{s_\Pi}\right]$, accounts for about half the gap (line 1). The profit share was high but declining; and the capital-output ratio was rising. Line 2 shows the residual, 0.3 percent per year. Under the null that the primal and dual are accurate, the residual reflects user-cost heterogeneity, $s_K(\hat{r}_U - \hat{r})$—reflecting differential tax effects (as found in Section III), favorable access to land and financing, and other unobserved subsidies. Hence, while both distortions (as well as taxes) drive a wedge between the primal and the dual, profits appear quantitatively the most important.

Obviously, these calculations take seriously that Singapore's labor's share was about a half. The data appendix discusses and defends this figure. However, even if we arbitrarily raised labor's share in revenue to 0.6 in all periods, profits would still explain a gap of 0.5 percentage points per year. Alternatively, if we arbitrarily halved the profit share by raising our estimate of α by 8.5 percentage points, profits would still explain a gap of 0.7 percentage points. In both cases, although s_Π would be much smaller, $\widehat{s_\Pi}$ would also be much more negative. The contribution of profits will remain important for the dual-primal gap unless one generates a sharply falling labor share to match the fall in (1- α). Although Young estimates a constant labor share, other data sources suggest labor's share of revenue (though low) might have risen a bit; there is no evidence at all to support a falling labor share. Hence, these calculations appear reasonably robust.

C. Quantitative Corroboration of Large Economic Profits

Anecdotal evidence suggests large pure profits in Singapore. But profits of ¼ of GDP are exceptional. We confirm the magnitude of profits with a back-of-the-envelope estimate. Following Rotemberg and Woodford (1995), we use factor shares and the capital-output ratio to back out an implied return to capital including profits. From 1970-1990, the nominal ratio of tangible capital to GDP averaged 2.38; in the mid-to-late 1980s, it was nearly 3. The average depreciation rate δ in Singapore appears relatively flat at 6.7 percent. Thus, $(i + \Pi/K + \delta)\left(qK/PY\right) = (i + \Pi/K + 6.7)\left(2.38\right) = s_K + s_\Pi = 0.484$. The implied value of $(i + \Pi/K)$ is 14 percent—substantially in excess of the corresponding U.S. rate of 6 percent.

Rotemberg and Woodford argue that 6 percent is the U.S. required return to capital, including an equity premium, and implies little if any pure profit. But if, because of capital mobility, Singapore's interest rate were similar to the U.S. rate, then the 'excess' return of 8 percent represents profits. Multiplying an 8 percent excess return by the capital-output ratio again suggests a rate of profit of close to 20 percent.[22]

Industry estimates also suggest very large profits. Kee (2002) estimates markups and returns to scale for manufacturing industries as in Hall (1990). He finds that most industries have large markups of price over marginal cost; but few have correspondingly large increasing returns, implying very large profits. Indeed, in a pooled specification, Kee's estimates imply that pure profits exceed 50 percent of value-added.[23]

D. How the Dual Missed "Favored" Treatment and Profits?

Why does dual TFP capture the user cost for the unfavored sector only? As section I.C. discusses, a dual user cost based on estimating a single value for $(i+\delta)q$ misses favored subsidies and tax treatment. In addition, it is likely to omit profits. Hence, apart from the tax correction discussed in Section III, it should be appropriate for a firm that does not receive subsidies and earns no profits. More specifically, three rate-of-return measures are used in Singapore's dual calculation : The earnings-to-price ratio (E/P); an average lending rate; and the return on equity (ROE). All omit subsidies/taxes, and two of the three omit profits.

First, consider the earnings-price ratio. A standard formula (e.g., Brealey and Myers, 1996, p69) says that a company's share price P_i is $P_i = E_i/i_i + PVGO_i$—the value of a perpetuity yielding E_i, plus the present value of growth opportunities—implying that $E_i/P_i = i_i - (i_i \cdot PVGO_i/P_i)$. Hsieh implicitly assumes we can ignore the second term. With perfect capital mobility, this measure i_i is the expected return for the global representative investor, which might be appropriate for a firm seeking private–sector financing. Note that exchange-listed companies earning large pure profits have higher earnings but also higher prices.

Second, the average bank lending rate is also more appropriate for unfavored firms. Young (1998) describes how a heavily regulated "cartel arrangement" kept lending rates above competitive levels. But GLCs, SBs, and multinationals generally had alternative, likely cheaper sources of funding, including government loans, FDI, and international lending. In the 1980s, for example, only 21 percent of Singapore bank loans to non-bank customers went to heavily favored manufacturing, transport, and communications—which accounted for 40 percent of GDP. FDI was a much more important funding source for these firms.

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[22] Studies for other countries also sometimes suggest that product market distortions lead to substantial economic rents. Blanchard and Giavazzi (2002) discuss the sharp decline in labor's income share in many European economies from the early 1980s to the mid-1990s. Consider Italy, where labor's share fell from almost 80 to about 60 percent. They attribute the decline to a reduction in labor's ability to capture the rents arising from product market restrictions. For such a large shift in rents to occur, the rents themselves must be large—e.g., for Italy, on the order of 15 to 20 percent of GDP.

Finally, the dual uses return on equity from Singapore's Registry of Companies and Businesses. ROE is the ratio of two easily manipulated elements in firm financial statements; it is an accounting not a market measure. Firms have considerable discretion in reporting intangible assets such as goodwill or brand name, which in turn affects the book value of shareholder equity; firms earning large profits seem particularly likely to report sizeable intangible assets. From 1980-90, the underlying asset figures for non-financial firms alone show a ratio to GDP that averages 4.5—compared with a capital-output ratio of 2.8 in the national accounts. In sum, we view the ROE figures as a much less reliable measure of the opportunity cost of funds than the E/P ratio or the average lending rate, both of which correspond primarily to the unfavored sector.

V. Two-Sector Framework: Dynamics, Productivity, and Technology

We now assess technology change in Singapore. As a byproduct, we describe how the two sectors and the aggregate economy evolved. As in Section I, with constant returns and perfect competition, the dual measures unfavored-sector technology, $\hat{a}_U$. Suppose all firms pay the same nominal wage and that all unfavored firms pay user cost $R_U=R_{DUAL}$. From equation (10) (where the final term is zero), the only additional information we need—beyond the components of the dual—are capital-share, α_U, and relative-price growth, $\hat{p}_U - \hat{p}$. Given positive overall wage growth and relatively flat user cost, $\hat{a}_U$ is thus likely to be positive (and close to Hsieh's estimate) unless unfavored relative-prices rise quickly.

Measuring favored technology growth, $\hat{a}_F$, and aggregate technology growth, $\hat{a} \equiv \omega_F \hat{a}_F + \omega_U \hat{a}_U$ requires further assumptions and additional data. To use equation (10), we need to know $\hat{r}_F$, $s_{\Pi,F}$, and $\widehat{s_{\Pi,F}}$. Equivalently, we can use the cost-share-weighted primal, which requires $\hat{y}_F$, $\hat{l}_F$, $\hat{k}_F$. We use the 1-digit output data along with the international factor shares to provide benchmark estimates.

Consistent with the anecdotal evidence from Section II, we define the favored sector as the following 1-digit SIC industries: Manufacturing, Finance, Utilities, and Transport. The unfavored sector is the remaining sectors: Agriculture and Fishing, Quarrying, Construction, Commerce, and Other Services. With this classification, $\hat{y}_F$ averages 9.6 percent from 1970-90; $\hat{y}_U$ averages 6.1 percent. On average, the favored sectors account for 59 percent of output. Unfavored prices rise 0.1 percentage point per year(pp) faster than

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[23] If μ equals P/MC and γ is returns to scale, then $\Pi/PY = (\mu - \gamma)/\mu$ (see, e.g., Basu and Fernald, 2001).

overall prices; favored prices rise 0.1 pp less (all deflators are Tornquist indices).

As in Section IV, we use one-digit international factor shares to estimate cost shares. Unfavored industries are labor intensive: average α_U is 19 percent. Favored industries have a much higher α_F equal to 42 percent. We estimate these shares every period; but they are very close to constant over time.

Several adjustments should be noted. First, our industry breakdown omits imputed bank services, which we cannot allocate. As a result, aggregate industry output grows 0.3 pp per year faster than Young's expenditure-side measure from 1970-90. This immediately translates into 0.3 pp faster growth in the primal's aggregate real wage. It does not, however, affect the GDP deflator, so it leaves the dual estimates unchanged. Second, we need to choose whether to use the primal or dual measure of wage growth. We use Young's primal measure; with the 0.3 pp adjustment, the aggregate real wage rises by 2.1 percent per year. Third, Section IV suggests that ROE is problematic as a measure of the real user cost. Hence, we drop that measure and average the E/P and bank-lending-rate measures.[24] This raises average dual user cost growth by about 0.3 percent. Finally, we incorporate the tax effect on the dual user cost discussed in Section III. On balance, our estimate of $\hat{r}_{Dual} - \hat{p}$ is -0.1 percent —qualitatively similar to the original estimate of 0.3 percent. We can now estimate unfavored technology (does not add up exactly due to rounding):

$$\hat{a}_{\mathrm{U}} = (1-\alpha_U)(\hat{w}-\hat{p}) + \alpha_U(\hat{r}_{Dual}-\hat{p}) + (\hat{p}-\hat{p}_U) = 0.81 \cdot 2.1 + 0.19 \cdot (-0.1) - 0.1 = 1.5 \text{ percent} .$$

This is similar to Hsieh's original estimate. In addition to the adjustments just described above, the key differences from Hsieh's calculations are that Hsieh used Young's aggregate labor shares whereas we use sectoral ones, and we measure real factor prices in terms of sectoral, not aggregate, deflators. Had Hsieh calculated dual TFP using Young's wage growth, without ROE, and with taxes, he would have estimated TFP growth of 1.0 percent per year. Hence, technology growth in the unfavored sector is actually higher than Hsieh's comparable dual estimate because of the higher weight on faster-rising wages.

Next, we use the cost-based primal to determine technology growth in the favored sector:

$$\hat{a}_F = \hat{y}_F - \left[(1-\alpha_F)\hat{k}_F + \alpha_F \hat{l}_F \right]$$

Labor growth is $\hat{l}_F = \hat{s}_{L_F} + \hat{y}_F + (\hat{p}-\hat{p}_F) - (\hat{w}-\hat{p})$. The sectoral data give us $\hat{y}_F$ and $\hat{p}-\hat{p}_F$; real-wage

[24] We continue to adjust for the fact that the measures cover different time periods.

growth is 2.1 percent per year. We get $s_{L,F}$ and $\hat{s}_{L,F}$ from the identity $s_L = \omega_F s_{L,F} + \omega_U s_{L,U}$: Young's data give us the aggregate s_L, the output data give us the weights, and the international cost share data give us $s_{L,U} = 1 - \alpha_U$. Thus, we can back out an estimated time series for $s_{L,F}$, which averages 31 percent, and for $\hat{s}_{L,F}$, which averages 2.9 percent per year. Together, these estimates imply that $\hat{l}_F$ is 10.4 percent per year.

For the unfavored sector, we use the dual user cost to back out $\hat{k}_U = \hat{s}_{K_U} + \hat{y}_U - (\hat{r}_U - \hat{p}_U)$ = 6.0 percent. We cannot use the same approach for $\hat{k}_F$ because we do not know $\hat{r}_F$. Given aggregate $\hat{k} = 11.0$ and $\hat{k}_U = 6.0$, plus the relationship $\hat{k} = \beta\hat{k}_F + (1-\beta)\hat{k}_U$, we can obtain $\hat{k}_F$ for any value of $\beta = K_F / K_U$. We obtain a benchmark by defining the user-cost ratio $\eta = R_F / R_U < 1$, and using the relationship:

$$\eta\beta = \frac{R_F K_F}{R_U K_U} = \frac{s_{K,F}}{s_{K,U}}\frac{\omega_F}{\omega_U} = \frac{0.23}{0.19}\frac{0.59}{0.41} \approx 1.75 \tag{13}$$

Hsieh's estimates show R_U of around 20 percent. As Sections II and III discuss, preferential tax treatment and subsidized capital plausibly reduced this cost by about 5 percentage points for the favored sector. Hence, we calibrate $\eta \approx 0.75$ and find $\beta = K_F / K_U \approx 2.3$ and $\hat{k}_F = \left(\hat{k} - (1-\beta)\hat{k}_U\right) / \beta$ =13.1 percent.[25]

These estimates imply that technology growth in the favored sector was abysmal: -2.0 percent per year. Aggregate technology is $\hat{a} = \omega_U \hat{a}_U + \omega_F \hat{a}_F$. As Table 6, column A shows, with $\hat{a}_F = -2.0$, $\hat{a}_U = 1.5$, and $\omega_F = 0.59$, we find $\hat{a}$ is -0.5 percent per year.

What key assumptions and features of the data drive these estimates? In the unfavored sector, constant returns and perfect competition are crucial, since they allow us to use the dual approach. These assumptions seem reasonable, given standard "replicability" arguments for constant returns combined with competition. In

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[25] Another condition implied by our model is $(\hat{r} + \hat{k}) = (1/(\alpha\beta+1))(\hat{r}_U + \hat{k}_U) + (\alpha\beta/(\alpha\beta+1))(\hat{r}_F + \hat{k}_F)$. $(\hat{r}_i + \hat{k}_i) = \hat{s}_{K,i} + \hat{y}_i + \hat{p}_i$, so the calibration in the text identifies all pieces other than $\alpha\beta$. This equation need not and does not yield the same value as (13)—our calibration is, loosely speaking, overidentified. But the two estimates (1.5 versus 1.75 in the text) are close. In essence, our story is not consistent with any arbitrary sectoral definitions. Placing manufacturing in the unfavored sector, for example, would yield a very large discrepancy between the estimates. Our allocation relied on qualitative evidence alone and allocates each industry entirely into one sector or the other, so the small difference corroborates our calibration. In addition, we verified that equations (10) hold for each sector and that (12) holds in the aggregate. (We used a time-varying profits term in (10); other equations do not appear sensitive to using a first-order approximation, but with large declines in the profit share over time, the approximation is less exact.)

the favored sector, we have used accounting decompositions (but *not* constant returns) to derive factor-quantity growth. The strong growth in $\hat{l}_F$ is driven by the increases in favored labor's share, i.e., by $\hat{s}_{L,F}$. Those increases are driven by the declining profit rate—which, in turn, is driven in the data by the constant aggregate labor share combined with the shift towards capital-intensive sectors. These are robust features of the data. Strong growth in $\hat{k}_F$ is driven by the large gap between strong observed aggregate capital growth and weak estimated growth in $\hat{k}_U$ (which is driven by the flat user cost).

Given the underlying forces in the data that drive the estimates, our quantitative and qualitative results are not particularly sensitive to the assumptions we have made (see Table 6). Increasing K_F/K_U reduces $\hat{k}_F$, which slightly improves $\hat{a}_F$. Including the ROE user-cost measure reduces $\hat{a}_U$ negligibly, since the capital-weight is small; it slightly improves $\hat{a}_F$ (because it raises $\hat{k}_U$ and reduces $\hat{k}_F$). We also consider the sensitivity to the large estimated profit shares by arbitrarily increasing the international capital-cost-share estimates by 9 percentage points in each sector and by increasing the growth-accounting labor share by 8 percentage points each year. These adjustments each halve the average profit share. The unfavored dual barely changes, since the change in weights is modest. Unfavored and aggregate technology improve relative to the benchmark, but remain strikingly poor; although the profit rate is smaller, its rate of change is larger.

Technology estimates are, however, sensitive to assuming constant returns in the favored sector. Measured technology would improve if returns to scale were sharply decreasing, $\gamma<1$. But decreasing returns would not necessarily imply a more optimistic assessment of Singapore's performance. Suppose each firm has a fixed cost *F* and increasing marginal cost: $Y = X^{\rho} - F$. X is composite input, and the parameter $\rho<1$ implies increasing marginal cost. $\gamma = d\ln Y/d\ln X = \rho(1+F/Y)$. The competitive equilibrium, where MC=AC, has $\gamma=1$. Government-supported entry barriers shift the firm's demand curve up as well as making it less elastic. If the upward shift dominates the reduced elasticity, then each firm produces more, which pushes $\gamma<1$. Subsidies to input use also lead firms to overproduce and push down γ. Thus, in this model, government interventions reduce the efficiency of the economy even if true technology does not change. Similarly, Restuccia and Rogerson (2004) offer a story in which firms have decreasing returns (e.g., from

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Further detail on levels and growth rates of key variables in the benchmark calibration is available upon request.

limited managerial span of control) but differ in productivity levels. Shifting resources away from the undistorted equilibrium—whether towards or away from high-productivity firms—reduces overall TFP and welfare. Hence, Singapore's heavy interventions could have led to falling TFP (and reduced our measured technology) even if it favored high-productivity firms.

Nevertheless, industry estimates for other countries generally suggest constant or increasing returns (e.g., Basu and Fernald, 2001, and Inklaar, 2006), so we believe constant returns is the right benchmark. Hence, Hsieh's dual TFP estimate slightly underestimates technology growth in Singapore's unfavored sector and Young's primal TFP substantially overestimates technology growth in the favored sector.[26] The qualitative conclusion is that overall technology growth in Singapore was singularly unimpressive.

VI. Explaining Hong Kong, Korea, and Taiwan

In Singapore, large but declining profits and heterogeneous costs of capital, reflecting government intervention, created the large dual-primal TFP gap. Tax effects also played a notable role. How did these factors play out in the other NIEs? Tax effects were smaller outside of Singapore; and profits and heterogeneity appear relatively unimportant in less-interventionist Hong Kong. But Taiwan and Korea also intervened heavily. Why is the gap so much smaller in Taiwan? Why isn't there a gap in Korea?

For Taiwan, Wade (1990) documents the considerable government intervention, especially for large-scale firms in favored sectors. Government intervention, however, does not inevitably lead to high profits—Singapore is the exception to world experience, not the rule. Estimated profits in Taiwan were small.[27] Hence, we attribute most if not all of capital's contribution to Taiwan's dual-primal gap as reflecting capital-cost heterogeneity, consistent with the anecdotal evidence of heterogeneity.

Korea also intervened, but the evidence suggests it did so without creating large profits or heterogeneity in the *growth rates* of the cost of capital.[28] First, our estimates, as well as Leipziger's (1988) and Kihwan and Leipziger's (1997) firm-level studies, suggest small profits. Second, Korea's transition also had heterogeneous costs of capital, but these different costs appeared to grow at similar rates. In particular, Hsieh notes the different *levels* of capital cost in Korea when he uses the curb loan rate (the market rate) versus the

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[26] These results are in part corroborated by Young's finding that technology growth in the manufacturing sector was even worse than that for the aggregate economy.
[27] For Taiwan, Hong Kong, and Korea, the estimated contribution of profits from equation (11) is small.
[28] Heterogeneity can also reflect differences in user-cost levels, but differing growth rates are a more direct source.

discount rate (the "preferred" rate). Hsieh could measure the preferred rate in Korea but not in Singapore, because Korean state-owned enterprises and Chaebols relied even more heavily on directed credit.[29]

In addition, idiosyncratic, one-time benefits offered to large multinationals to entice FDI are particularly difficult to account for. FDI played a huge role in Singapore's development but had negligible impact on Korea in the 1970's and 1980's. IFS statistics confirm that by 1990, FDI amounted to nearly half of investment in Singapore but only 1 percent of investment in Korea.

In sum, there are many similarities in the broad development strategies of Singapore, Taiwan, and Korea. But in Korea, the lack of profits and the similar growth rates in favored and unfavored costs of capital resulted in consistent dual and primal TFP estimates.

VII. Conclusions

We show how product and output market distortions, in principle and in practice, resolve two important empirical puzzles regarding Asian development. First, we reconcile divergent estimates of TFP from the dual and primal sides, thereby resolving a controversy that has generated heat but also considerable smoke. Heterogeneity in the cost-of-capital (reflecting intentional programs to direct resources to particular firms and/or sectors) and large but declining pure economic profits explain much of the dual-primal gap. Second, we reconcile the constant or increasing labor shares in revenue with the intuitive story that rapid Asian growth relied heavily on a shift towards capital-intensive export sectors. The declining profit share allowed labor's share to remain flat or even rise despite a shift (which we document) towards capital-intensive sectors.

We offer a more detailed view of Singapore, an important but poorly understood development case. After controlling for the economic distortions, technology declined during its fast-growth period—consistent with Young's original findings using TFP. Indeed, Young was, in part, too optimistic: He *overstates* technological progress in the favored sector of Singapore's economy. Our best estimate is that in the favored sector, output grew nearly 10 percent per year for two decades, with sharply negative technology growth. Since this was the sector that received most FDI flows, our results raise questions about the value of costly government policies designed to lure foreign investment. For the unfavored sector, on the other hand, we find that technology growth was even better than Hsieh's original dual TFP results for the aggregate economy.

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[29] Rhee (1997) discusses the dual structure of Korea's financial market.

Finally, our detailed examination of the NIEs provides both important caveats to, and new applications of, primal and dual growth accounting. When undertaking growth accounting for a country or across countries, there is value in carefully constructing both primal and dual measures. Resolving discrepancies can shed light on the underlying structure of the economy, in addition to providing insight into possible mismeasurement. Thus, this paper reinforces the message of a growing body of empirical and theoretical work that recommends looking inside the black box of aggregate growth accounting.

Appendix

A. Data sources and discussion

TFP Estimates

Dual data calculations are from Hsieh (2002); his detailed spreadsheet was obtained from http://www.wws.princeton.edu/chsieh on June 13, 2003.

Primal estimates are from Young (1995, 1998).

Singapore Statistics series on multifactor productivity: Purchased from Singapore Statistics, February 23, 2006. These figures are available from 1973 on; the major conceptual difference from Young is that they do not adjust labor or capital for quality or composition. Average unadjusted TFP growth was only 0.7 percent per year from 1973-90—indeed, TFP growth was negative from 1973-1985. These figures are very close to Young's unadjusted TFP growth from 1970-90. Young's input-composition adjustment removes about 1.2 percent per year from the unadjusted figures.

Dale Jorgenson's industry dataset for the United States was downloaded from http://post.economics.harvard.edu/faculty/ jorgenson/data/35klem.html (Oct 2002).

National Accounts

GDP by expenditure: From Singapore Statistics, via CEIC Asia. Downloaded February 14, 2006. These include investment data, which we used to construct capital stocks. In particular, gross fixed capital formation data by sector (public and private) and by type of capital (residential buildings, nonresidential buildings, other construction and works, transport equipment, and machinery and equipment) from 1960 to 2005 were downloaded from CEIC Asia Database on March 17, 2006. Real investment is measured in S$2000 prices.

These investment data were used to construct perpetual inventory measures of each type of capital stock. Depreciation rates follow Hsieh: residential = 0. 0.013, nonresidential buildings = 0.029, other construction = 0.021, transport = 0.182, and machinery and equipment = 0.138. Initial 1960 values of the capital stock were set at the 1960 value of investment, divided by the sum of the average investment growth from 1960 to 1965 and the depreciation rate for each type of capital.

Capital input aggregates are measured as share-weighted growth rates (i.e., as Tornquist indices). The weights are estimated user costs of each type of capital, measured as a constant real interest rate equal to 0.05 plus the depreciation rate, multiplied by the nominal value of each type of capital. Capital input is not very sensitive to the assumed real interest rate.

GDP by industry: One-digit GDP-by-industry data are from CEIC (downloaded Feb. 1999). For Hong Kong, industry data for 1970-79 are from United Nations (1979, 1984). For Singapore, we also downloaded updated data on February 2, 2006. The updated data include owner-occupied dwellings as a separate industry; rental housing, however, remains a part of the much broader "finance, insurance, and real estate.

GDP by income component: Purchased from Singapore Statistics (http://shop.asiaone.com/stores/singstat/gdi.html) on February 1, 2006.

One-digit factor shares

We use Sarel's (1997) estimates of one-digit industry cost shares from a large sample of countries. These countries are primarily developed ones, where data quality is likely to be relatively high. We assume that average pure profits are small, so that the shares provide a good approximation to cost shares.

Net fixed assets, pre-tax profit or loss, and taxation by industry:

Provisions for taxes by local-controlled and foreign-controlled firms as well as by sector are from Department of Statistics, Singapore (1992b, 1995, 2006). These rely on corporate financial reports, and also report net income by sector as well as selected balance sheet information.

Hsieh (2002) used assessed corporate taxes from various annual reports of the Inland Revenue Authority (we thank him for making his data available). These report assessed taxes rather than taxes paid (as Asher, 1989, discusses). The Inland Revenue and corporate-sector data track reasonably well, but note that we do not expect them to track perfectly. For example, total corporate-reported net earnings include firms that make losses, and hence owe no tax; this raises the average rate paid. In contrast, the Inland Revenue measure of assessed income is for firms owing tax, not for all firms, so it excludes this source of volatility. In addition, corporate net income uses accounting measures of depreciation whereas assessed income uses tax depreciation.

Department of Statistics, Singapore (1992b, 1995, 2006) also includes book-value estimates of net fixed assets (NFA) in the corporate sector.

Data on U.S. Multinationals are from the Bureau of Economic Analysis (BEA) annual survey of U.S. direct investment abroad. Files from 1983 onward were downloaded from http://www.bea.gov/bea/ai/iidguide.htm#link12b (March 2006). Earlier data was obtained (from hardcopy) from the BEA, March 2006. Desai, Foley, and Hines (2002) have an extensive discussion of these data. We thank Ariel Burstein for providing the cross-country average-tax-rate data in summary form.

Return on Equity and Return on Assets

Asset data taken from the Department of Statistics, Singapore (1992a). This is the report cited by Hsieh as the source of ROE data; but ROA data (not ROE data) are found in the report. Numbers consistent with Hsieh's ROE calculations are found in Department of Statistics, Singapore (1995).

Present value of depreciation allowances:

To calculate the present value of depreciation allowances in Singapore, we consider the four major types of non-residential capital identified in the national accounts: Machinery, transport equipment, industrial buildings, and other construction. (We exclude residences, even for private investment, on the grounds that a large share of it is presumably owner-occupied rather than business-owned.) We use information on the tax code from Commerce Clearing House (various years) and Inland Revenue Authority (various years). These sources identify the initial and annual allowances, as well as the type of accounting required—declining balance or straight-line. The major changes over the 1970-90 period are (i) in 1978, initial and annual allowances for industrial buildings become much more generous; and (ii) in 1980, allowances for transport and machinery become more generous because of the move from declining-balance to straight-line depreciation.

We assume that other construction received the same treatment as industrial buildings. We also assume firms did not take advantage of accelerated depreciation for equipment, since until the late 1980s it was available only to manufacturing firm, most of whom were foreign and many of whom had pioneer status. A firm with pioneer status (and thus a low or even zero tax rate) would generally prefer to preserve some of the depreciation for the post-pioneer period, when income became taxable. In the mid-1980s, accelerated depreciation for equipment became available to all firms, which would accentuate the rise in the present value of depreciation allowances relative to our conservative calculation, and hence would accentuate the decline in the user cost of capital.

We use a constant nominal interest rate of 8 percent to calculate the present value of allowances D_i for each type of capital. We confirmed that results are not sensitive to using other rates (e.g., 6 percent or 10 percent), or to using the actual time series on interest rates used by Hsieh (2002).

To obtain an overall weighted average D, we weight the separate D_i by estimated shares in capital income, calculated assuming a real rate of 5 percent. Results are not particularly sensitive to the specific weights, since allowances for all types of capital became more generous.

Estimating Tax Rate for Foreign Manufacturing Pre-1980

Department of Statistics, Singapore (1992b) provides summary profit/loss statements for Singapore's corporate sector beginning in 1980. These data have net income before tax (or profit/loss) as well as provisions for income tax, from corporate financial statements. These data are available for the entire corporate sector, as well by major industry, and for local-controlled versus foreign-controlled firms. These data begin in 1980. For the 1970-1979 period, Singapore Statistics provided us with selected data for local- and foreign-controlled firms; industry income-statement data are not, however, available, though selected balance sheet data are. Conceptually, the overall tax rate for foreign-controlled firms is the share-weighted average of foreign manufacturing and foreign non-manufacturing. We assume manufacturing's share of net profits are proportional to their share of net fixed assets, and assume that non-manufacturing firms pay the same average rate as local firms. These two assumptions allow us to estimate the rate for foreign manufacturing. For the period from 1980 on, the estimated rate is quite similar to the actual rate. We splice the estimated and actual data in 1980. Results in the text appear robust to reasonable alternative choices, such as using the statutory rate for non-manufacturing firms, or using the manufacturing share from 1980.

Tax Parameters for Hong Kong, Korea, and Taiwan

Main source of depreciation allowances and investment tax credits is Price Waterhouse, "Corporate taxes, a worldwide summary." For Taiwan, other sources included Price Waterhouse, "Doing Business in Taiwan," 1989, 1991 and 1996, and Deloitte, Haskings, & Sells "Taxation in Taiwan, ROC (Republic of China)" (1982). Tax rates were obtained by email from Taiwan's Ministry of Finance (April 2006) and from Chou and Wu (1994). For Korea, corporate tax rates are from Hyun et al (2000). Other sources were Price Waterhouse's "Doing Business in Korea" (1992). For Hong Kong, our sources were Ho (1979) and Ho and Chau (1988). We confirmed the depreciation schedules with Hong Kong's Inland Revenue Department. Further details on our calculations are available from the authors.

Surpluses of Statutory Boards

Current surpluses of seven major statutory boards are from the *Economic Survey of Singapore* (various issues). The seven are the Housing and Development Board (HDB), Jurong Town Corp (JTC), Public Utilities Board (PUB), Port of Singapore Authority (PSA), Telecommunications Authority of Singapore (Telecoms), Urban Redevelopment Authority (URA), and Sentosa Development Corp (SDC). Singapore Statistics confirmed in personal correspondence (March 20, 2006) that current surpluses of SBs that produce market output are included in corporate gross operating surplus.

Miscellaneous Data

Penn World Tables data are from Heston, Summers, and Aten (2002). 1996 was the latest year for which there was data (rgdpch) for all NIEs.

IMF International Financial Statistics (IFS) data are from the IFS CD-ROM; data were obtained March 16, 2006 at UC Berkeley's main library.

Confirming Singapore's Labor's Share:

To verify the labor share figures used by Young (1994) and Hsieh (2002), we used the GDP by income components data from Singapore Statistics. These data were produced for the first time in the late 1990s, so they were not available when Young did his work; they are available only back to 1980. Since we want factor shares in output measured at prices received by producers (i.e., prices that include indirect taxes on factors of production, such as property taxes, license fees, motor vehicle registration fees, and so forth), we also used Singapore Statistics data on gross value added at basic prices (part of their GDP by industry data). Finally, we obtained data on self-employment from various Censuses of Population and from Singapore Statistics (1993).

Labor's share is often low in developing countries because self-employment income (e.g., from farming) is allocated to capital not labor. Gollin (2002) reports that after correctly allocating proprietors' income (i.e. self-employment income), labor shares are almost always in the range of 0.65 to 0.8.

Unallocated proprietors' income does not explain Singapore. In data on income components of GDP, proprietors' income was only 10 percent of gross value added at basic prices in 1980 and 7 percent by 1990. Labor's share, which incorporates all compensation including employers' contributions to the CPF and private pension/insurance funds, was 40 percent in 1980 and 45 percent in 1990, so any reasonable allocation of proprietors' income will keep labor's share at around 50 percent. This data source does suggest that labor's share might have edged up a bit over time.

To measure factor shares, Young's figures use the input-output tables, which properly incorporate all capital-related taxes in capital income (i.e., they correspond to gross value added at basic prices). In 1990, the input-output tables have a labor share of 44 percent. (They thus differ only very slightly from the more recently produced GDP-by-income-components data, which incorporate more recent revisions including minor methodological changes.) He then imputes wages for proprietors and unpaid family workers using micro data. Gollin cites Young (1995) as exemplifying the "best approach" to estimating factor shares (Gollin, p. 467). Despite differences in data sources, his figures are fairly consistent with the income-components data,

A few studies have proposed replacing Singapore's actual labor share of 1/2 with a more "normal" labor share of 2/3. (For example, IMF, 2004) One justification, as in Sarel (1997), is that such shares might better measure true shares in cost. In our two-sector model of Section I, however, it is not appropriate to simply use cost shares—one needs to estimate from the bottom up. (We discuss this further in the appendix on aggregation in the two-sector model.)

In our view, one needs to understand why labor's share is so low: One cannot arbitrarily adjust them because they are out of line with other economies. In any case, adjusting capital's share down doesn't reconcile Young with Hsieh. Young's figures still imply that capital returns fell at nearly 3 percent per year, whereas Hsieh's suggest that the user cost was about constant.

B. Aggregation, TFP, and technology in a two-sector economy

The Divisia index for aggregate output, from the text, is:

$$\begin{aligned}\hat{y} &\equiv \omega_F\left(\hat{a}_F+\alpha_F\hat{k}_F+(1-\alpha_F)\hat{l}_F\right)+\omega_U\left(\hat{a}_U+\alpha_U\hat{k}_U+(1-\alpha_U)\hat{l}_U\right)\\ &=\hat{a}+\left[\omega_F\alpha_F\hat{k}_F+\omega_U\alpha_U\hat{k}_U\right]+\left[\omega_F(1-\alpha_F)\hat{l}_F+\omega_U(1-\alpha_U)\hat{l}_U\right]\end{aligned} \tag{14}$$

Aggregate TFP growth is

$$\hat{y}-s_L\hat{l}-(1-s_L)\hat{k}=\hat{a}+\left[\omega_F\alpha_F\hat{k}_F+\omega_U\alpha_U\hat{k}_U-(1-s_L)\hat{k}\right]+\left[\omega_F(1-\alpha_F)\hat{l}_F+\omega_U(1-\alpha_U)\hat{l}_U-s_L\hat{l}\right] \tag{15}$$

The last term in brackets is a weighted average of the contribution of labor to output in the two sectors, minus aggregate labor growth multiplied by labor's aggregate share. We can write out this term as:

$$\begin{aligned}\left[\omega_F(1-\alpha_F)\hat{l}_F+\omega_U(1-\alpha_U)\hat{l}_U-s_L\hat{l}\right] &= \left(P_FY_F/PY\right)\left(wL_F/(R_FK_F+wL_F)\right)\hat{l}_F\\ &+\left(P_UY_U/PY\right)\left(wL_U/(R_UK_U+wL_U)\right)\hat{l}_U-\left(w(L_F+L_U)/PY\right)\left(\left(L_F/L\right)\hat{l}_F+\left(L_U/L\right)\hat{l}_U\right)\end{aligned}$$

Rearranging:

$$\left[\omega_F(1-\alpha_F)\hat{l}_F+\omega_U(1-\alpha_U)\hat{l}_U-s_L\hat{l}\right]=\left(\frac{wL_F}{PY}\right)\left[\frac{P_FY_F}{(R_FK_F+wL_F)}-1\right]\hat{l}_F+\left(\frac{wL_U}{PY}\right)\left[\frac{P_UY_U}{(R_UK_U+wL_U)}-1\right]\hat{l}_U$$

The second term on the right-hand-side is zero since, with no pure profits in the unfavored sector, $P_UY_U=R_UK_U+WL_U$. For the first term, note that $P_FY/(R_FK_F+wL_F)=1+\Pi_F/(R_FK_F+wL_F)$, so that the overall expression simplifies considerably:

$$\begin{aligned}\left[\omega_F(1-\alpha_F)\hat{l}_F+\omega_U(1-\alpha_U)\hat{l}_U-s_L\hat{l}\right] &=\left(\frac{wL_F}{PY}\right)\frac{\Pi_F}{(R_FK_F+wL_F)}\hat{l}_F=\left(\frac{wL_F}{(R_FK_F+wL_F)}\right)\frac{\Pi_F}{PY}\hat{l}_F\\ &=(1-\alpha_F)s_\Pi\hat{l}_F\end{aligned} \tag{16}$$

Note that we have used the assumption that all profits are in the favored sector, so that $\Pi=\Pi_F$. In essence, the only reason that the aggregate estimate $s_L\hat{l}$ differs from the share-weighted output contribution of the individual sectors is because of profits, which occur only in the favored sector.

Now consider the first, capital-growth, term in brackets of equation (15). Noting that $(1-s_L)=s_K+s_\Pi$, we can write out this term as:

$$\left[\omega_F\alpha_F\hat{k}_F+\omega_U\alpha_U\hat{k}_U-s_K\hat{k}-s_\Pi\hat{k}\right]=\left(P_FY_F/PY\right)\left(R_FK_F/(R_FK_F+wL_F)\right)\hat{k}_F$$
$$+\left(P_UY_U/PY\right)\left(R_UK_U/(R_UK_U+wL_U)\right)\hat{k}_U-\left((R_KK_F+R_UK_U)/PY\right)\left(\left(K_F/K\right)\hat{k}_F+\left(L_U/L\right)\hat{k}_U\right)-s_\Pi\hat{k}$$
$$=\left(\frac{R_FK_F}{PY}\right)\left[\frac{P_FY_F}{(R_FK_F+wL_F)}-\frac{R}{R_F}\right]\hat{k}_F+\left(\frac{R_UK_U}{PY}\right)\left[\frac{P_UY_U}{(R_UK_U+wL_U)}-\frac{R}{R_F}\right]\hat{k}_U-s_\Pi\hat{k}$$
$$=\left(\frac{R_FK_F}{PY}\right)\left[\frac{\Pi_F}{(R_FK_F+wL_F)}+1-\frac{R}{R_F}\right]\hat{k}_F+\left(\frac{R_UK_U}{PY}\right)\left[1-\frac{R}{R_F}\right]\hat{k}_U-s_\Pi\hat{k}$$
$$=\left(\frac{R_FK_F}{R_FK_F+wL_F}\right)\left(\frac{\Pi_F}{PY}\right)\hat{k}_F+\left[\left(\frac{K_F(R_F-R)}{PY}\right)\hat{k}_F+\left(\frac{K_U(R_U-R)}{PY}\right)\hat{k}_U\right]-s_\Pi\hat{k}$$

Note that the average cost-of-capital is $R=(K_U/K)R_F+(K_U/K)R_U$. It follows that $R_F-R=(K_U/K)(R_F-R_U)$ and $R_U-R=(K_F/K)(R_U-R_F)$. Thus,

$$\begin{aligned}&\left[\omega_F\alpha_F\hat{k}_F+\omega_U\alpha_U\hat{k}_U-s_K\hat{k}-s_\Pi\hat{k}\right]=\\&=\alpha_F(s_\Pi\hat{k}_F-\hat{k})+\left(\frac{K_FK_U}{PY\cdot K}\right)(R_F-R_U)(\hat{k}_F-\hat{k}_U)\end{aligned}\tag{17}$$

Putting equations (15), (16), and (17) together, we have equation (12) from the text:

$$\begin{aligned}\widehat{tfp}&=\hat{a}+s_\Pi(\alpha_F\hat{k}_F+(1-\alpha_F)\hat{l}_F-\hat{k})+\left(\frac{K_FK_U}{PY\cdot K}\right)(R_F-R_U)(\hat{k}_F-\hat{k}_U)\\&\equiv\hat{a}+s_\Pi(\hat{x}_F-\hat{k})+\Sigma_K\end{aligned}.$$

Thus, revenue-share-weighted TFP growth differs from technology growth because of two terms, one of which reflects profits and the other of which reflects reallocations of capital across uses. Using a cost-share-weighted aggregate residual would change the form of these terms but would not eliminate them. In particular, following a similar analysis, one finds:

$$\hat{y}-\left[(1-\alpha)\hat{l}+\alpha\hat{k}\right]=\hat{t}+\Sigma_\Pi+\Sigma_K\tag{18}$$

where Σ_Π and Σ_K reflect reallocations of inputs across uses:

$$\Sigma_\Pi=\left(\frac{\omega_F\omega_U}{(1-s_\Pi)}\right)\left(s_{\Pi,F}-s_{\Pi,U}\right)(\hat{x}_F-\hat{x}_U)$$
$$\Sigma_K=\left(\frac{K_FK_U}{(RK+WL)(K_F+K_U)}\right)(R_F-R_U)(\hat{k}_F-\hat{k}_U)$$

The first reallocation term represents shifts of resources towards sectors where the profit rate is higher, i.e., where the share of the sector in output exceeds the share in cost. Economically, this reflects that output is measured using relative market prices not relative costs of production. With differential profit rates, relative prices need not equal relative costs of production (i.e., the marginal rate of substitution is not equal to the marginal rate of transformation). Output is (quite appropriately) aggregated using prices, which are equated to marginal rates of substitution, not using marginal rates of transformation.

The second reallocation term reflects the fact that if capital is shifted to where it has a higher cost-of-capital, aggregate output and aggregate TFP rises, other things equal. With a higher cost-of-capital, firms' cost-minimizing conditions for capital input use imply that the marginal product of capital is higher. Reallocating resources to where their marginal products are higher raises aggregate output.

C. Systematic National Accounting Errors?

In principle, systematic errors in the national accounts could reconcile the primal and the dual. Hsieh (2002) suggests that the national accounts overstate growth in the capital-output ratio by about 3 percentage points per year. Hsieh's example of national accounting errors concerns output rather than investment: Singapore uses a low, subsidized rental rate to measure the service flow from owner-occupied housing.[30] This suggests that the accounts might understate nominal housing, though not necessarily its real service flow, which rose 11 percent per year from 1970-1990. Suppose mismeasured housing services caused us to understate true output growth by 3 percent per year from the mid-1960s to 1990. Then by 1990, true output would have been more than twice its measured level (i.e., 3 percent compounded for 25 years)—making Singapore by far the richest country in the world, with owner-occupied housing accounting for over half of GDP. Singapore was quite wealthy by 1990, but these counterfactuals seem implausible.[31]

Could Singapore instead have overstated capital growth by 3 percentage points per year? Suppose there were growing errors in real investment from the mid-1960s on. Like most countries, Singapore measures expenditure from ongoing surveys of its components. Large errors in the investment surveys would not be offset by large errors in the consumption surveys. Hence, both output and the GDP deflator would also be mismeasured (and incorrect when used for the dual). But Singapore uses different surveys to measure GDP from the expenditure, output, and income sides. If expenditure-based nominal GDP were mismeasured, then there would counterfactually be a large and growing statistical discrepancy.

Might the investment deflator grow too slowly? After adjusting the machinery and equipment deflator for exchange-rate changes, the growth in Singapore's deflator rises about 2 percentage points per year faster than the U.S. deflator from 1970-1990—consistent with Singapore not incorporating hedonic adjustments into their deflators.32 Hence, Singapore plausibly understates rather than overstates real investment growth.

A more plausible way to reduce capital growth is to raise the initial level of investment. In the 1960s, gross fixed capital formation averaged 18 percent of GDP; this share rose to 36 percent in the 1970s and to 40 percent in the 1980s. Suppose we raised the share of investment in GDP to 36 percent for each year from 1960-1969 and then reestimate capital growth. From 1970-90, this alternative capital series grows 3.2 percent per year less than what the national accounts suggest. (The 1960 level of capital is benchmarked as $I_{60}/(g+\delta)$, where g is the average growth from 1960 to 1965; this alternative path raises the estimated initial capital level about nine-fold.)

Nevertheless, such an increase in initial investment and capital seems unlikely. First, it implies, counterfactually, a statistical discrepancy averaging 18 percent of GDP in the 1960s; the actual discrepancy was fairly small (see Young, 1998). Second, the 1960s were a time of political upheaval and civil unrest, so the investment climate was not particularly favorable relative to the '70s and '80s. Third, Young (1995) uses data on residential construction and retained imports of cement to extend structures investment back to 1947; those figures do not suggest widespread errors in the initial capital or investment values in the 1960s. Finally, Hsieh provides no evidence of major underestimates of initial investment and capital.

In sum, Hsieh has identified an interesting puzzle. But before relying on the unsupported hypothesis of largescale national accounting errors, one needs to assess other probable explanations.

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[30] If marginal rates of substitution reflect the subsidized rate then Singapore's treatment is appropriate. But if subsidized housing is quantity-rationed, then this rate is not the right shadow value.

[31] Non-housing TFP growth is virtually identical to overall TFP growth. Non-housing output rises 0.1 pp per year more slowly from 1970-1990 than overall output; non-housing capital grows 0.1 pp per year faster. In addition, labor's share of income increases by 0.02 (since housing services are part of capital income), so on balance, share weighted inputs rise about 0.1 pp per year more slowly.

[32] In personal correspondence (March 23, 2006), Singapore Statistics confirmed that they have not implemented any hedonic adjustments to their investment deflators.

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Table 1
Asian Growth Estimates
(Percent per year)

	Output Growth per Capita (1960-1996)	Total Output Growth (1970-1990)	Total Factor Productivity	
			Primal Estimates	Dual Estimates
	(1)	(2)	(3)	(4)
Singapore	8.2	7.8	-0.5	1.8
Taiwan	8.0	8.8	2.2	3.7
Korea	7.5	9.5	1.7	1.9
Hong Kong	7.1	7.5	2.3	2.3
Unweighted Average	7.7	8.4	1.4	2.4

Notes: Column (1) is average annual log-change in "rgdpch" from Heston, Summers, and Aten (2002). Columns (2) and (3) are from Young (1998) for Singapore and Young (1995) for Taiwan, Hong Kong, and Korea. For Taiwan, data exclude agriculture and include Young's adjustment of public sector output. Column (4) is from Hsieh (2002). For each economy, Hsieh offers three or four different measures of TFP based on different measures of the real user cost; column (4) shows the average. Each measure is available for slightly different time periods; all measures approximately cover 1970 – 1990. In columns (2) and (3), we give the (weighted) averages across sub-periods of Young's primal TFP to match the time periods for Hsieh's dual TFP. Numbers may not add up due to rounding.

Table 2
Decomposing the Sources of Difference in Primal and Dual Estimates
(Except where indicated, all entries are percent per year)

			Singapore	Taiwan	Korea	Hong Kong
(1a)	Wage growth	Young $\hat{w}$	1.8	4.0	4.2	3.6
(1b)		Hsieh $\hat{w}_{Dual}$	3.2	5.4	4.4	4.1
(2a)	Capital payment Growth	Young $\widehat{(r+\pi/k)}$	-2.9	-3.4	-4.3	0.1
(2b)		Hsieh $\hat{r}_{Dual}$	0.3	-1.2	-4.1	-0.5
(3)	Labor's share s_L (Sample average)		51.6	74.4	70.3	62.4
(4a)	Primal TFP growth		-0.5	2.2	1.7	2.3
(4b)	Dual TFP growth		1.8	3.7	1.9	2.3
(5)	Labor contribution to difference: $s_L(\hat{w}_{Dual} - \hat{w})$		0.7	1.0	0.1	0.3
(6)	Capital contribution to difference: $(1-s_L)\left(\hat{r}_{\text{Dual}} - \widehat{(r+\pi/k)}\right)$		1.6	0.6	0.1	-0.3
(7)	Difference (Dual-Primal)		2.3	1.6	0.1	0.1

Notes: Sample periods are adjusted to match Hsieh (2002) and are approximately 1970-1990. Lines (1b) and (2b) are the averages across the different measures reported by Hsieh (for which sample periods occasionally differ slightly). For Singapore, Young's primal data is taken from updated figures in Young (1998), other data are derived from Young (1995, Tables V, VII, and IX). Young's tables include data by subperiod for on $\hat{y}$, $\hat{l}$, $\hat{k}$, s_L, and s_K; we derive (implicit) growth in real factor prices from $\hat{w} = \widehat{s_L} + \hat{y} - \hat{l}$ and $\hat{r} = \widehat{s_K} + \hat{y} - \hat{k}$. We use a weighted average of growth rates over subperiods to adjust Young's numbers to cover the identical time period as each of Hsieh's measures (e.g., for a measurement of the 1973-1990 rate, we would take 7/17 of the 1970-1980 rate and add it to 10/17 of the 1980-1990 rate). The periods are all highly similar and approximately cover 1970 – 1990. When original growth rate calculations are needed (i.e. growth of average labor share), the best approximation to end points are used (i.e. for 1975-1990 growth rates, the calculation might use the 10-year growth from the average during the 1970-1980 period to that during 1980-1990). For Taiwan, data exclude agriculture and include Young's adjustment of public sector output. Numbers may not add up due to rounding.

Table 3: Contribution of Corporate Taxes to the User Cost
(percentage points)

	Singapore	Taiwan	Korea	Hong Kong
$\hat{t}$	-0.7	-0.6	-0.3	0.0
Contribution to dual-primal-gap $=-(1-s_L)\hat{t}$	0.4	0.2	0.1	0.0

The top line shows the estimated growth rate in the tax adjustment, $T=(1-\tau D)/(1-\tau)$. The second line shows the contribution to the dual-primal gap. For Singapore, the figures refer to unfavored firms who were paying the regular statutory tax rate. (Conceptually, the difference between that figure and the overall weighted average is part of the contribution of user-cost heterogeneity.)

Table 4
Estimation of Capital and Profit Shares, 1970-1990
(Except where indicated, all entries are percent per year)

		Singapore	Taiwan	Korea	Hong Kong
1)	Share of capital and profits *(1-s_L)*	48.4	25.6	29.5	37.5
2)	Growth in share of capital and profits	0.0	-0.2	-0.9	0.7
3)	Estimated "true" capital cost share (using international data by industry)	32.6	30.1	24.8	32.6
4)	Growth in "true" capital cost share	0.6	0.3	0.1	0.8
5)	Estimated "true" capital revenue share	25.0	32.1	23.3	30.1
6)	Growth in "true" capital revenue share	1.0	0.6	0.5	0.7
7)	Estimated profit share	23.5	-6.5	6.2	7.4
8)	Growth in profit share	-1.2	-3.3	-9.5	0.6

Notes: Line 1 is the capital shares used by Young (1995,1998) and also by Hsieh (2002). Line 3 is calculated as a weighted average of Sarel's (1997) capital share estimates, with the weights determined by the industry-share of GDP (1-digit SIC from the CEIC database). Line 7, the estimated profit share of revenues, is calculated as $(1-s_L-\alpha)/(1-\alpha)$, where α is the capital share of cost shown in line 3. (In line 8, since Taiwan's profit rate was negative and becoming more negative, we report the average change in the profit rate divided by the absolute value of the mean profit rate.) Finally, the capital share in revenues (line 5) is equal to Young's capital share (line 1) minus the estimated profit share (line 7). Numbers may not add up due to rounding.

Table 5
Contributions to the Difference in Primal and Dual Estimates for Singapore
(Except where indicated, all entries are percent per year)

		Using Average of Hsieh's Measures
(1)	Contribution of Profits to Difference (Dual-Primal)	0.8
(2)	(Residual) Contribution of Heterogeneous Costs of Capital to Difference (Dual-Primal)	0.3
(3)	Tax Correction Term	0.4
(4)	Capital Contribution to Total Difference (Dual-Primal)	1.6

Notes: Using the calculations in Tables 2 and 3, plus the disaggregation of the capital-payments contribution to the dual-primal gap in equation (7), and finally taking into account the gap attributable to the tax correction, we calculate lines 1 through 4 above. Numbers may not add up because of rounding.

Table 6
Benchmark Results of Sectoral and Aggregate Technology Calibration and Robustness Checks
(Except where indicated, all entries are percent per year)

		Benchmark	With ROE	$K_F / K_U = 4$	α_i increased by 0.09	s_L increased by 0.08
	Technology Growth	(A)	(B)	(C)	(D)	(E)
(1)	Unfavored Sector	1.5	1.5	1.5	1.3	1.5
(2)	Favored Sector	-2.0	-1.9	-1.6	-1.4	-0.8
(3)	Aggregate Economy	-0.5	-0.5	-0.3	-0.3	0.1

Notes: Benchmark calculated using methodology described in Section V. Aggregate technology calculated from sectoral technologies as $\hat{a} = \omega_U \hat{a}_U + \omega_F \hat{a}_F$. Column (B) includes Hsieh's ROE-based measurement of the cost of capital in the average used to generate $\hat{r}_U$. Column (C) increases the ratio of favored to unfavored capital from 2 to 4. Column (D) halves the aggregate profit share by arbitrarily increasing the capital share of costs (taken from international data) by 9 percentage points in every 1-digit sector. Column (E) halves the aggregate profit share by arbitrarily increasing the labor share of revenue estimate used in both the primal and dual by 8 percentage points. Numbers may not add up due to rounding.

Figure 1.A: Statutory Tax Rate and Average Rates Paid

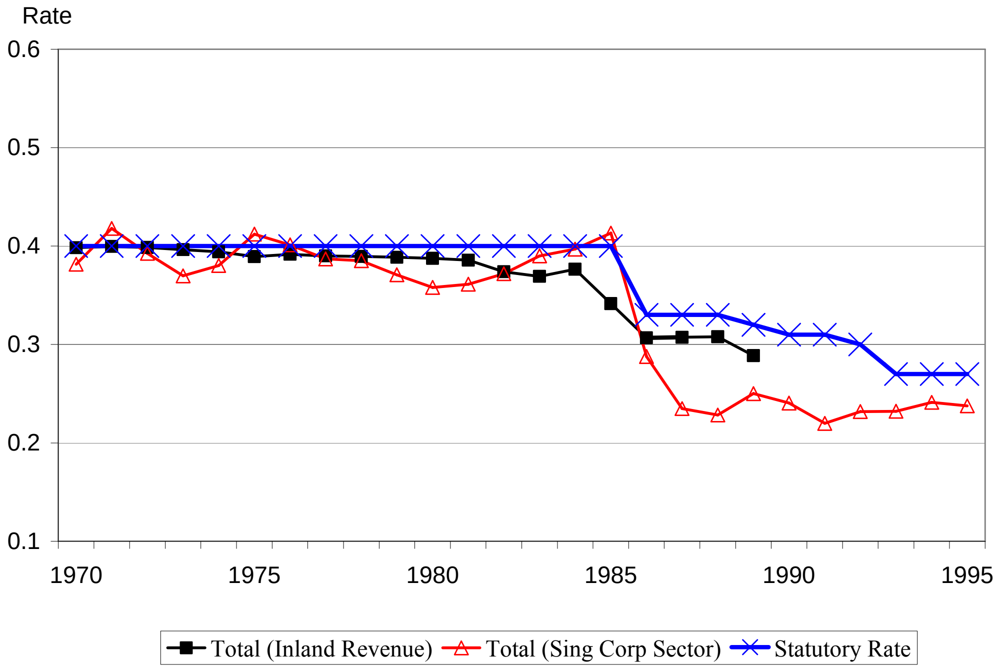
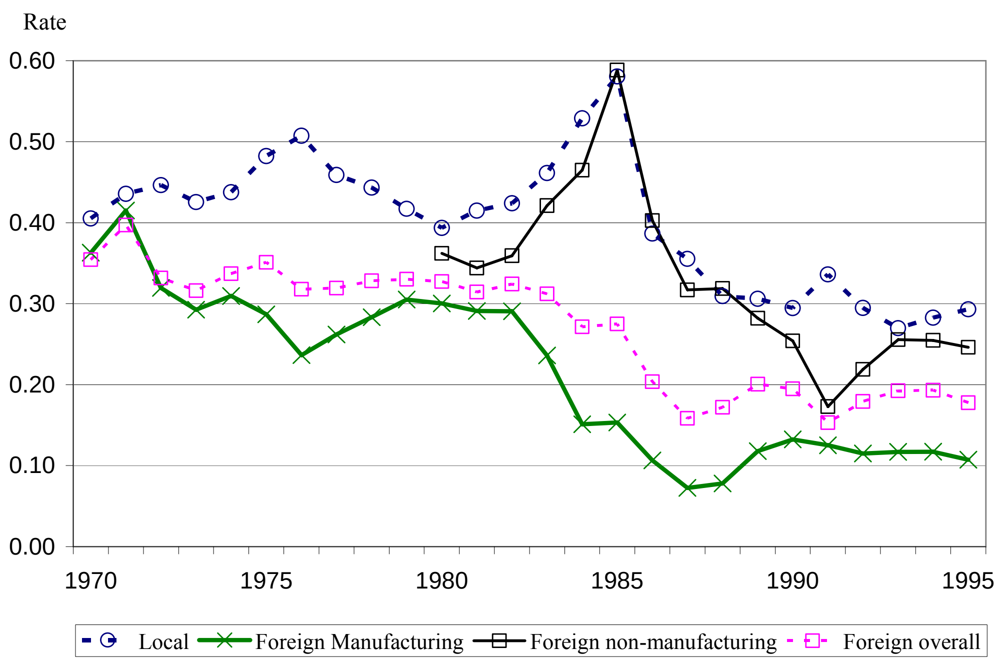


Figure 1.B: Average Rates Paid for Different Firms



Notes: Sources are Inland Revenue Authority (various years) and Department of Statistics, Singapore (1992b, 1995, and 2006). Pre-1980 foreign manufacturing is estimated.