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Measuring Productivity Growth in Asia: Do Market Imperfections Matter?

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Abstract: Recent research reports contradictory estimates of productivity growth for the newly industrialized economies (NIEs) of Asia. In particular, estimates using real factor prices find relatively rapid TFP growth; estimates using quantities of inputs and output find relatively low TFP growth. The difference is particularly notable for Singapore, where the difference is about 2-1/4 percentage-points per year. We show that about 2/3 of that difference reflects differences in estimated capital payments. We argue that these differences reflect economically interesting imperfections in output and capital markets, including sizeable economic profits in Singapore and government-directed credit. We derive a measure of technology growth, corrected for the imperfections that we quantify.

I. Introduction

In empirical assessments of economic growth, the experience of Asia's newly industrialized economies (NIEs) looms large. Singapore, Hong Kong, Korea, and Taiwan grew at rates of 8 or 9 percent for decades, thereby pulling themselves in rankings of economies from the among the poorest to (particularly in the case of Singapore and Hong Kong) among the richest.

Controversy surrounds the sources of growth in the NIEs. Did total factor productivity (TFP) growth (presumably capturing, to a large extent, the process of technology transfer) play an important role? Or did these economies grow almost exclusively through factor accumulation?

In a series of extraordinarily influential and widely cited papers, Young (1992, 1994, 1995) overturned the notion that TFP growth played an important role. He undertook careful 'primal' (quantity-based) growth accounting and established the new conventional wisdom that the NIEs grew almost exclusively through factor accumulation with only a modest contribution from TFP.[1] This new conventional wisdom, however, has not gone unchallenged. In particular, Hsieh (2002) reexamines the issue from the point of view of dual (price-based) growth accounting. With internally consistent data, the primal and the dual measures of TFP are necessarily equal. But with independent data on quantities and factor prices, the two measures can and, in the case of these economies, do differ. Hsieh finds that in the NIEs, TFP grew reasonably quickly.

This controversy has generated considerable heat and smoke. For Singapore, in particular, Hsieh attributes the sizeable differences to errors in the national accounts data used by Young. Young (1998), in turn, responding to an early version of Hsieh's paper, cites a long list of what he sees as errors in Hsieh's implementation of the dual.

In this paper, we seek to shed further light on Asia's growth experience. We reinterpret the primal/dual results as complementary rather than competing. In particular, two "facts" lie at the heart of the controversy over Asian productivity growth. First, primal TFP growth—particularly in Singapore—

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[1] The influence extends well beyond the academic literature. For example, in an investment research letter, Anderson (2003) says, "Ten years ago, one of the most famous economics series in Asian history—as set of papers that generated a storm of controversy and are credited in part with fomenting the Asian crisis—was published by Alwyn Young…"

was abysmal. Indeed, the rapid increases in capital–output ratios in the national accounts imply rapid declines in returns to capital. But second, reasonable cost-of-capital measures show little decline.

We show that heterogeneity in the cost-of-capital—consistent with Asian governments' efforts to direct growth and resources—as well as large economic profits, can reconcile the differences. We provide a range of evidence that in Singapore, where the difference is most pronounced, these aspects do indeed play an important role in reconciling the two results.

In our benchmark case, we assume that the national accounts and Young's quantity-based growth accounting were done completely correctly. We also assume that Hsieh's factor-price based growth accounting is completely correct except for observing factor payments for only a *part* of the economy—for example, he misses heterogeneity in the cost-of-capital coming from unobservable preferential tax rates and subsidies. The primal-dual difference then reflects economically interesting imperfections in output, labor, and capital markets including heterogeneity in the user cost of capital and sizeable economic profits. At the same time, these distortions imply that standard TFP growth does not measure technology.

Under these assumptions, we conclude that Young was, in part, too optimistic: He *overstates* technological progress in the favored sector of Singapore's economy. We estimate that in the favored sector, output grew nearly 10 percent per year for two decades, with negative TFP growth. However, this does not mean that Singapore had no worthwhile investments. In particular, under our interpretation, the relatively unfavored sector had slower output growth, about 6 percent per year, despite rapid TFP growth of around 2-1/2 percent per year.

Our interpretation of the divergent primal-dual results seems more plausible than the alternatives— that the National Accounts grossly overstate investment or that major computational errors render Hsieh's calculations irrelevant. Young (1998) thoroughly rebuts concerns about the national accounts (at least relative to concerns about the reliability of factor-price measures).[2] But dismissing Hsieh's dual results as

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[2] Moreover, given the national accounts identity, reducing real investment growth means adjusting real output and income growth downwards, or adjusting other expenditure growth upwards. How the mismeasurement shows up matters. For example, suppose nominal GDP (in principle, equaling factor payments and value added) is measured accurately but real GDP is overestimated by a growing amount. Then dual TFP, measured by growth in real factor prices (deflated by the GDP deflator) are biased upwards. This case would undo Hsieh's results, even if investment were overestimated. Given Young's defense of the national accounts, though, we do not make this argument. Barro (1999) also discusses possible interpretations of the primal-dual discrepancy for the national accounts.

error-laden throws out the important information they contain. Young argues effectively that Hsieh's measurements for the cost of capital are unlikely to capture the entire economy and ignore key tax benefits. We agree. In our interpretation, these measurement difficulties are indeed central—but the pattern of mismeasurement is economically interesting. The market distortions (such as market power, favorable access to capital, and tax preferences)—which, in many cases, grew over time—favored parts of the economy but not others. We interpret Hsieh as coming close to measuring technology growth in the non-favored sector (it's not exact, though, since factor-shares need to be adjusted). In sum, our explanation is largely consistent with Young's, except that we view the dual growth accounting results as informative about a large chunk of the economy.

Section II shows how the primal and dual could yield different results with market distortions. Section III discusses anecdotal evidence for Singapore (where the gap is largest) suggesting the plausibility that these distortions played an important role. Section IV calibrates our identities with results from Young and Hsieh, seeking to quantify the importance of these distortions for the dual-primal discrepancy. Our results indicate that profits in Singapore play a substantial role and contribute approximately half of the total gap. Section V takes these results—which largely involve manipulating identities—and interprets them in terms of technology in the overall economy, the favored sector, and the unfavored sector. Section VI discusses why these effects are more important in Singapore than elsewhere. We then conclude.

II. Primal and Dual Measures of Productivity

This section defines our terms (primal and dual TFP) and shows that these measures ought to be similar, if not identical. But in practice, they are substantially different. We present a simple decomposition to clarify the role of labor versus capital in explaining the differences—since both play a role. Finally, we show conditions under which the two measures might differ, for economically interesting reasons, in an economy with substantial distortions.

A. Identities

In the national accounts, real output Y equals real factor payments to capital and labor:

$$Y = RK + WL. \tag{1}$$

R is the real rate of payments to capital, K is capital input, W is the real wage, and L is labor input. R and W are deflated by the GDP deflator. Implied payments to capital RK include any economic profits.

For any variable J, define $\hat{j}$ as the percent change dJ/J. Define s_L to be the share of labor in output. The share of payments to capital, taken as a residual, is then $(1-s_L)$. Totally differentiating (1):

$$\hat{y} = \left[s_L \hat{l} + (1 - s_L)\hat{k} \right] + \left[s_L \hat{w} + (1 - s_L)\hat{r} \right] \tag{2}$$

TFP, aka the Solow residual, is defined as output growth in excess of share-weighted input growth:

$TFP_{\text{Primal}} \equiv \hat{y} - \left[s_L \hat{l} + (1 - s_L)\hat{k} \right]$. (Later, we assess whether TFP, so defined, measures technology.)

Rearranging equation (2), one finds that this primal measure of TFP necessarily equals a "dual" (i.e., price) measure that is a weighted average of the growth in real factor prices.:

$$TFP_{\text{Primal}} \equiv \hat{y} - \left[s_L \hat{l} + (1 - s_L)\hat{k} \right] = \left[s_L \hat{w} + (1 - s_L)\hat{r} \right] \equiv TFP_{\text{Dual}} \tag{3}$$

The second equality shows that in data satisfying the accounting identity (1), the primal and the dual approaches necessarily give the same result. However, there are independent data on factor prices. Hence, if one is skeptical of the national accounts—as Hsieh is—dual TFP provides an alternative.

Implementing the dual requires estimating a Hall-Jorgenson (1963) cost of capital, C.[3] As we discuss below, different investors may have different costs of capital. (For example, government capital may have a different shadow value than private capital, or some borrowers may have preferred access to bank loans.) In principle, we need an appropriate weighted average of these factor costs.

Given practical difficulties, the "dual" cost of capital—which we call C_{Dual} —may differ from the national accounts' rate of payments to capital, R. In principle, wage data are easier to observe. Nevertheless, in practice Young and Hsieh use slightly different data sources and methods, so their measures of wages as well as capital-costs differ. Then the dual Solow residual becomes:

$$TFP_{\text{Dual}} \equiv s_L \hat{w}_{\text{Dual}} + \left(1 - s_L\right) \hat{c}_{\text{Dual}} \tag{4}$$

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[3] One common cost-of-capital specification (see, for example, Hall 1990) is $C = \left(\rho + \delta \right)T$, where $T = (1 - \tau d - itc)/(1 - \tau)$ measures various tax adjustments. ρ is the required real rate of return, δ is the depreciation rate, τ is the corporate tax rate, d is depreciation allowances, and itc is the investment tax credit.

Not surprisingly, the primal measure differs from the dual if either wage growth or capital-payment growth differs between them. This relationship is:

$$TFP_{\text{Dual}} - TFP_{\text{Primal}} = s_L(\hat{w}_{\text{Dual}} - \hat{w}) + (1 - s_L)(\hat{c}_{\text{Dual}} - \hat{r}) \ . \qquad (5)$$

Table 2 provides this decomposition for the NIEs, using data from Young (1995, 1998) and Hsieh (2002). Hsieh provides several estimates of the cost of capital for each country. These measures generally tell the same story, so Table 2 averages them. Table 3 takes a closer look at Singapore, where results are most different, for each cost-of-capital estimate. Young does not explicitly report factor prices, but we back them out from his data on factor shares and quantity growth. (For example, $s_L = wL/Y$, implying that $\hat{w} = \hat{s}_L + \hat{y} - \hat{l}$).[4] Lines 1 to 3 show the individual items that appear on the right hand side of equation (5), while Line 4a and 4b show the primal and dual measures of TFP growth. Lines 5 and 6, respectively, show the contribution of wages and capital payments to the primal-dual difference.

This decomposition clarifies whether the discrepancies arise primarily from the labor/wage data or the capital/rental data. Tables 1 and 2 show that the primal and dual differ substantially only in Singapore and Taiwan. In both cases, wages play an important role; indeed, wages account for the bulk of the difference in Taiwan. Hsieh (2002) has little discussion of the role of wages. Young (1998, Section V) expresses concerns with Hsieh's wage data but does not quantify their importance. Table 2 (line 5) makes clear that for Singapore and Taiwan, the wage differences are, in fact, quantitatively important. However, we view the wage discrepancies as a pure measurement issue.

In the rest of the paper, we focus on economic or conceptual issues raised by capital's contribution on Line 6. In Singapore, especially, capital payments account for most (1.6 percentage points) of the primal-dual gap. Hsieh suggests that the national accounts data overstate the cost-of-capital decline. In response, Young (1998) asserts that Hsieh's methods for estimating the cost-of-capital $\hat{c}_{\text{Dual}}$ are flawed.[5] We now present an alternative interpretation.

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[4] Young (1998, p.13) discusses this differentiation. Note that with multiple types of labor (e.g., with different educational levels), labor input is a composition-corrected index. The corresponding growth in wages is the difference between the growth rate of nominal payments to labor and the growth rate of composition-corrected labor input.

[5] For example, Young (1998, page 13) argues that Hsieh conflates the real rental rate (i.e., the cost of capital, which includes the real interest rate, depreciation, and tax adjustments) and "real capital returns" (i.e. the real interest rate). Hsieh (2002), however, addresses some of Young's major concerns.

B. Role of directed credit/capital market imperfections/profits:

Suppose the national accounts and hence $\hat{r}$ are measured appropriately on the primal side. Also suppose that a researcher does a careful job constructing the cost-of-capital measure $\hat{c}_{\text{Dual}}$ from available data. $\hat{r}$ and $\hat{c}_{\text{Dual}}$ may nevertheless differ from one another, for at least two economically interesting reasons. First, different borrowers may face different costs of capital—perhaps reflecting government intervention such as directed credit—which may grow at different rates. Second, even if the cost of capital does not change, the rate of pure economic profits—which are included in $\hat{r}$—may change.

Suppose the economy has one type of capital and two firms, with different costs of capital, C_U and C_F (ultimately, though for now without loss of generality, representing "unfavored" and "favored" sectors). [6] Payments to capital RK (calculated as a residual from (1)) include "required" payments—which depend on the costs of capital—and any economic profits. The economy's implied rate of payments to capital R is total "payments" to capital divided by the capital stock. If the aggregate capital stock is $K = K_U + K_F$ and total economic profits are $\Pi = \Pi_1 + \Pi_2$, then:

$$R \equiv \frac{C_U K_U + C_F K_F + \Pi_U + \Pi_F}{K_U + K_F} = \left[\left(\frac{K_U}{K} \right) C_U + \left(\frac{K_F}{K} \right) C_F \right] + \frac{\Pi}{K}. \tag{6}$$

The implicit rate of payments to capital in (6) has two parts. The first is a capital-share-weighted average of the two costs of capital C_U and C_F. Hence, the capital-payment rate R can change if the firms' costs of capital change, or if the weights change. The second is the ratio of true economic profits to the capital stock. If profits fall relative to capital, then R can fall even if the costs of capital are unchanged.

In practice, it is difficult both to measure costs of capital for *all* firms and to measure pure economic profits—especially in countries where the government creates heterogeneous costs of capital through privately negotiated, or firm-specific, tax treatment or other financing advantages. Suppose we measure dual TFP growth using just the first firm's cost-of-capital estimate, so $C_{Dual}=C_U$. From equation (6), this

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[6] The extension to multiple types of capital is straightforward. Each type of capital has a different depreciation rate and, possibly, different tax treatment. The overall growth in the cost of capital is a weighted average of the different cost-of-capital growth rates. Perfect capital markets would imply that different borrowers have the same cost of capital for a given type of capital. This extension is not central to our main points.

measure may differ from the aggregate accounting measure R for three reasons: (i) C_U differs from C_F; (ii) the weights of capital K_i/K in the two industries change; (iii) the profits-capital ratio changes.

Clearly, these three reasons may also cause the relative growth *rate* of aggregate capital payments $\hat{r}$ to differ from the observed (unfavored) cost of capital $\hat{c}_U$. From equation (5), these relative growth rates, along with those of payments to labor, determine the relationship between the primal and dual measures of productivity. To see this relationship, take the total differential of equation (6) and divide through by RK. Substituting into equation (5) and ignoring the wage term, one obtains a relatively intuitive equation:

$$TFP_{Dual} - TFP_{Primal} = (1 - s_L)(\hat{c}_U - \hat{r})$$
$$= s_K(\hat{c}_U - \hat{c}) + s_\Pi \left[\hat{c}_U + \hat{k} - \hat{\pi} \right] \qquad (7)$$

where the profit share is $s_\Pi = \Pi/Y$, the average cost of capital is $C = \left(C_U K_U + C_F K_F \right)/K$, and the 'true' capital share in costs is $s_K \equiv CK/Y = 1 - s_L - s_\Pi$.

The two terms in Equation (7) capture important factors for understanding why the dual might exceed the primal. The first term reflects the "representativeness" of $\hat{c}_U$: does its observed growth rate differ from the unobserved overall average? The second term reflects economic profits, since the national accounting measure R includes them. Note that we can rewrite the profits term as:

$$s_\Pi \left(\hat{c}_U + \hat{k} - \hat{\pi} \right) = s_\Pi \left(\hat{c}_U + (\hat{k} - \hat{y}) - (\hat{\pi} - \hat{y}) \right) \qquad (8)$$

Suppose there are true economic profits, so s_Π is non-zero. For unchanged $\hat{c}_U$, the profits term is likely to be positive if the profit rate falls over time, if the capital-output ratio rises, or both.

With free factor mobility and competitive output markets, these terms disappear: rates of return are equalized, and there are no profits. Indeed, Fernald and Ramnath (2003) find that in the U.S., the primal and the dual give quite similar results. But the vast literature on the Asian crisis makes clear that Asian economies did not have competitive factor and output markets. Hsieh uses a range of real interest rates to construct the cost of capital. But these measures are unlikely to capture much of the capital-cost-heterogeneity, since many of the differences are not easily observed. For example, governments intentionally directed credit to particular firms through access to low interest government loans or through pressure on banks to lend to favored firms. Even a cursory reading of Young (1992, 1995, 1998) makes

clear that tax rates and investment incentives often varied across firms in ways that are difficult to control for in any systematic way. Direct government investment was often very high, with an unobservable level and growth rate of the shadow value of that capital.

Do capital and product market interventions/distortions necessarily lead the dual to exceed the primal? Clearly no. In steady state, for example, the terms in equation (7) should equal zero. If the profit rate and capital-output ratio are constant, then the profits term is zero. And even if the level of C_U and C_F differ, their steady state growth rates will be the same (in most models, equaling zero), so the capital-cost-heterogeneity term is also zero.

During the transition to steady state, the two terms may, but need not, be positive. For example, state-preferred firms may have market power but not earn profits, so the second term would disappear. And even if C_U and C_F differ, their rates of change may be similar. In part, this will depend on the institutional structure of the economy and the way in which preferences were extended. In particular, these terms appear substantial in Singapore but not in Korea, even though Korea also intervened heavily in markets. To better understand the reasons, we now discuss the Singaporean case in greater detail. We return to Korea and the other NIEs in Section VI.

III. Singapore: Large Profits and Favoritism

Anecdotal evidence strongly suggests that economic profits were large and the cost of capital heterogeneous in Singapore. Singapore's transition from a poor country in the 1960s to a rich, modern economy involved considerable direct and indirect government participation in the economy as well as vast inflows of FDI. Firms in "preferred" or "favored" sectors appeared to earn large (though diminishing) profits, reflecting market power and favorable factor prices for so-called government linked corporations (GLCs), statutory boards (SBs), and the multinationals that directly invested in Singapore. Indeed, favoritism appears to have increased over time, suggesting that the (unobserved) preferred cost of capital fell more rapidly than that of the (observed) unpreferred sector. These profit and cost-of-capital effects, capturing the two terms in equation 7, plausibly account for the primal-dual gap.

A. *Large Profit Share*

GLCs, companies at least 20-percent government-owned, contributed as much as 25 percent of

Singapore's GDP by the late 1980's.[7] The closely-related SBs have mandates such as regulating industries

and infrastructure, providing education and other public services, and managing state utility assets.

Examples of SBs include the Telecom board, the Port of Singapore Authority, and the Housing and

Development Board. As U.S. Embassy (2001) notes, "some analysts assert that the presence of top civil

servants as directors on the boards of GLCs and statutory boards … constitutes an unfair advantage."

Many SBs and GLCs appeared to earn huge profits by capitalizing on entry barriers. Some barriers,

e.g., in telecom, reflected traditional "natural monopoly" considerations.   Others, though, reflected

government entry restrictions. For example, the Port of Singapore Authority (PSA) controls a valuable

public asset with no competition. The Economist (2001) reports that the port had profit margins as high as

40 percent. Even with a large customer, Maersk, "begging PSA for years for permission to run its own

terminal in Singapore … The Singaporeans, determined to keep control, rebuffed Maersk." Similarly,

Seaward (1985) reports that a GLC, the National Iron and Steel Mills (NISM), controlled 90 percent of the

steel market. He notes, "It is no secret that NISM benefited from strong government protection in the early

1960s … which essentially gave the company a monopoly over the market." Singapore Airlines, in an

industry where the government controls access to airport gates, had decades of accounting profitability and

high relative return on equity to shareholders (presumably indicating economic profits). EuroMoney

(1984) estimates that the (accounting) profits of GLCs and SBs *alone* equaled about one-third of GDP.[8]

Over time, profits seem to have declined. Recently, some notable GLCs and SBs, including

Singapore Airlines, have encountered serious problems and have not been profitable. But over the decades

studied by Hsieh and Young (primarily the 70's and 80's), stories abound of high profits by these firms.

Singapore's active enticement of FDI also led to large profits. From 1972 to 1990, FDI amounted to

an average of almost ¼ of gross fixed capital formation (IFS). Singapore negotiated a wide range of

incentives (not available to domestic firms) to entice such extraordinary inflows. Negotiated terms are not

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[7] Most of the GDP contribution comes from GLCs more than half government-owned. Late 1980s share is from IMF
(1995). Since the 1980s, some SBs have been privatized and are now GLCs. Department of Statistics (2001) argues,
however, that by the mid-90s, the GLC share of GDP was only a bit over 10 percent.

public, so it is hard to quantify the exact measures used. But even if foreign companies faced competition in export markets, the measures likely reduced production costs and allowed for economic profits. As an article entitled "A juicier carrot for foreign investors " (Senkuttuvan, 1975) notes: "Shrewd industrialists who invest when times are not so good can receive enormous incentives from the Singapore Government." Incentives ranged from tax and depreciation benefits to training grants to beneficial export treatment.[9]

Further, anecdotal evidence suggests that beneficial tax treatment, such as tax holidays for technology upgrades granted by the Economic Development Board, resulted in multinationals adjusting internal transfer pricing to realize high profits in low-tax Singapore.[10] In sum, given these statistical differentials and anecdotal evidence, it seems logical and consistent to posit that foreign companies, like the government's "favored" domestic firms, received "special" treatment leading to large economic profits.

B. Heterogeneous Cost of Capital

SBs, GLCs, and multinationals also help explain the dual-primal gap because their cost of capital grew at different rates from the rest of the economy. They received "special treatment" including artificially high credit worthiness (reflecting the assumption that the government would bail out bad performers)[11], tax relief, political connections, or direct government financing. Further, these benefits seemed to grow over time, so the favored cost of capital fell faster than the non-favored one.

According to Burton (1995), GLCs generally "enjoy a competitive advantage in terms of financing. Their costs of capital are usually lower than for companies in the private sector …." U.S. Embassy (2001) argues that this seems to be "because they enjoy an implicit Government guarantee of repayment. In the early years of economic development, GLCs were given preferential rates by DBS Bank, itself a GLC." Other benefits took the form of tax relief. For example, the Economic Expansion Initiatives Act reduced taxes from 40% to 4% on certain export-intensive industries. "Pioneer" firms, designated by the

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[8] We obtained this citation from Young (1992).

[9] Singapore, A Case Study in Rapid Development, IMF Occasional paper, February, 1995.

[10] For multinationals, financing presumably occurs at a world rate. As such, the "preferential" treatment would be through tax or other benefits as opposed to access to capital. Regardless, these benefits would drive the multinational's cost of capital below its level elsewhere.

[11] This holds particularly true for GLCs, like the utility Pan-Electric. Far Eastern Economic Review (1995), in an article titled, "A politic helping hand: Creditors offer Singapore's debt-plagued Pan-Electric a long lifeline" states that "Bankers and brokers regard Pan-Electric as too important a company to be allowed to go under."

government, received major tax relief and in 1991 accounted for nearly 2/3 of manufacturing value added and 4/5 of value added in chemicals, electronics, and instruments (IMF 1995).

These sectors had very heavy GLC and foreign involvement, so this program acted to reduce the cost of capital for a favored subset of the economy.   Indeed, as discussed in Young (1998), the tax breaks to these companies increased over time. Hsieh (2002) notes, in response, that the overall average effective tax rate increased. Together, these observations suggest that even while the effective tax rate for *favored* firms was falling, the rate for *unfavored* firms rose—thus accounting for rising overall tax collection with a widening gap in the cost of capital.

Foreign companies were also well suited to take advantage of Singapore's official, formal tax breaks. Young [1992] describes such tax incentives as neutral in principal, but biased toward foreign investment in practice. Bowring (1995) claims that "Government critics do not find it difficult to show that the tax … systems have not only directed cash flow to officially decreed ends, but have in effect also discriminated in favour of state and foreign enterprises." Preferential treatment extended beyond tax breaks. Young [1992] cites claims of academics and popular writers that "the Singaporean government … subsidize[s] the return to foreign capital (beyond the tax incentives) by, for example, providing preferential loans, leasing land and buildings at reduced cost, shouldering labor-training costs, and assuming large equity positions."

In addition to some of the more subtle subsidization methods above, many of these government linked and foreign organizations were financed by direct government loans. As described in more depth by Young [1992], the government was able to sustain such outflows by borrowing from the Central Provident Fund (CPF), a public saving fund akin to Social Security in the U.S. The government required increasing contributions to the CPF though did not offer reasonable returns directly to the workers. [12] Indeed, other than for medical costs and housing investments, it was quite difficult to access the fund at all! The government relied heavily on the fund, though, and as Young [1992] describes, some 95% of the fund was invested in government shares. In essence, the CPF served as a very large tax on private savings to subsidize the cost of capital of certain firms – namely SBs, GLCs, and multinationals. This increasing

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[12] As detailed by Young, the [employee/employer match] contribution increased from 5%/5% to 15%/15% to 25%/25% over the time period studied. IMF(1995, p45) documents the below-market returns to CPF investments.

subsidization, regardless of its form, resulted in an increasing wedge between the "favored" and

"unfavored" costs of capital.

IV. Measuring the Effects of Economic Distortions

Singapore was not alone in intervening heavily in markets.[13] We now assess the empirical

importance of this intervention for the primal-dual difference, in terms of equation (7). Combining

capital's contribution to the dual-primal gap (from Table 3) with an estimate of the profits term, we back

out the contribution of the cost-of-capital-heterogeneity term.

A. Accounting for the Dual-Primal Gap

We begin by calibrating the role of profits. Section III argued qualitatively that in Singapore,

government policy led to market power, low average factor prices, and large profits. Suppose market

power is the only imperfection, with no heterogeneity in capital costs. The right-hand side of equation (7)

then reduces to $s_\Pi \left[\hat{s}_K - \hat{s}_\Pi \right]$. This expression equals zero if profits are zero or if the "true" capital share,

$\hat{s}_K$, grows at the same rate as the profit share, $\hat{s}_\Pi$. Given a relatively constant labor share, however, this

condition becomes $\hat{s}_K = \hat{s}_\Pi = \hat{s}_L = 0$. Hsieh (2002, p.505) thinks it unlikely that profits drive much wedge

between the primal and dual. But his argument requires that either the level or the growth rate of the profit

share be small. We argue below that both conditions are violated in Singapore, although not elsewhere.

How large are profits? Singapore's strikingly low labor share—about ½—matches qualitative stories

of large pure profits. Labor's share is often low in developing countries because self-employment income

(e.g., from farming) is allocated to capital not labor. This story does not explain Singapore: The

agricultural sector is tiny and, besides, Young (1995) carefully allocated proprietors' income.[14]

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[13] This was widely noted even before the Asian crisis. See, for example, the World Bank (1993); Leipziger and Thomas (1994), and the discussions of Singapore in Young (1992, 1995, and 1998).

[14] Gollin (2002) reports that after correctly allocating proprietors' income, labor shares are almost always in the range of 0.65 to 0.8. He cites Young (1995) as exemplifying the "best approach" to estimating factor shares (Gollin, p. 467). If anything, though, Young overstates labor's share, implying that we may understate profits. First, Young (2000) suggests that he overcompensated for proprietors' income, since it appears that national accountants already attribute some proprietors' income to labor, in contravention of the U.N. System of National Accounts. Second, Young (1995, footnote 8) also implies that, if anything, he has *overstated* labor's share, since he explicitly ignores a labor share series from Singapore Statistics that has an even lower labor share than the input-output series he used.

Labor's share could also be abnormally low because of the country's mix of industries. For example, Sarel (1997) reports that in financial services, labor's share (averaged across countries for which industry data are available) is about 0.4. We estimate "true" factor shares in *cost* (as opposed to output or revenue) by combining Sarel's data on industry capital-cost shares with data on the industry mix of output.[15] Given these estimated cost shares, we can back out the implied profit share, s_Π. In particular, if capital's share in total cost is α and labor's share is $(1-\alpha)$, then the profit rate s_Π equals $\big((1-s_L)-\alpha\big)/(1-\alpha)$.

Table 4 shows our estimates of cost shares and the profit rate for the NIEs. Line 1 shows Young's estimated 'residual' capital share, $(1-s_L)$; Line 2 shows the estimate using Sarel's approach, α. Line 3 is the implied capital share in revenues and line 4 is the estimated profit share. Singapore is the only country with substantial profits. Labor's share is about ½ but our estimated capital cost share is only a bit above 1/3 (line 2). When we decompose $(1-s_L)=s_K+s_\Pi$, capital's output share s_K equals about ¼ (line 3) and the profit share s_Π is also about ¼ (line 4). (Note that with a profit share of 1/4, costs (i.e., s_K+s_L) account for 3/4 of output. Labor payments are then 2/3 of cost, and capital payments are 1/3 of cost.)

Although the anecdotal evidence supports the notion of large profits, pure economic profits amounting to ¼ of GDP clearly raises questions. We used two alternative back-of-the-envelope estimates to confirm its magnitude. First, we follow Hall (1990) and Rotemberg and Woodford (1995), who provide careful, indirect arguments that U.S. pure profits are small. In particular, we use evidence on the capital-output ratio to back out the implied rate of return to capital consistent Singapore's measured output shares.

From 1985 through 1990, the ratio of tangible capital to GDP averaged 2.89; the investment-output ratio was 0.38 (both ratios were relatively stable over the sample period).[16] Over the 1970-90 period, investment growth averaged 8.5 percent per year. Thus, the implied average rate of depreciation was about 5 percent (since, with a single type of capital, $I/K = g + \delta$), equal to the U.S. rate reported by Rotemberg

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[15] We obtained one-digit GDP-by-industry data from CEIC Asia Database (downloaded Feb. 1999). Sarel estimates industry capital and labor shares from a large sample of (primarily developed) countries. We assume constant factor shares within an industry. (Jones (2003) argues that factor shares are not constant; but as long as deviations from strict Cobb-Douglas are small relative to mean differences across industries, this won't matter much.)

[16]   We used constant S$1985 figures on investment, capital stocks, and GDP. Numbers would probably be similar with disaggregated nominal values, which would better allow for variation in the relative investment prices.

and Woodford. Taking payments to capital (including profits) as an implicit capital-payment rate r plus the depreciation rate δ implies that: $(r + \delta)(K/Y) = s_K + s_\Pi = 0.484$.

The implicit r equals about 13 percent—substantially in excess of the corresponding U.S. rate of 6 percent. Rotemberg and Woodford argue that 6 percent approximately equals the U.S. required return to capital, including an equity premium; hence, their estimate implies pure profits are small. If, because of capital mobility, Singapore's required rate of return was similar to the U.S. rate, then the 'excess' return of 7 percent represents profits. Multiplying that 7 percent excess return by the capital-output ratio again suggests a rate of profit in Singapore that was plausibly around 20 percent.

As a second alternative estimate, we took Hsieh's estimates of the cost of capital C literally, while assuming the national accounts measure investment properly. In particular, we estimate required payments to capital by multiplying Hsieh's cost-of-capital estimates by the estimated value of capital stock.[17] This method assumes that all of the dual-primal gap comes from the profit term of equation (7). The implied profit shares, though variable, are frequently in the 15-20% range and generally show a downward trend.[18]

Although such large pure profits are clearly unusual, studies for other countries do sometimes suggest that product market distortions (e.g., entry restrictions) lead to substantial economic rents. For example, Blanchard and Giavazzi (2002) discuss the sharp decline in labor's share in income in many European economies between the early 1980s and the mid-1990s. Consider Italy, where labor's share fell from about 78 percent to only about 60 percent (their Figure 5). They attribute this 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., in the case of Italy, on the order of 15 to 20 percent of GDP.

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[17] We assume that there is only one cost of capital C. We downloaded Hsieh's data for C (from http://www.wws.princeton.edu/~chsieh/data.html) and backed out the profit rate as $s_\Pi = (1 - s_L) - C \cdot (Y/K)$. Hsieh argues that the national accounts overstate investment and, hence, implies that the capital-output ratio is overstated. A lower capital-output ratio would imply even larger profits. Alternatively, if there are no profits and Singapore overstates investment, then either: (i) Hsieh's cost-of-capital estimates are too low (so growth rates are suspect); or (ii) the true capital-output ratio is actually much higher than implied by the national accounts.

[18] This method, which assumes that profits explain the entire gap, produces a lower average profit share than that shown in Table 4, where we considered an additional contribution from heterogeneous costs of capital. This results because the high-calculated level was accompanied by lower profit-share growth whereas the lower level was coupled with higher profit-share growth. Both profit level and growth rate are important in the third term of equation (7).

What happened to Singapore's profit share over time? We estimated this time series using the GDP-by-industry data. Consistent with government subsidies for capital-intensive industries, we estimate that the "true" capital share in revenue, s_K (estimated with Sarel's industry shares) grew over time. A rising true capital-cost share combined with a relatively constant labor share implies that the profit share fell over time. A large level and negative growth rate of the profit share yields a large magnitude contribution of the second term of equation (7), i.e., a significant contribution of profits to the dual-primal gap.

Table 5 uses this calibration to decompose Singapore's dual-primal gap into the role of profits and cost-of-capital heterogeneity. Across Hsieh's three methods, capital on average contributes about 2/3 of the total gap; and profits on average contribute 2/3 of capital's portion. Heterogeneous capital costs contribute about 1/3 of capital's portion. Hence, both wedges appear significant in driving a wedge between the primal and the dual, with profits being the single most important factor.[19]

B. *How did Hsieh miss the "favored" cost of capital and profits?*

Is it sensible to presume that dual TFP estimates incorporate the cost of capital only for the "unfavored" subset of the economy? To assess this, we now discuss the three rate-of-return measures Hsieh uses to estimate the cost of capital in Singapore: the earnings-to-price ratio (E/P); an average lending rate; and the published return on equity (ROE).

First, consider the earnings-price ratio. Using a standard (Brealey and Myers) formula, a company's share price P_i is $P_i = E_i/r_i + PVGO_i$—the value of a perpetuity yielding E_i, plus the present value of growth opportunies. Rearranging implies that $E_i/P_i = r_i - (r_i \cdot PVGO_i/P_i)$. With perfect capital mobility, this interest rate is the expected (or required) return for the global representative investor, equal to a discount rate, ρ, plus a firm-specific risk premium θ_i.

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[19] We have referred to the second term as the contribution of profits, as if it were distinct from heterogeneous costs of capital. However, the second term depends in part on the "representativeness" of the observed $\hat{c}_U$. An alternative representation of equation (7) is $TFP_{Dual} - TFP_{Primal} = s_K(\hat{c}_U - \hat{c}) + s_\Pi \left[\hat{c} + \hat{k} - \hat{\pi}\right] + s_\Pi(\hat{c}_U - \hat{c})$. The first two terms capture heterogeneity and profits, respectively, while the third term captures a combination of the two. However, zero profits would leave only the first term in our existing equation (7) and zero heterogeneity would leave only the second term, so we use this form to measure the impact of the two effects.

Singapore's stock market does not comprise a representative set of companies, and it is unlikely to capture expected returns for 'favored' companies (namely, GLCs, SBs and foreign firms). In particular, few GLCs were listed prior to the government's 1985 privatization strategy, and multinationals generally list elsewhere. This wouldn't matter if capital were freely mobile (so required returns are set by the global representative investor) and if unlisted companies had risk premia and growth opportunities that were similar to those of listed companies. But GLCs, SBs, and multinationals tend to be lower-risk firms, with lower implicit or explicit θ_i – either because the government backed them (GLCs and SBs) with favorable access to funds and/or implicit insurance; or because they were substantially larger and likely more diversified (multinationals). [20] As such, the E/P ratio is likely to be a better measure of expected returns in the 'unfavored' sector than the favored sector. [21] Finally, the earnings-price ratio would also exclude any tax/subsidy components of the cost-of-capital formula—which clearly favor certain firms over others.

Second, Hsieh's average bank lending rate also more likely represents the required returns for the "unfavored" sector than for the "favored" sector. As Young (1998) describes in detail, the banks were heavily regulated in a "cartel arrangement" through at least 1985, with lending rates above competitive levels.[22] But GLCs, SBs, and multinationals generally had alternative, likely cheaper sources of funding. These sources, for example, included loans from the Central Providence Fund, international lending (especially for MNCs, who didn't need to rely on local cartel lenders), and very low-interest loans available to exporters (see the discussion in Young 1998). In addition, the lending rate will, again, miss any favorable tax/subsidy treatment.

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[20] This classification is more subtly suggested in a 1999 report funded by the National University of Singapore ("Singapore's Global Reach: An Executive Report," by Henry Wai-Chung Yeung) that determined that many surveyed private sector firms found Singapore's business and commercial laws to be biased in favor of bigger corporations, both GLCs and foreign multinationals.

[21] Hsieh (2002) dismisses the idea that a declining overall risk premium could explain the primal-dual divergence. More specifically, he argues that in developing countries, private and public risk premia are highly correlated; he then shows that Singapore's public risk premium is low. For all the reasons described in Section III, though, the premise of a close correlation between the public and private premia in Singapore is flawed. Moreover, our argument here relies on the heterogeneity of risk premia across firms.

[22] Though the Singaporean Yearbook of Statistics indicates the end of interest rate regulation in 1975, Young explains in detail why in practice, this did not occur until the mid-80's.

Of course, the average rate may still not be a perfect measure of the opportunity cost of funds to the less-favored sector, given the heavily regulated financial sector. But it appears more representative of the cost of capital for less favored than for favored firms, for all the reasons discussed.

Finally, Hsieh uses a ROE calculation from the Singapore Registry of Companies and Businesses. In principle, these figures cover most, if not all, firms and should incorporate economic profits. Given our arguments in Section II, it should therefore give results similar to primal estimates. But closer examination of the ROE figures, and the return-on-asset figures underlying it—suggest that these figures may not be reliable.[23] The ratio of assets to output averages over *13* for 1980-1990—an extremely high number, far larger than the capital-output ratio of under 3 in the national accounts (a figure that Hsieh implies is overstated). A large share of these assets (and equity) are in the financial sector, and represent financial claims rather than tangible, non-financial assets. But even in the non-financial sector alone, the asset-output ratio still averages 4.5, well in excess of national accounts estimates. In terms of growth rates, the overall and non-financial asset-output ratios grow at 4.7 percent and 3 percent, respectively, from 1980-1990, in line with the rate of capital-output growth in the national accounts.

Thus, although total assets are not the same as tangible capital, it is nevertheless the case that the ROE and ROA data are inconsistent with Hsieh's implicit or explicit claims that the national accounts overstate the level and rate of growth of the capital-output ratio. In sum, accountants and statisticians who calculate (and then aggregate) the book values of individual companies have a different focus than do growth accountants. In our view, these figures are significantly less reliable as a 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.

The above indicates that Hsieh did not capture the heterogeneous costs of capital in two of his three calculations (and casts doubt on what exactly the third measure captures). Our argument also assumes that

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[23] Asset data taken from the Department of Statistics report, "Efficiency of Singapore Companies: A Study of the Returns to Assets Ratios," June 1992. This is the same report cited by Hsieh as the source of the ROE data, even though ROA data (not ROE data) is actually found in the report. Numbers consistent with Hsieh's ROE calculations are found in "Foreign Equity Investment in Singapore, 1992," also by the Department of Statistics in March 1995.

Hsieh's measures exclude profits.[24] The lending rate would clearly exclude profits. The numerator of ROA should incorporate profits, but as just discussed, we have serious questions about the reliability of the denominator. Finally, if exchange-listed companies earned large pure profits, those would show up in earnings, but would also be capitalized into the price in the denominator. In equilibrium, returns embodied in the earnings-price ratio are those expected by the investor. If profits are expected to be temporary (so prospects for the growth in earnings are low), then profits could cause the E/P ratio to be high. Nevertheless, in our view, most profits in Singapore were earned by GLCs, SBs, and multinationals – typically not listed on the Singaporean market.

V. Primal vs. Dual revisited: Productivity and Technology

We have argued that, in practice, the primal and the dual differ because of output and factor-market distortions and, hence, the gap reflects important aspects of the economic environment. Even more important, these distortions imply that TFP growth does not equal technology growth. But with a few assumptions, the primal and dual estimates together yield insight into technology growth in the favored and unfavored sectors.

A. Productivity and technology

In Singapore, economic profits were large. With market power, of course, the Solow residual does not measure technology (see, for example, Hall 1988, 1990). Hall suggested that with market power but constant returns to scale, a cost-based TFP residual measures technology. The standard and cost-based residuals differ by a single term, reflecting the different weighting of capital and labor:

$$\hat{y} - \left[(1-s_L)\hat{k} + s_L\hat{l}\right] = \hat{y} - \left[(1-s_L^{Cost})\hat{k}_i + s_L^{Cost}\hat{l}_i\right] + \left[s_L^{Cost} - s_L\right](\hat{l} - \hat{k})$$

As in Hall (1988, 1990), we have defined the share of required payments to each factor in total costs by

$$s_{J,i}^{Cost} = s_{j,t}/(s_{K,t} + s_{L,t}), \ J = K, L.$$

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[24] Young [1998, p33] dismisses the role of profits in reconciling the results because he concludes that Hsieh's measures of the cost of capital would include profits.

How does the aggregate cost-based residual relate to technology? Hall's argument applied to a single firm. But suppose there are two sectors, each of which has constant returns, takes factor prices as given,[25] but potentially produces with market power. We define aggregate technology growth as a share-weighted average of technology growth, $\hat{t} = \omega_U \hat{t}_U + \omega_F \hat{t}_F$, where ω_i is the sector's nominal share in aggregate output, $P_i Y_i / (P_U Y_U + P_F Y_F) \equiv P_i Y_i / PY$.

As shown in the appendix, the aggregate Solow residual equals:

$$\hat{y} - \left[s_L \hat{l} + (1 - s_L)\hat{k} \right] = \hat{t} + \left[s_L^{Cost} - s_L \right](\hat{l} - \hat{k}) + \left[\Sigma_\Pi + \Sigma_K \right], \tag{9}$$

where Σ_Π and Σ_K reflect reallocations of inputs across uses:

$$\Sigma_\Pi = \left(\frac{\omega_F \omega_U}{(1 - s_\Pi)} \right)\left(s_{\Pi,F} - s_{\Pi,U}\right)(\hat{x}_F - \hat{x}_U)$$

$$\Sigma_K = \left(\frac{K_U}{K} \right)\left(\frac{\omega_F s_{K,F}}{1 - s_\Pi} \right)\left(1 - \frac{C_U}{C_F} \right)(\hat{k}_F - \hat{k}_U)$$

Σ_Π reflects reallocations of inputs across sectors where they have different profit rates. The term is positive (i.e., TFP grows more quickly than technology) if high-profit sectors grow more quickly than low-profit sectors. This term arises because aggregate output reflects relative market prices (i.e., relative valuations) rather than relative costs of production.

Σ_K, which reflects reallocations of capital across sectors with different costs of capital, is positive if capital grows more quickly in sectors with a higher cost of capital. With cost minimization, capital's marginal product is proportional to the cost of capital. If capital shifts to where its marginal product is higher, then output rises. At least for a while, directed credit likely leads this term to be negative, since favored sectors have both a lower cost of capital and (during transition to a new steady state) grow faster.

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[25] Blanchard and Giavazzi (2002) discuss alternative labor market assumptions, e.g., efficient bargaining. Their paper suggests the question of why, given the rents, workers didn't bargain for a larger share of them. We view the process of Singapore's wage negotiations as, essentially, giving all of the bargaining power to employers.

In Singapore's case, these reallocation terms appear to largely offset: The high-profit sector was the same as the low cost-of-capital sector, and grew more quickly.[26] We therefore ignore these terms in Singapore. (In Korea, profits were small but resources were pushed towards the favored sector, so the capital-reallocation term is likely negative—suggesting that $\hat{t}$ exceeds measured TFP growth.)

We now use equation (9) to calibrate aggregate technology in Singapore. Measured TFP growth differs from technology growth because, with profits, TFP underweights labor relative to capital. Labor's share in cost averages about 2/3 (0.67) using the Sarel approach; but labor's share in revenue averages about ½ (0.51). Hence, $\left[s_L^{Cost} - s_L \right]$ is about 1/6. Young (1998, Table II) reports that from 1970 to 1990, $\hat{l}$ averaged 6.2 percent and $\hat{k}$ averaged 11.0 percent. Thus, the entire non-technological term is $\left[s_L^{Cost} - s_L \right](\hat{l} - \hat{k})$ is (0.15)(4.8 percent)=0.77 percent.

Thus, we find that Young *understates* overall technological progress by about 3/4 percentage point per year from 1970 to 1990. He reports TFP growth of –0.5 percent per year, so true technology growth averaged about +0.3 percent (-0.5+0.77) per year.[27] Nevertheless, the qualitative conclusion from this exercise is that, as Young suggests, technology growth in Singapore was singularly unimpressive.

B. *Sectoral differences in technology growth*

We can now use Hsieh's dual estimate to estimate sectoral technology growth in the unfavored sector, which we take to be everything except manufacturing, finance, utilities, and transport.

We assume that there are no profits in this sector (this is easily generalized), that all unfavored firms pay the same wages and cost of capital, and have the same distribution of capital/worker types as the aggregate economy. (These assumptions ensure that within-sector reallocation terms are zero and that the sector's input composition equals the aggregate.) Cost shares and revenue shares are then equal, so standard TFP growth (calculated either from the primal or the dual) correctly measures technology growth (see appendix). The key difference from Hsieh's calculations are (i) he used Young's aggregate labor

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[26] For example, we set ω_U =0.4, $s_{\Pi,U} = 0$, $s_{\Pi,F} = 0.3$, C_U=20 percent, C_F=10 percent, K_I/K =1/3, $\hat{x}_U = 4.5$ percent, $\hat{x}_F = 10$, $\hat{k}_U = 5.5$, and $\hat{k}_F = 13.7$. $\Sigma_{\Pi} = +0.5$ percent and Σ_K = -0.5 percent. We experimented with a range of other values, but if the favored sector has both higher profits and faster growth, the sum is generally small.

shares, and (ii) we need to measure real factor prices in terms of sectoral, not aggregate, deflators. Since Hsieh deflates wages and the cost of capital by the GDP deflator, we have to add the difference between the aggregate and unfavored sector deflators, $(\hat{p} - \hat{p}_U)$. Sectoral technology growth equals:

$$\hat{t}_U = \left[s_{L,U}^{Cost} \hat{w} + (1 - s_{L,U}^{Cost}) \hat{c}_U \right] + (\hat{p} - \hat{p}_U). \tag{8}$$

The relative price term (measured with Tornquist price indices calculated from one-digit data) averages only -0.11 percent per year.

Using Sarel's estimated industry cost shares for the five unfavored industries, labor's share averages 0.81 (the unfavored sectors tend to be labor intensive). Using Hsieh's (average) estimates of wage and cost-of-capital growth shown in from Table 2, technology growth in the unfavored sector averaged about 2.5 percent per year. This figure is a good bit *higher* than his reported estimate of 1.8 percent because the cost-share weight on labor (whose factor price grew faster) is much larger than labor's aggregate share in revenue. Given a value for ω_P, we can now back out technology growth in the favored sector:

$$\hat{t}_F = \left(\hat{t} - (1 - \omega_F)\hat{t}_U \right) / \omega_F.$$

For our categories of 'favored' industries, the share ω_F averaged 0.6 from 1970-90. Hence, $\hat{t}$ equal to 0.25 percent per year and $\hat{t}_U$ equal to 2.2 percent per year implies that $\hat{t}_F$ equals –1.0 percent per year.[28]

Hence, we find that Hsieh's dual TFP *underestimates* technology growth in Singapore's unfavored sector; Young's primal TFP *overestimates* technology growth in the favored sector. The favored sector had output growth of 9.9 percent per year with negative technology growth. The less favored sector grew at 6.3 percent per year, with technology growth of 2.2 percent per year.

What of other Asian economies? Given small pure profits we do not adjust for differences between labor's cost and revenue shares. However, in Korea and, to a lesser extent Taiwan, directed credit appears to have shifted resources to where they had a lower marginal product – thereby reducing measured TFP

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[27] Young (1995, p.648) discusses the possibility of monopoly profits, noting that 'the reader can make an easy correction for this factor'. This is in essence what we have done here.

[28] Young's estimates implied lower wage growth than Hsieh's. The same calculations, but using Young's implicit wage growth from Table 2, would imply $\hat{t}_U$ equal to 1.2 percent per year, whereas $\hat{t}_F$ equals –0.3 percent.

relative to technology growth (by a magnitude that, by some back-of-the-envelope calibrations, is probably

under ½ percent). Such adjustments do not substantively change one's assessment of these economies.[29]

VI. If Singapore, why not Korea?

We have argued that large, variable profits and different growth rates for different capital costs – both

resulting largely from governments' subsidizing and protecting certain sectors – created the large primal-

dual TFP gap in Singapore. But why isn't there a gap in Korea? State intervention in Korea has garnered

as much or more attention as Singapore, Inc. Indeed, the development strategy of both countries involved

large government intervention. Why should the primal and dual match better for Korea than Singapore?

It is important to remember that market imperfections need not cause a dual-primal divergence. As

noted earlier, consider the steady state of a two-sector neoclassical growth model with market power and

favorable access to credit. In steady state, the profit share, capital-output ratio, and costs-of-capital are

constant; thus the primal-dual gap disappears.   What about during the transition?

First, monopoly power, reflecting in part government entry barriers, led to high profits in Singapore.

But high profits are obviously not an inevitable consequence of government intervention—Singapore

seems the exception to world experience, not the rule. For Korea, we calculated in Table 2 that the profit

share was small (6.5 percent). Leipziger's (1988) and Kihwan and Leipziger's (1997) firm-level studies

also suggest relatively small profits.   Kihwan and Leipziger suggest this lack of profitability may result

from Korea's Confusion heritage, which emphasize freedom to hire workers but less freedom to fire them.

"Korean businessmen," they argue, "often care more about business expansion than profits."

Second, the mere existence of heterogeneous costs of capital need not necessitate differing growth

rates for the costs of capital, as occurred in Singapore. Though Korea's transition also had heterogeneous

costs of capital for favored and unfavored sectors, these different costs seemed to grow at similar rates.

Hsieh notes the different *levels* of capital cost in Korea when he uses the curb loan rate (the market rate)

versus the discount rate (the "preferred" rate). However, these two rates both declined at very similar

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[29] Lee (1996) finds that TFP growth was lower in government-favored Korean industries than in non-favored ones.
Such effects are already incorporated into aggregate TFP.

paces. A transition with these characteristics would not produce a gap between the primal and dual.[30]

Finally, why was the favored cost-of-capital observed in Korea but not in Singapore? It is helpful to think through the mechanisms by which heterogeneity was introduced. In Singapore, we argued that it is difficult to include "unobservable" benefits to a favored sector. Differential tax rates, which affect the cost-of-capital across firms, are difficult to account for. By contrast, Korea seemed to rely much more on preferential access to capital (such as directed credit to state-owned enterprises and Chaebols), and the different interest rates are more easily observed.

In addition, the 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. Leipziger (1988) confirms that Korea "failed to encourage FDI in their early development years … it took Korea until 1984 to become an active recipient of original FDI." Indeed, IFS statistics confirm that while FDI amounted to nearly half of investment (15% of GDP) in Singapore by 1990, FDI amounted to only 1% of investment (a negligible share of GDP) in Korea by 1990.

In sum, though the broad development strategies were similar in Korea and Singapore, the lack of profits and the similar measured growth rates in favored and unfavored costs of capital in Korea resulted in consistent dual and primal TFP estimates.

VII. Conclusions

We show how product and output market distortions can, in principle and in practice, reconcile apparently divergent quantity- and price-based measures of TFP in Asia. We thus view these divergent results as complementary, providing insight into the economic environment. In particular, heterogeneity in the cost-of-capital (reflecting intentional programs of many Asian governments to direct resources to particular firms and/or sectors) and pure economic profits can explain much of the difference.

Perhaps our most striking empirical claim is that in Singapore, economic profits averaged nearly 1/4 of GDP. Such sizeable profits—especially when earned by state-favored firms—are clearly an anomaly in

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[30] Korea's official bank rates, though lower than the curb loan rate, still relied on some market mechanism. Rhee (1997) discusses the dual structure of Korea's financial market.

world experience. But these large profits not only explain Singapore's extremely low labor share, they are also consistent with a wide range of indirect anecdotal evidence (e.g., on entry barriers) in Singapore.

With substantial distortions, TFP growth does not, of course, measure technology. Drawing on recent macroeconomic literature on aggregating TFP under imperfect competition, we conclude that for Singapore, 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 negative TFP growth. However, this does not mean that Singapore had no worthwhile investments. In particular, under our interpretation, the relatively unfavored sector had slower output growth, about 6 percent per year, despite rapid TFP growth of around 2-1/2 percent per year.

Taking a step back, it is striking that despite substantial economic distortions in several of the NIEs, they nevertheless managed to achieve very rapid growth. In the case of Singapore, GDP per capita in the Penn World Tables rose from a level 1/5 (19 percent) of the U.S. level in 1960 to a level comparable to (or even slightly above) the U.S. level by the late 1990s. How did they achieve such stunning results, with such a distorted economy? First, it appears that they have, as Young and Krugman argued, been successful in marshalling substantial investment and capital accumulation. In 1998, Singapore was 2nd in GDP per capita in the PWT, but was 24th per capita in consumption (including government consumption) per capita; in terms of expenditures, about 57 percent of GDP was invested either at home or abroad.[31] With an apparently low social discount rate—in part reflecting intentional government policy to promote saving— standard neoclassical growth theory would predict fast growth, albeit with a declining marginal product. Endogenous growth models such as Ventura (1997) could help explain how Singapore was able to maintain rapid growth with massive structural change. Second, some of the distortions in Singapore's economy could have offset each other. For example, a standard problem with monopolies is that they underproduce relative to the social optimum; Singapore could have partially offset that distortion via subsidies. Finally, large swaths of Singapore's economy—ironically enough, the relatively unfavored sector—maintained rapid TFP growth for decades.

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[31] Figures from http://www.bized.ac.uk/dataserv/penndata/penn.htm (downloaded July 27, 2003).

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Table 1
Asian Growth Estimates
(percent per year)

	Output Growth (1970-1990)	Total Factor Productivity	
		Young (1995, 1998)	Hsieh (2002)
Singapore	7.8	-0.5	1.8
Taiwan	8.8	2.2	3.7
Korea	9.5	1.7	1.9
Hong Kong	7.5	2.3	2.3
Unweighted Average	8.4	1.4	2.4

Note: Here we give the arithmetic averages of Hsieh's and Young's results for each line above from the calculations for each of the time periods used by Hsieh. Young's numbers were adjusted (using a weighted average of growth rates over subperiods) to cover the identical time period as each of Hsieh's measures. Hsieh (2002) offers three or four different measures of TFP, each based on different measures of the real return and over slightly different time periods. The periods are all highly similar and approximately cover 1970 -- 1990. Young (1998) was used for Singapore and Young (1995) was used for Taiwan, Hong Kong, and Korea. For Hong Kong growth, Young's data for 1971-1991 was used. For Taiwan, data exclude agriculture and include Young's adjustment of public sector output. 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 $\hat{r}$	-2.9	-3.4	-4.3	0.1
(2b)		Hsieh $\hat{c}_{Dual}$	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: $s_K(\hat{c}_{Dual} - \hat{r})$		1.6	0.6	0.1	-0.3
(7)	Difference (Dual-Primal)		2.3	1.6	0.1	0.1

Notes: Here we give the arithmetic averages of Hsieh's and Young's results for each line above from the calculations for each of the time periods used by Hsieh. Young's numbers were adjusted (using a weighted average of growth rates over subperiods) to cover the identical time period as each of Hsieh's measures (e.g., for a measurement of the 1975-1990 rate, we would take 5/15 of the 1970-1980 rate and add it to 10/15 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. 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), using: $\hat{w} = \hat{s}_L + \hat{y} - \hat{l}$ and $\hat{r} = \hat{s}_K + \hat{y} - \hat{k}$. Young's tables include data on $\hat{y}, \hat{l}$, $\hat{k}$, s_L, and s_K. Numbers may not add up due to rounding.

Table 3
Decomposing the Sources of Difference in Primal and Dual Estimates for Singapore
(Except where indicated, all entries are percent per year)

			Hsieh's source for calculation of real interest rate		
			Return on Equity (1971-1990)	Average Lending Rate (1968-1990)	E-P ratio (1973-1990)
(1a)	Wage growth	Young $\hat{w}$	1.6	2.5	1.4
(1b)		Hsieh $\hat{w}_{Dual}$	3.2	2.7	3.6
(2a)	Capital payment Growth	Young $\hat{r}$	-3.1	-3.0	-2.7
(2b)		Hsieh $\hat{c}_{Dual}$	-0.2	1.6	-0.5
(3)	Labor's share s_L (Sample average)		51.6	51.5	51.6
(4a)	Primal TFP growth		-0.7	-0.2	-0.6
(4b)	Dual TFP growth		1.5	2.2	1.6
(5)	Labor contribution to difference: $s_L(\hat{w}_{Dual} - \hat{w})$		0.8	0.1	1.2
(6)	Capital contribution to difference: $s_K(\hat{c}_{Dual} - \hat{r})$		1.4	2.3	1.1
(7)	Difference (Dual-Primal)		2.2	2.4	2.2

Notes: Young's primal data is taken from updated figures in Young (1998), other data are derived from Young (1995, Tables V, VII, and IX), using: $\hat{w} = \hat{s}_L + \hat{y} - \hat{l}$ and $\hat{r} = \hat{s}_K + \hat{y} - \hat{k}$. Young's tables include data on $\hat{y}, \hat{l}$, $\hat{k}$, s_L, and s_K by subperiod. Young's numbers were adjusted (using a weighted average of growth rates over subperiods) to cover the identical time period as each of Hsieh's measures (i.e. for a measurement of the 1975 -- 1990 rate, we would take 5/15 of the 1970-1980 rate and add it to 10/15 of the 1980-1990 rate). 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). Numbers may not add up due to rounding.

Table 4
Estimation of Profit Share
(Except where indicated, all entries are percent per year)

		Singapore	Taiwan	Korea	Hong Kong
(1)	Share of profits and capital *(1-s$_L$)*	48.4	25.6	29.7	37.6
(2)	Estimated "true" capital cost share (using Sarel)	32.7	30.1	24.8	34.7
(3)	Estimated "true" capital revenue share	25.0	32.0	23.2	33.3
(4)	Estimated profit share	23.4	-6.3	6.5	4.3

Notes: Line 2 is calculated as a weighted average of Sarel's capital share estimates, with the weights determined by the industry-share of GDP (1-digit SIC from the CEIC database). Line 4, the estimated profit share of revenues, is calculated as $\dfrac{(1 - s_L - \alpha)}{1 - \alpha}$, where α is the capital share of cost shown in line two. Finally, the capital share in revenues (line 3) is equal to Young's capital share (line 1) minus the estimated profit share (line 4). 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)

		Hsieh's source for calculation of real interest rate		
		Return on Equity (1971-1990)	Average Lending Rate (1968-1990)	E-P ratio (1973-1990)
(1)	Young's capital share	48.4	48.5	48.4
(2)	Estimated "true" capital cost share (using Sarel)	32.7	32.4	32.8
(3)	Estimated "true" capital revenue share	25.1	24.7	25.2
(4)	Estimated "true" capital revenue share growth	1.1	1.1	1.0
(5)	Estimated profit share	23.3	23.8	23.2
(6)	Estimated profit share growth	-1.2	-1.4	-1.0
(7)	Contribution of Profits to Difference (Dual-Primal)	0.9	1.3	0.8
(8)	Contribution of Heterogeneous Costs of Capital to Difference (Dual-Primal)	0.4	0.8	0.3
(9)	Total Difference (Dual-Primal)	2.2	2.4	2.2

Notes: Lines 1 to 3 and line 5 follow exactly as described in the note to table 4. Given CEIC industry shares are known and changing over time, the calculation of "true" capital cost share changes over time. Hence, we present growth rates for the key statistics. 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). Then, using these data and the disaggregation of the capital-payments contribution to the dual-primal gap in equation (7), we calculate lines 7 and 8. Note that lines 7 and 8 do not add up to line 9. Line 9 is the total gap, not just that from the capital side, and includes differences in wages growth estimates. Numbers may not add up because of rounding.

Appendix: Technology with multiple types of firms

We assume that there are two sectors, each of which produces potentially with market power but with constant returns to scale. Output elasticities are then correctly given by the share of required factor payments in total costs, $s_{J,i}^{Cost}$, $J = K, L$ (Hall 1988, 1990. Basu and Fernald 2001 survey the literature that followed Hall. Modifying the derivations for increasing returns and intermediate inputs is straightforward). We assume that firms are price-takers in factor markets. Differentiating, we find:

$$\hat{y}_i = \left[s_{K,i}^{Cost} \hat{k}_i + s_{L,i}^{Cost} \hat{l}_i \right] + \hat{t}_i \equiv \hat{x}_i + \hat{t}_i, \quad i = 1, 2. \tag{A.1}$$

$\hat{x}_i$ is cost-share-weighted growth of capital and labor income, and $\hat{t}_i$ is the growth rate of technology. If there are pure economic profits in either of these sectors, then the cost-share weights do not equal the weights used in calculating standard TFP. Hence, TFP would not correctly measure technology. In particular, if $s_{L,i}$ is the share of payments to labor in *revenue*, then TFP growth equals:

$$\begin{aligned}
\hat{y}_i - \left[(1 - s_{L,i}) \hat{k}_i + s_{Li} \hat{l}_i \right] &= \hat{y}_i - \left[(1 - s_{L,i}^{Cost}) \hat{k}_i + s_{Li}^{Cost} \hat{l}_i \right] + \left[s_{L,i}^{Cost} - s_{L,i} \right] (\hat{l}_i - \hat{k}_i) \\
&= \hat{t}_i + \left[s_{L,i}^{Cost} - s_{L,i} \right] (\hat{l}_i - \hat{k}_i)
\end{aligned} \tag{A.2}$$

If capital growth exceeds labor growth (as Young 1995 reports it did it in every one of the NIE's), then standard TFP growth—the left hand side—will understate technology growth in the sector.

What will the dual measure show for the sector? As derived in the main text, the dual necessarily equals the primal in equation (A.2), as long as the data are consistent with the accounting identity (1). Hence, if the primal doesn't measure technology, then neither does the dual. We will assume in what follows that all sectors pay the same wages. Hence:

$$\hat{t}_i + \left[s_{L,i}^{Cost} - s_{L,i} \right] (\hat{l}_i - \hat{k}_i) = s_{Li} \hat{w} + (1 - s_{L,i}) \hat{r}_i$$

Some minor rearrangement yields the following:

$$\hat{t}_i = \left[s_{Li}^{Cost} \hat{w} + (1 - s_{L,i}^{Cost}) \hat{r}_i \right] - \left(s_{L,i}^{Cost} - s_{L,i} \right) \left(\left(\hat{w} + \hat{l} \right)_i - \left(\hat{r}_i + \hat{k}_i \right) \right)$$

With a constant labor share, the final term is zero and the cost-based dual residual measures technology—as long as payments to capital includes profits. With an estimated cost of capital, we have:

$$\hat{t}_i = \left[s_{Li}^{Cost} \hat{w} + (1 - s_{L,i}^{Cost}) \hat{c}_i \right] + \left(1 - s_{L,i}^{Cost} \right) (\hat{r}_i - \hat{c}_i)$$

Noting that $\hat{r} = \hat{c} + \left(\Pi/RK\right)\left(\hat{\pi} - \hat{k} - \hat{c}\right)$, the above equation becomes:

$$\hat{t}_i = \left[s_{Li}^{Cost} \hat{w} + (1 - s_{L,i}^{Cost})\hat{c}_i \right] + \left(\Pi_i/(R_i K_i + WL_i)\right)\left(\hat{\pi}_i - \hat{k}_i - \hat{c}_i\right)$$

Thus, the cost-based dual residual potentially differs from technology with pure economic profits.

We aggregate across sectors with a Divisa index, which approximates chain weighting. Aggregate output growth, $\hat{y}$, equals:

$$\hat{y} = \omega_1 \hat{y}_1 + \omega_2 \hat{y}_2 \tag{A.3}$$

ω_i is the sector's nominal share in aggregate output, $P_i Y_i / \left(P_1 Y_1 + P_2 Y_2\right) \equiv P_i Y_i / PY$. It will also be

useful to define $\omega_i^{Cost} = \left(C_i K_i + WL_i\right) / \left(C_1 K_1 + C_2 K_2 + WL_1 + WL_2\right)$ as the sector's share in total cost.

(ω_i and ω_i^C differ if the rate of pure profit differs substantially across sectors.) Using (A.1), we find:

$$
\begin{aligned}
\hat{y} &= \omega_1 \left\{ \left[s_{K,1}^{Cost} \hat{k}_1 + s_{L,1}^{Cost} \hat{l}_1 \right] + \hat{t}_1 \right\} + \omega_2 \left\{ \left[s_{K,1}^{Cost} \hat{k}_1 + s_{L,1}^{Cost} \hat{l}_1 \right] + \hat{t}_1 \right\} \\
&= \left[\omega_1 \hat{t}_1 + \omega_2 \hat{t}_2 \right] + \omega_1 \hat{x}_1 + \omega_2 \hat{x}_2 \\
&= \hat{t} + \left[(\omega_1 - \omega_1^{cost})\hat{x}_1 + (\omega_2 - \omega_2^{cost})\hat{x}_2 \right] + \omega_1^{cost}\left[s_{K,1}^{Cost} \hat{k}_1 + s_{L,1}^{Cost} \hat{l}_1 \right] + \omega_2^{cost}\left[s_{K,2}^{Cost} \hat{k}_2 + s_{L,2}^{Cost} \hat{l}_2 \right] \\
&= \hat{t} + (\omega_2 - \omega_2^{cost})(\hat{x}_2 - \hat{x}_1) + \left[\omega_1^{cost} s_{K,1}^{Cost} \hat{k}_1 + \omega_2^{cost} s_{K,2}^{Cost} \hat{k}_2 \right] + \left[\omega_1^{cost} s_{L,1}^{Cost} \hat{l}_1 + \omega_2^{cost} s_{L,2}^{Cost} \hat{l}_2 \right]
\end{aligned}
\tag{A.4}
$$

We have defined $\hat{t} = \omega_1 \hat{t}_1 + \omega_2 \hat{t}_2$. The second term on the last line uses the fact that $\omega_1 = (1 - \omega_2)$.

We now consider each of the non-technology terms in turn. First, we can rewrite the second term in terms of profit reallocations as follows:

$$
\begin{aligned}
(\omega_2 - \omega_2^{cost})(\hat{x}_2 - \hat{x}_1) &= \omega_2 \left(1 - \omega_2^{cost}/\omega_2\right)(\hat{x}_2 - \hat{x}_1) \\
&= \omega_2 \left(1 - \left(s_{K,i} + s_{L,i}\right)/\left(s_K + s_L\right)\right)(\hat{x}_2 - \hat{x}_1) \\
&= \omega_2 \left(1 - \left(1 - s_{\Pi,2}\right)/\left(1 - s_{\Pi}\right)\right)(\hat{x}_2 - \hat{x}_1) \\
&= \left(\frac{\omega_2}{\left(1 - s_{\Pi}\right)}\right)\left(s_{\Pi,2} - s_{\Pi}\right)(\hat{x}_2 - \hat{x}_1)
\end{aligned}
$$

Since $s_{\Pi} = \left(\Pi_1 + \Pi_2\right)/PY = \omega_1 s_{\Pi,1} + \omega_2 s_{\Pi,2}$, we can write this expression as:

$$(\omega_2 - \omega_2^{cost})(\hat{x}_2 - \hat{x}_1) = \left(\frac{\omega_1 \omega_2}{\left(1 - s_{\Pi}\right)}\right)\left(s_{\Pi,2} - s_{\Pi,1}\right)(\hat{x}_2 - \hat{x}_1) \tag{A.5}$$

Second, we can write the next-to-last expressions in equation (A.4) in terms of aggregate capital growth, plus reallocation effects.

$$
\begin{aligned}
&\left[\omega_1^{cost} s_{K,1}^{Cost} \hat{k}_1 + \omega_2^{cost} s_{K,2}^{Cost} \hat{k}_2 \right] \\
&= \frac{C_1 K_1 + WL_1}{CK + WL} \frac{C_1 K_1}{C_1 K_1 + WL_1} \hat{k}_1 + \frac{C_2 K_2 + WL_2}{CK + WL} \frac{C_2 K_2}{C_2 K_2 + WL_2} \hat{k}_2 \\
&= \frac{C(K_1 + K_2)}{CK + WL} \frac{C_1 K_1}{C(K_1 + K_2)} \hat{k}_1 + \frac{C(K_1 + K_2)}{CK + WL} \frac{C_2 K_2}{C(K_1 + K_2)} \hat{k}_2 \qquad (A.6) \\
&= \frac{C(K_1 + K_2)}{CK + WL} \frac{K_1}{(K_1 + K_2)} \hat{k}_1 + \frac{C(K_1 + K_2)}{CK + WL} \frac{K_2}{(K_1 + K_2)} \hat{k}_2 + \frac{(C_1 - C)K_1}{CK + WL} \hat{k}_1 + \frac{(C_2 - C)K_2}{CK + WL} \hat{k}_2 \\
&= s_K^{Cost} \hat{k} + \frac{(C_1 - C)K_1}{CK + WL} \hat{k}_1 + \frac{(C_2 - C)K_2}{CK + WL} \hat{k}_2
\end{aligned}
$$

Note that $C \equiv C_1 \left(K_1 / (K_1 + K_2) \right) + C_2 \left(K_2 / (K_1 + K_2) \right)$. Hence,

$$
\begin{aligned}
(C_1 - C) &= C_1 - C_1(K_1 / (K_1 + K_2)) + C_2(K_2 / (K_1 + K_2)) \\
&= (C_1 - C_2)(K_2 / (K_1 + K_2))
\end{aligned}
$$

Substituting this expression into (A.6), we find:

$$
\left[w_1^{cost} s_{K,1}^{Cost} \hat{k}_1 + w_2^{cost} s_{K,2}^{Cost} \hat{k}_2 \right] = s_K^{Cost} \hat{k} + \left(\frac{K_1 K_2}{(CK + WL)(K_1 + K_2)} \right)(C_1 - C_2)(\hat{k}_1 - \hat{k}_2) \qquad (A.7)
$$

Since we have assumed that labor is paid the same wage in both sectors, the corresponding expression for labor is even simpler:

$$
\left[w_1^{cost} s_{L,1}^{Cost} \hat{l}_1 + w_2^{cost} s_{L,2}^{Cost} \hat{l}_2 \right] = s_L^{Cost} \hat{l} \qquad (A.8)
$$

We inserting (A.7) and (A.8) into (A.4) and rearrange. The aggregate cost-based residual equals:

$$
\hat{y} - \left[s_L^{Cost} \hat{l} + s_K^{Cost} \hat{k} \right] = \hat{t} + \Sigma_\Pi + \Sigma_K \qquad (A.9)
$$

where Σ_Π and Σ_K reflect reallocations of inputs across uses:

$$
\begin{aligned}
\Sigma_\Pi &= \left(\frac{\omega_F \omega_U}{(1 - s_\Pi)} \right)\left(s_{\Pi,F} - s_{\Pi,U} \right)(\hat{x}_F - \hat{x}_U) \\
\Sigma_K &= \left(\frac{K_F K_U}{(CK + WL)(K_F + K_U)} \right)(C_F - C_U)(\hat{k}_F - \hat{k}_U)
\end{aligned} \qquad (A.10)
$$

Hence, after a fair amount of tedious algebra, we have derived a relatively straightforward result: the cost-based residual equals technology growth plus two reallocation terms. 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 the fact 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.

Note that we can rewrite this term in a way that is easier to calibrate:

$$
\begin{aligned}
\Sigma_K &= \left(\frac{K_F K_U}{(CK + WL)(K_F + K_U)} \right)(C_F - C_U)(\hat{k}_F - \hat{k}_U) \\
&= \left(\frac{K_U}{K_F + K_U} \right)\left(\frac{Y}{CK + WL} \right)\left(\frac{P_i Y_i}{Y} \right)\left(\frac{C_F K_F}{P_i Y_i} \right)\left(1 - \frac{C_U}{C_F} \right)(\hat{k}_F - \hat{k}_U) \\
&= \left(\frac{K_U}{K} \right)\left(\frac{\omega_F s_{K,F}}{1 - s_\Pi} \right)\left(1 - \frac{C_U}{C_F} \right)(\hat{k}_F - \hat{k}_U)
\end{aligned}
$$

Appendix Table 3A
Decomposing the Sources of Difference in Primal and Dual Estimates for Taiwan
(Except where indicated, all entries are percent per year)

			Hsieh's source for calculation of real interest rate			
			Curb loan rate (1966-1990)	One-year deposit rate (1966-1990)	Secured loan rate (1966-1990)	Three-month treasury bill rate (1975-1990)
(1a)	Wage growth	Young $\hat{w}$	4.0	4.0	4.0	4.0
(1b)		Hsieh $\hat{w}_{Dual}$	5.3	5.3	5.3	5.8
(2a)	Capital payment Growth	Young $\hat{r}$	-3.7	-3.7	-3.7	-2.4
(2b)		Hsieh $\hat{c}_{Dual}$	-0.4	-0.1	-2.0	-2.1
(3)	Labor's share s_L (Sample average)		74.3	74.3	74.3	74.6
(4a)	Primal TFP growth		2.1	2.1	2.1	2.4
(4b)	Dual TFP growth		3.8	3.9	3.4	3.8
(5)	Labor contribution to difference: $s_L(\hat{w}_{Dual} - \hat{w})$		0.9	0.9	0.9	1.3
(6)	Capital contribution to difference: $s_K(\hat{c}_{Dual} - \hat{r})$		0.9	0.9	0.4	0.1
(7)	Difference (Dual-Primal)		1.8	1.8	1.3	1.4

Notes: Data exclude agriculture and include Young's adjustment of public sector output. Young's primal data is taken from updated figures in Young (1998), other data are derived from Young (1995, Tables V, VII, and IX), using: $\hat{w} = \hat{s}_L + \hat{y} - \hat{l}$ and $\hat{r} = \hat{s}_K + \hat{y} - \hat{k}$. Young's tables include data on $\hat{y}, \hat{l}$, $\hat{k}$, s_L, and s_K by subperiod. Young's numbers were adjusted (using a weighted average of growth rates over subperiods) to cover the identical time period as each of Hsieh's measures (i.e. for a measurement of the 1975 -- 1990 rate, we would take 5/15 of the 1970-1980 rate and add it to 10/15 of the 1980-1990 rate). 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). Numbers may not add up due to rounding.

Appendix Table 3B
Decomposing the Sources of Difference in Primal and Dual Estimates for Korea
(Except where indicated, all entries are percent per year)

			Hsieh's source for calculation of real interest rate		
			Curb market Loan rate (1966-1990)	Deposit rate (1966-1990)	Discount rate (1966-1990)
(1a)	Wage growth	Young $\hat{w}$	4.2	4.2	4.2
(1b)		Hsieh $\hat{w}_{Dual}$	4.4	4.4	4.4
(2a)	Capital payment Growth	Young $\hat{r}$	-4.3	-4.3	-4.3
(2b)		Hsieh $\hat{c}_{Dual}$	-4.0	-3.4	-4.9
(3)	Labor's share s_L (Sample average)		70.3	70.3	70.3
(4a)	Primal TFP growth		1.7	1.7	1.7
(4b)	Dual TFP growth		1.9	2.1	1.6
(5)	Labor contribution to difference: $s_L(\hat{w}_{Dual} - \hat{w})$		0.1	0.1	0.1
(6)	Capital contribution to difference: $s_K(\hat{c}_{Dual} - \hat{r})$		0.1	0.3	-0.2
(7)	Difference (Dual-Primal)		0.2	0.3	-0.1

Notes: Young's primal data is taken from updated figures in Young (1998), other data are derived from Young (1995, Tables V, VII, and IX), using: $\hat{w} = \hat{s}_L + \hat{y} - \hat{l}$ and $\hat{r} = \hat{s}_K + \hat{y} - \hat{k}$. Young's tables include data on $\hat{y}, \hat{l}, \hat{k}, s_L$, and s_K by subperiod. Young's numbers were adjusted (using a weighted average of growth rates over subperiods) to cover the identical time period as each of Hsieh's measures (i.e. for a measurement of the 1975 -- 1990 rate, we would take 5/15 of the 1970-1980 rate and add it to 10/15 of the 1980-1990 rate). 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). Numbers may not add up due to rounding.

Appendix Table 3C
Decomposing the Sources of Difference in Primal and Dual Estimates for Hong Kong
(Except where indicated, all entries are percent per year)

			Hsieh's source for calculation of real interest rate		
			Prime Lending Rate (1966-1991)	Call money rate (1966-1991)	E-P ratio (1973-1991)
(1a)	Wage growth	Young $\hat{w}$	3.7	3.7	3.4
(1b)		Hsieh $\hat{w}_{Dual}$	4.1	4.1	4.1
(2a)	Capital payment Growth	Young $\hat{r}$	0.0	0.0	0.3
(2b)		Hsieh $\hat{c}_{Dual}$	-1.1	-1.5	1.0
(3)	Labor's share s_L (Sample average)		62.8	62.8	61.6
(4a)	Primal TFP growth		2.3	2.3	2.2
(4b)	Dual TFP growth		2.1	2.0	2.9
(5)	Labor contribution to difference: $s_L(\hat{w}_{Dual} - \hat{w})$		0.2	0.2	0.5
(6)	Capital contribution to difference: $s_K(\hat{c}_{Dual} - \hat{r})$		-0.4	-0.6	0.2
(7)	Difference (Dual-Primal)		-0.2	-0.3	0.7

Notes: Young's primal data is taken from updated figures in Young (1998), other data are derived from Young (1995, Tables V, VII, and IX), using: $\hat{w} = \hat{s}_L + \hat{y} - \hat{l}$ and $\hat{r} = \hat{s}_K + \hat{y} - \hat{k}$. Young's tables include data on $\hat{y}, \hat{l}, \hat{k}, s_L$, and s_K by subperiod. Young's numbers were adjusted (using a weighted average of growth rates over subperiods) to cover the identical time period as each of Hsieh's measures (i.e. for a measurement of the 1975 -- 1990 rate, we would take 5/15 of the 1970-1980 rate and add it to 10/15 of the 1980-1990 rate). 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). Numbers may not add up due to rounding.

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