On the Myth and Mystery of Singapore's 'Zero TFP'*

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This paper questions recent analyses about the sources of growth and the role of technical progress in Singapore. Using econometric estimation of aggregate production functions or growth accounting, these analyses have concluded that technological progress, or total factor productivity (TFP) growth, has played no role (if not a negative one) in the growth episode of the city-state. I show that these analyses cannot establish conclusively that Singapore grew without productivity. First, the notion of aggregate production function is questioned on theoretical grounds. Second, it is shown that aggregate production functions and income accounting identity (i.e., value added equals the wage bill plus profits) are isomorphic representations to one another, and that the latter can be rewritten via an algebraic transformation as a form that looks like a production function. This isomorphism prevents the proper testing of the production function, and the unambiguous connection of TFP growth with technical progress.

I. Introduction

Since the publication of Young's (1992) comparative work on total factor productivity (TFP) growth for Singapore and Hong Kong, the debate about the sources of growth in East Asia has become an important topic for scholars of growth and development (for an overall evaluation of this literature see Felipe, 1999). Young (1992, 1995) hypothesized a translog production function with constant returns to scale to describe Singapore's technological production possibilities, and performed growth accounting (data covering from the mid 1960s to early 1990s) – thus assuming profit maximization and perfect competition, and estimated the rate of TFP growth. Young (1992) concluded that Singapore's rate

of TFP growth had been zero; but that Hong Kong's had been significant, representing around one third of overall growth. Young (1995) extended the analysis to the four Asian NIEs, and concluded that the share of TFP growth in Hong Kong, Taiwan and Korea was relatively important (though lower than in developed countries). In Singapore, however, it was again zero.

Young's initial work was followed by that of Kim and Lau (1994), who also considered the four East Asian NIEs. Kim and Lau (1994) fitted econometrically a translog production function pooling data for the G-5 countries and the four NIEs, together with the first-order condition for labour (their production function included factor-augmentation parameters). They concluded that technical progress was capital-augmenting and that disembodied technical progress was zero in all four NIEs. Likewise, Kim and Lau rejected statistically the hypotheses of linear homogeneity, profit maximization and perfect competition implicit in growth accounting exercises.

These papers seem to have provided empirical evidence that East Asia's spectacular growth during the last thirty years was due (mostly) to factor accumulation rather than to productivity gains. Krugman (1994) took these analyses to their ultimate conclusions and compared the East Asian economies growth model to that of the Soviet Union. The possibility that East Asia's growth miracle was just an episode of factor input accumulation without efficiency gains seems to be an unresolved puzzle. This is not to say that some authors have not attempted to refute the conclusions of this work. See, for example, the exchange between Pack and Page (1994a, 1994b) and (Young 1994b), and the works of Wong and Gan (1994), Rao and Lee (1995), Sarel (1995, 1996), Collins and Bosworth (1997), Hsieh (1997, 1999), or Nelson and Pack (1999). The *very low TFP growth rates* are, nevertheless, the standard view.

By far the most controversial result is the zero-TFP (or even negative) growth of Singapore. To date this remains the departing point for analyses of growth in the city-state, and the burden of proof lies with those who disagree with this result. This literature has had such an impact on the city-state, that the Government created the Singapore Productivity and Standards Board (SPSB) and set the target of achieving a TFP growth rate of 2% a year – the only country in the world with such a target. In the words of the Prime Minister: 'We have reached a stage where TFP becomes more than just a theoretical concept' (quoted from Huff 1999a, p. 238).

As indicated above, some authors have tried to reach conclusions about the sources of growth in East Asia more consistent with intuition, i.e., that technical progress was indeed an important component of the recipe. However, this has been done by performing growth accounting or estimating regressions with different data sets, or under slightly different assumptions (e.g., what if the capital share were smaller?).[1] This has been futile. Interestingly, none of these attempts

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1. Nelson and Pack (1999) provide a rationale for why the capital share could be smaller than had been thought. See Felipe and McCombie (2000a) for an empirical implementation and evaluation.

has questioned (at least seriously) the methodology(ies) used. This paper explores this possibility. The purpose of the paper is to present a theoretical argument and detailed empirical evidence to show that standard analyses about the sources of growth in Singapore are not robust. The paper does not try to disprove the standard view by providing a positive estimate of TFP. That road is subject to decreasing returns. The argument in this paper is that such a puzzling finding (i.e., zero TFP growth) opens the door to hypothesizing that something may be amiss with the methods used, and even with the notion of TFP itself (however standard it is), and that the estimates of TFP growth may be detecting not technical progress but something else. Indeed that is the case. This paper shows that the income accounting identity (according to which value added equals the wage bill plus profits) can be rewritten in a form identical to a production function. This prevents the *testing* of the production function, and the unambiguous interpretation of TFP growth as productivity.

The paper is organized as follows. Section II shows that aggregate production functions and national income accounting identity are isomorphic representations. The original proof was developed by Simon (1979) and Shaikh (1980) in the context of the Cobb-Douglas. However, since unfortunately it has been largely ignored, it is worth summarizing it. Section III works out the implications of the argument. I extend it to the translog production function. Sections IV and V reconsider the case of Singapore in detail. While standard econometric analysis leads one to conclude that Singapore's production function is a translog with non-constant returns to scale and varying elasticity of substitution, it is shown that in fact a Cobb-Douglas with constant returns to scale performs better (in the econometric sense), and encompasses the former. However, this is simply the result of the underlying accounting identity, and thus implies nothing about the contribution of technological progress to Singapore's phenomenal growth. Likewise, it is shown that the Solow residual derived from growth accounting exercises cannot be unambiguously identified with the rate of technical progress. Section VI summarizes the paper.

II. The Income Accounting Identity and the Production Function

To begin with it is important to recall that over three decades ago, Franklin Fisher proved in a series of seminal papers that the concepts of aggregate output, aggregate capital, aggregate labour and aggregate production function do not have a sound theoretical basis (Fisher's work has been brought together in Fisher, 1993). Fisher showed that such aggregates could be derived only under extremely stringent conditions which, in general, do not hold in real economies. Simply stated, there is no such thing as an aggregate production function, even as an approximation. Paraphrasing Fisher, it seems that economists continue using aggregate production functions simply because they seem to work when estimated econometrically. This is pure *instrumentalism*. Fisher then argued that the relevant question to ask is why aggregate production functions seem to work

when we know that they should not. This section provides a rationale for the puzzle.

Following Simon (1979) and Shaikh (1980), it is shown that one can rewrite the income identity that relates value-added to the wage bill plus overall profits in a form identical to a production function (a similar argument can be developed for gross output). The latter is, therefore, also an identity. The argument is introduced in terms of the Cobb-Douglas production function (later on I develop the argument for the translog). I begin by expressing the value of total output in real terms (i.e., value added deflated) at time t as:

$$Q_t = w_t L_t + r_t K_t \tag{1}$$

where Q, w, r, L and K denote real output, real wage rate, average profit rate, level of employment and stock of capital, respectively. Equation (1) is an accounting identity that holds for every period at the firm, sector and economy-wide levels, and does not need any behavioural assumption to support it (e.g., perfect competition). It simply expresses how value-added is distributed between labour and capital. The profit rate r_t is not the user cost of capital, but the ex-post (or accounting) average profit rate (i.e., the ratio of overall profits to the stock of capital). I leave aside problems regarding the meaning of the stock of capital; except to mention that it is not a physical quantity, but (constant) dollars. The same applies to Q: it is not physical output, but dollars of output. Differentiating Equation (1) with respect to time we obtain

$$q_t = \varphi_t + a_t \ell_t + (1 - a_t) k_t \tag{2}$$

where

$$\varphi_t = a_t \varphi_{wt} + (1 - a_t) \varphi_{rt} \tag{3}$$

The variables q, ℓ and k denote the growth rates of output, labour and capital, and φ_{wt} and φ_{rt} are the growth rates of the wage and profit rates, respectively. Finally, $a_t = (w_t L_t)/Q_t$ and $(1 - a_t) = (r_t K_t)/Q_t$ represent the labour and capital shares in total output.

To continue with the argument, and without loss of generality, assume that factor shares in this economy are constant, i.e., $a_t = a$ (in the next section I use a different path). Then, substituting in Equation (3) and integrating yields

$$\ln Q_t = c + a \ln w_t + (1 - a) \ln r_t + a \ln L_t + (1 - a) \ln K_t \tag{4a}$$

where c is the constant of integration; or, taking anti logarithms

$$Q_t = A_0 w_t^a r_t^{1-a} L_t^a K_t^{1-a} \tag{4b}$$

The previous two equations are (obviously) the income accounting identity under the assumption of constant shares. I also assume without loss of generality that wage and profit rates statistically follow the paths $w_t = \exp[\varphi_{1w} t + \varphi_{2w} t^2]$ and $r_t = \exp[\varphi_{1r} t + \varphi_{2r} t^2]$, where φ_{iw} and φ_{ir}, $i = 1, 2$ are constants. Plugging into Equation (4b) yields

$$Q_t = A_0 e^{\varphi_1 t + \varphi_2 t^2} L_t^a K_t^{1-a} \tag{5}$$

where $\varphi_1 = a\varphi_{1w} + (1-a)\varphi_{1r}$ and $\varphi_2 = a\varphi_{2w} + (1-a)\varphi_{2r}$. It is clear why this second assumption need not have any theoretical content, for any other trends can be obtained by varying this hypothesis. Equation (5) is, again, the income accounting identity, now rewritten under the two assumptions that factor shares are constant, and that wage and profit rates follow the above paths. If these assumptions (which are empirically testable) are correct, the (unrestricted) econometric estimation of Equation (5) will yield a perfect fit (for being an identity), coefficients equal to the factor shares and, as a consequence, constant returns to scale. This equation, however, does not have any behavioural interpretation for being an identity. The interesting point of this derivation is that Equation (5) is a form identical to the Cobb-Douglas production function with linear and quadratic trends, and constant returns to scale. The coefficient $(\varphi_1 + 2\varphi_2 t)$ could be interpreted as the growth rate of TFP. The important issue is that even in the improbable case that an aggregate production function existed, and this happened to be a Cobb-Douglas, there would be no way to know whether what one had estimated was indeed the production function or the identity.

It is important to pause at this point and analyse the above arguments. I am not merely restating that the Cobb-Douglas production function implies constant factor shares under profit maximization and competitive markets. What the derivation indicates is that in economies where factor shares are roughly constant, one cannot argue that the reason must be that the underlying technology is Cobb-Douglas. A constant mark-up on unit labour costs (Hall and Hitch, 1939), the role of trade unions, or the Kaldorian theory of distribution (Kaldor, 1956), which do not depend upon an underlying Cobb-Douglas production function, also imply constant factor shares. Furthermore, Fisher (1971a) in his seminal simulation work, generated a series of micro-economies characterized by a Cobb-Douglas. Then, he aggregated them, violating the aggregation conditions. When he estimated the aggregate form, the elasticities were close to the factor shares. He then concluded:

> the view that the constancy of labor's share is due to the presence of an aggregate Cobb-Douglas production function is mistaken. Causation runs the other way and the apparent success of this aggregate production function is due to the relative constancy of labor's share (Fisher, 1971a, p. 306).

III. Implications for Empirical Analysis

In this section I elaborate on the implications of the above analysis and extend it to the case of the translog, for this is the form Kim and Lau (1994) used in their analysis of the sources of growth in East Asia (the analysis can be equally extended to any other functional form. See Felipe and McCombie (2000b) for the CES). To stress the arguments in Section II: if there is no such thing as an

aggregate production function, how should we interpret the results of econometric estimation of aggregate production functions and growth accounting exercises for Singapore? The previous section has shown that it is possible to rewrite the income accounting identity as a functional form that looks like a production function. Thus, provided the assumptions about the paths of the wage and profit rates and of the factor shares are correct, Equation (5) is the accounting identity (rewritten), and its econometric estimation has no *behavioural* content. Therefore, fitting Equation (5) can be interpreted unambiguously only as a test for the empirical validity of those paths (hypotheses). If the fit is good, the most one will be able to conclude (unambiguously) is that the said paths describe adequately the data. This is independent of whether the aggregate production function describing the aggregate technology exists or not. If it does, and it happens to be a Cobb-Douglas, we will nevertheless be able to transform the identity into a form like Equation (5) and fit it (but which one of the two was estimated?); and if the aggregate production function does not exist, one can always fit Equation (5) and (falsely) think that it is a production function. There is a series of further implications:

III.1 Constant Returns to Scale

An important aspect of the derivation above is that constant returns to scale emerge naturally. For a data set that follows the above paths, fitting Equation (5) (unrestricted) can lead only to the conclusion that the 'production function' exhibits constant returns to scale. Elasticities must add up to one, and must coincide with the factor shares. If the data do not follow those paths but one nevertheless fits Equation (5), it is likely that the estimated elasticities will differ from the factor shares, and one may conclude that there are other than constant returns to scale; but this will indicate only that the functional form chosen for the data at hand is wrong. I show below how the translog production function arises when the data follow other paths. Its estimation must also indicate constant returns to scale.

III.2 Profit Maximization and Competitive Markets

One further consideration is that economists usually test the assumptions of profit maximization and perfect competition using the first-order conditions (Chen, 1991; Kim and Lau, 1994). These conditions state that wage and profit rates are equal to the marginal productivities of labour and capital, respectively; or, alternatively, that the elasticities of output with respect to labour and capital are equal to the factor shares. Recently, however, discussing the studies about the sources of growth in East Asia, Stiglitz (1997, p. 16) asked: 'Does anyone who has studied wage setting in Singapore, for example, really believe that wages are set in a competitive process, so that the real wage equals the marginal product of labour, as most of the studies assume?'

In the light of the previous arguments, the marginal productivity conditions are not testable for they cannot be refuted statistically. Suppose the correct form, given the paths of the factor shares and of the wage and profit rates, is a Cobb-Douglas, and that one correctly estimates Equation (5). Denote the labour and capital elasticities α and β, respectively. The marginal productivity condition for labour derived from the Cobb-Douglas is $w_t = \alpha(Q_t/L_t)$. To test the marginal theory of factor pricing, one would fit the previous equation to data on the wage rate and labour productivity, estimate the coefficient α, and test whether it is significantly different from the elasticity of labour estimated in the production function (this is Kim and Lau's 1994 test). However, by virtue of the definition of the labour share we can write $w_t = a_t(Q_t/L_t)$. But if the labour share is (sufficiently) constant, i.e., $a_t = a$, then the econometric estimation of this labour share equation, i.e., $w_t = a(Q_t/L_t)$ (where the parameter to estimate is a) will be equivalent to estimating the first-order condition above, and one will conclude that $a = \alpha$. This regression is simply a 'test' for the constancy of the labour share. That is, profit maximization and competitive markets cannot be rejected. This exercise is not a test since the proposition tested cannot be refuted (we know that in empirical work they often are rejected. We will see how this happens).

What if in practice there is imperfect competition? We have just seen that a correct test within this framework must always indicate that markets behave competitively. Only if the test is performed on the wrong functional form can one reject perfect competition.[2]

III.3 The Solow Residual and Technical Progress

If there is no aggregate production function, and all we are estimating is an accounting identity, why is the Solow residual a measure of Singapore's technical progress? In the standard analysis, the coefficients of the time trends in the production function proxy the rate of technical progress. However, from Equation (3) in the accounting identity we know that what the trends do is to proxy the motion of the weighted average of the growth rates of the wage and profit rates. Note that Equation (3) will be zero if $\varphi_{wt} = \varphi_{rt} = 0$, which implies constant wage and profit rates; or if $a_t\varphi_{wt} = -(1 - a_t)\varphi_{rt}$. We will see in section V that this second case is what happened in Singapore. This need not be interpreted as a lack of technical progress.

From a methodological point of view, it is important to understand that the fact that the income identity leads to Equations (2)–(3) *does not* imply that these equations are the primal (i.e., $q_t - a_t\ell_t - (1 - a_t)k_t$) and dual (i.e., $a_t\varphi_{wt} + (1 - a_t)\varphi_{rt}$) measures of TFP growth that can be derived from the

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2. Hall (1988, 1990) has tried to test the hypothesis of competitive markets. See Felipe and McCombie (2000c) on the problems of such test.

neoclassical production and cost functions, respectively.[3] How does one derive implications from an accounting identity?[4]

When one derives the Solow residual from the production function, one must assume the existence of such entity (which Fisher proved cannot be done), constant returns to scale and the conditions for producer equilibrium (i.e., the first order conditions so that the factor elasticities can be equated to the factor shares). Nothing is assumed in the identity. But even having religious faith in the existence of an aggregate production function, and arguing that the identity is 'consistent' with a production function with constant returns and competitive markets (as Jorgenson and Griliches 1967 did), what the identity indicates is that constant returns and competitive markets will be irrefutable propositions, for Equations (2)–(3) hold for every single economy, whether the production function exists or not; with or without constant returns to scale; and with or without profit maximization and perfect competition. Summing up: the production function cannot be tested.

Therefore, there is no unambiguous reason why one should interpret the expressions $\varphi_t = q_t - a_t \ell_t - (1 - a_t)k_t$ and $\varphi_t = a_t\varphi_{wt} + (1 - a_t)\varphi_{rt}$ as measures of the rate of technical progress as long as one cannot test (i.e., empirically reject) the production function. Moreover, if they simply reflect the income identity, there is no logical reason why the products $(a_t \ell_t)$ and $[(1 - a_t)k_t]$ should be interpreted as the contribution of factor input growth to overall output growth *in a causal sense*. Viewed this way, TFP is just a combination of the wage and profit rates where the weights are simply the result of the identity. And the putative dual $\varphi_t = a_t\varphi_{wt} + (1 - a_t)\varphi_{rt}$ should be interpreted simply as a measure of distributional changes (not in a zero-sum sense).

III.4 The Translog Production Function

In this subsection I discuss how the translog production function is related to the income identity. As above, we continue to assume the probability that an aggregate production function does not exist, and yet we fit it and it appears to work. Suppose now that factor shares in the economy under consideration show some trend, so that the assumption that they are constant, i.e., $a_t = a$, is incorrect. Suppose they can be modelled as

$$a_t = \alpha_L + B_{KL} \ln K_t + B_{LL} \ln L_t \tag{6a}$$

$$1 - a_t = \alpha_K + B_{KL} \ln L_t + B_{KK} \ln K_t \tag{6b}$$

3. It is indeed a mistake to interpret this as implying that the accounting identity yields the Solow residual without any assumption about the underlying technology, and with the only 'condition' that output equals factor incomes. See Hsieh (1999) for such interpretation.

4. Perhaps the easiest way to understand the problem at hand is by asking what would happen if one ran a regression of Equation (2) in the form $q_t = \gamma_1 (\varphi_t) + \gamma_2 (a_t l_t) + \gamma_3 [(1 - a_t)k_t]$ where γ_i are the coefficients to estimate (elasticities of the growth of factor contribution to output growth). We know that the three parameters γ_i will be unity for being an identity (and the fit will be perfect). This regression says nothing.

where α_s and β_s are some parameters. There can be many reasons why factor shares might follow the paths (6a) and (6b). If factor shares vary enough, the factor shares paths $a_t = f(\ln L_t, \ln K_t)$, where $\ln L_t$ and $\ln K_t$ (denote the logarithms of labour and capital) are likely to be trended, should, theoretically, provide a better approximation than if we assumed them constant as in the Cobb-Douglas, i.e., $a_t = a$. Thus, even if there is no technological relationship between the share and the logarithms of labour and capital, the above forms may capture the path of the factor shares well.

Let us also assume that the weighted average of the growth rates of the wage and profit rates follows the path

$$\varphi_t = a_t\,\varphi_{wt} + (1 - a_t)\varphi_{rt} = \delta_1 + \delta_2 t \tag{6c}$$

If we now substitute Equations (6a)–(6b)–(6c) into Equation (2) (the identity) we obtain:[5]

$$q_t = \delta_1 + \delta_2 t + (\alpha_L + B_{KL} \ln K_t + B_{LL} \ln L_t)\ell_t + (\alpha_K + B_{KL} \ln L_t + B_{KK} \ln K_t)k_t \tag{7}$$

Integrating Equatioin (7) yields

$$\ln Q_t = \alpha_0 + \alpha_K \ln K_t + \alpha_L \ln L_t + \delta_1 t + \frac{B_{KK}}{2}(\ln K_t)^2$$

$$+ B_{KL}(\ln K_t)(\ln L_t) + \frac{B_{LL}}{2}(\ln L_t)^2 + \frac{\delta_2}{2}t^2 \tag{8}$$

Equation (8) *looks like* the translog production function. If an aggregate translog production function *did not* exist, but (6a)–(6b)–(6c) happened to track well the trending shares, and wage and profit rates, Equation (8) would fit perfectly well.[6]

As we saw in the case of the Cobb-Douglas, constant returns to scale are embedded in the analysis. To see this, note that adding up Equations (6a) and (6b) for a_t and $(1 - a_t)$ above yields

$$1 = \alpha_L + \alpha_K + (B_{KK} + B_{KL}) \ln K_t + (B_{LL} + B_{KL}) \ln L_t \tag{9}$$

This implies that the parameters will satisfy

$$\alpha_L + \alpha_K = 1 \tag{10a}$$

$$B_{KK} + B_{KL} = B_{LL} + B_{KL} = 0 \tag{10b}$$

Notice that these are the restrictions that the parameters of the translog production function must satisfy for constant returns to scale. But given the

5. Path (6c) follows if wage and profit rates follow the identical path $w_t = r_t = \exp\left[\delta_1 t + \frac{\delta_2}{2}t^2\right]$. This implies that the growth rates of the wage and profit rates equal $\varphi_{wt} = \varphi_{rt} = \delta_1 + \delta_2 t$. Substituting into Equation (3) yields Equation (6c).

6. It is true that the factor shares' paths (6a) and (6b) look like the first-order conditions (in the Cobb-Douglas we had constant factor shares). It must be stressed, however, that empirically they could fit the data well for any reason other than profit maximization and competitive markets.

relationships for a_t and $(1 - a_t)$ above, Equations (10a) and (10b) will always be satisfied. Thus, they are not a restriction to be tested since they cannot be rejected. This result does not mean that there are not increasing (or decreasing) returns in the economy; rather, it implies that the production function representation of the data (i.e., the accounting identity) cannot be used to estimate and test the degree of returns to scale. If the 'correct' functional form of the production function is fitted, the only possible result is constant returns to scale.

Regarding profit maximization and competitive markets, it also follows from Equations (6a) and (6b) that

$$a_t = \frac{w_t L_t}{Q_t} = \alpha_L + B_{KL} \ln K_t + B_{LL} \ln L_t \tag{11a}$$

$$1 - a_t = \frac{r_t K_t}{Q_t} = \alpha_K + B_{KL} \ln L_t + B_{KK} \ln K_t \tag{11b}$$

The right-hand sides of Equations (11a) and (11b) are the factor elasticities. Once again, they must equal the factor shares. Profit maximization and perfect competition cannot be refuted statistically.

This analysis leads us to conclude that fitting production functions can be simply regarded as a search for the best approximation to the accounting identity Equation (1). The best approximation will depend on the path followed by the factor shares and φ_t (weighted average of the growth rates of the wage and profit rates).

IV. Singapore's Rate of Technological Progress: A Reassessment

As noted in Section I, Young (1992, 1995) and Kim and Lau (1994) concluded that the role of disembodied technical progress in the development process of Singapore was virtually zero. In this section we use a data set for the city-state that covers the period 1970–90 (annual data), and show how the exercise of fitting aggregate production functions is a search for the best approximation to the value added accounting identity, and that it has no implications whatsoever for the discussion of Singapore's aggregate technology, should it exist. Such search must yield a production function with constant returns to scale, and an extremely high R^2, theoretically 1. This, however, does not constitute independent evidence that there are constant returns to scale in the economy under consideration. It simply follows from the fact that the value-added accounting identity is linearly homogeneous, and thus a parameterization must also be linearly homogeneous.

I proceed in four steps. I begin with the standard analysis and fit a sufficiently general form, a translog production function like Equation (8). The linear and quadratic trends capture the effect of Hicks-neutral technical progress. I then test the Cobb-Douglas restrictions, as well as for constant returns to scale. Second, I show that the same exercise can be done from the point of view of the accounting identity. We will see, however, that a Cobb-Douglas form provides a better representation of the data than the translog. Third, I discuss the importance of

the time trends in approximating the weighted average of the growth rates of the wage and profit rates. Finally, I discuss the test for profit maximization and competitive markets. It is shown that the first-order conditions associated with the Cobb-Douglas cannot be refuted. One must always conclude that profit maximization and perfect competition prevail.

IV.1   Standard Econometric Analysis

Table 1 shows the estimates of the translog and Cobb-Douglas production functions, as well as the diagnostic tests on the error term. Both regressions appear to be correct from the point of view of these tests. Output labour and capital were tested for the presence of unit roots. In the cases of output and employment, the null hypothesis of one unit root could not be rejected, while the capital stock seems to be integrated of order 2. Nevertheless, given the arguments in the previous sections, I disregard these issues as irrelevant (I will return to this question below).[7] And for the same reason, problems of exogeneity and simultaneous equation bias do not exist in the context of an identity, and thus the estimation

Table 1   OLS Estimates of Translog and Cobb-Douglas Production Functions for Singapore. 1970–90

			TRANSLOG				
Constant	t	t^2	$\ln L_t$	$\ln K_t$	$(\ln K_t)^2$	$(\ln L_t)^2$	$(\ln K_t)(\ln L_t)$
0.04	−0.02	0.0011	1.257	0.216	−0.56	−5.31	3.45
(0.31)	(−1.38)	(3.33)	(9.00)	(2.61)	(−3.76)	(−3.53)	(3.71)

$R^2 = 0.9997$; DW = 2.34; A: $\chi_1^2 = 0.81$; B: $\chi_1^2 = 0.12$; C: $\chi_2^2 = 0.51$; D: $\chi_1^2 = 1.68$
Cobb-Douglas restrictions: F(3, 13) = 4.71 (p-value = 0.019);
Constant Returns: $\chi_3^2 = 21.95$ (p-value = 0)

		COBB-DOUGLAS		
Constant	t	t^2	$\ln L_t$	$\ln K_t$
0.188	−0.037	0.0014	0.86	0.43
(1.60)	(−2.91)	(6.20)	(10.87)	(6.99)

$R^2 = 0.99938$; DW = 1.92; A: $\chi_1^2 = 0.21$; B: $\chi_1^2 = 0.079$; C: $\chi_2^2 = 0.46$; D: $\chi_1^2 = 1.66$
Constant returns: $\chi_1^2 = 7.24$ (p-value = 0.007)

Notes: t-statistics in parenthesis. A: Lagrange Multiplier test for residual serial correlation; B: Ramsey's RESET test for functional form; C: Normality test; D: Heteroscedasticity test.
Source: see MICROFIT 3.2 (1991) for details.

7. Of course this is not to say that if the equation fitted is not the correct approximation to the identity (e.g., one estimated a Cobb-Douglas when the correct form is a translog), and the regression is spurious, it will induce a higher R^2. This issue is studied by Felipe and Holz (2000) using Monte Carlo simulation. The conclusion is that what drives the high R^2 in a production function is the identity, with a relatively small contribution from spuriousness. Likewise, the variables may appear to be cointegrated. This is inconsequential in the context of an identity.

procedure (OLS, IV) is not an issue. All regressions in the paper are OLS. The only problem these regressions have is of *misspecification of the identity*, as will be shown below.

The table also shows the test for constant returns to scale (Wald tests) for both functional forms, and the test for the Cobb-Douglas restrictions (*F*-test) in the translog. All three are rejected. The regression results also indicate that Singapore's TFP rate was negative until the early 1980s. Overall, these results are consistent with Kim and Lau's (1994) analysis, and lead one to conclude that Singapore's production function is a translog with varying returns to scale and varying elasticity of substitution.

IV.2   The Accounting Identity

The next step in the discussion is to show that an analysis following the arguments in Sections II and III leads to different conclusions from those above. We know by now that all we have done is to search for the best approximation to the income accounting identity. The results so far seem to indicate that such approximation is provided by the translog form. In this subsection I show that a Cobb-Douglas (different from the one in Table 1) provides a better fit to the data set at hand (and in fact it encompasses the translog. This will be shown later on).

Let's begin by returning to the Cobb-Douglas. We saw that in order to derive it as a transformation from the identity we needed two assumptions about the data. The first is the constancy of the factor shares, and the second is about the path of φ_t (where $w_t = \exp[\varphi_{1w}t + \varphi_{2w}t^2]$ and $r_t = \exp[\varphi_{1r}t + \varphi_{2r}t^2]$). I test the appropriateness of those two paths sequentially. Is there any way to test whether factor shares are sufficiently constant? Figure 1 plots Singapore's labour share. The series has a mean ($\bar{a}$) of 0.39 with maximum and minimum values of 0.48 and 0.32, respectively, and a standard deviation of 0.0397. To test this hypothesis one has to go back to the identity in growth rates, Equations (2) and (3), assume *only* $a_t = a$, and integrate. This is Equation (4a).

If factor shares are constant enough, Equation (4a) should provide a very good approximation to the identity, with a very high fit, and parameters equal to the factor shares. Results of the (unrestricted) estimation are shown in Table 2. Regressions are in levels and in growth rates (the constant disappears in the latter case) to stress the point that since what is being estimated is an approximation to the accounting identity, econometric problems, and in particular spuriousness (which does not seem to be the problem here), are not relevant issues. What matters is that in both cases the parameters estimated are almost identical to the average factor shares. Also note that *t*-values are very large in both regressions, much larger than those in the regressions in Table 1. All this can be explained only by the fact that what is being estimated in an identity.[8]

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8.   Even if one estimated exactly an accounting identity, the diagnostic tests could indicate the presence of autocorrelation, or other problems in the error term. For example, for the data set at hand, the estimation of the identity Equation (1) as $Q_t = \gamma_1(w_t L_t) + \gamma_2(r_t K_t)$ yields R^2 and parameters of unity, but a Durbin-Watson of 0.25, as well as functional form and heteroscedasticity problems.

Figure 1   Singapore's Labour Share and Translog Approximation
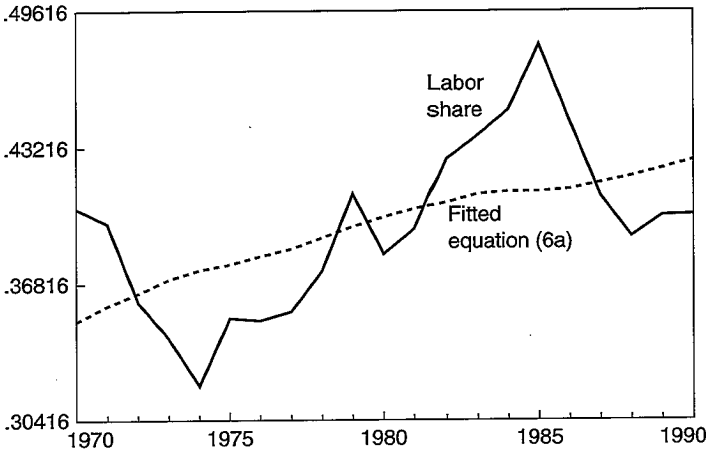
These results confirm that factor shares are sufficiently constant, and thus a Cobb-Douglas *should* be the correct production function. These estimates are very close to the factor shares, contrary to those in the lower half of Table 1 using the Cobb-Douglas with the trends. And it is worth emphasizing that the parameters of labour and capital add up to one, as the theoretical derivation indicates, although this does not necessarily imply that there are constant returns to scale.

Further corroboration can be obtained by fitting Equation (6a), the translog labour share path. If indeed Singapore's production function were the translog, Equation (6a) should correctly track the labour share. The estimation yields (see Figure 1)

$$a_t =\quad 0.39 \;+\; 0.043\ln L_t +\; 0.018\ln K_t$$
$$\quad\quad (36.63)\quad (0.23)\quad\quad\ \ (0.31)$$

with $R^2 = 0.31$, and DW $= 0.55$. The null hypothesis that the coefficients of $\ln L_t$ and $\ln K_t$ are equal to zero cannot be rejected, thus indicating that the translog labour share path does not perform better than a constant, i.e., $a_t = a$, as in the Cobb-Douglas. Incidentally, notice that the constant of the regression equals the true average labour share, $\bar{a} = 0.39$. This analysis confirms that Singapore's data set should be better described by a Cobb-Douglas production function, and not by a translog as standard analysis leads one to conclude. The question is: what Cobb-Douglas?

IV.3   The Solow Residual and Technical Progress

We should begin by asking why the Cobb-Douglas restrictions were rejected in Table 1; likewise, why did the Cobb-Douglas regression yield such different estimates of the elasticities of labour and capital from those in Table 2? To provide an answer I now discuss how good the assumption regarding the paths

Table 2   OLS Estimates of the Cobb-Douglas Expression (4a)

			LEVELS		
Constant	ln w_t	ln r_t	ln L_t	ln K_t	$\bar{a}$
−0.14	0.387	0.585	0.354	0.613	0.39
(−10.17)	(45.26)	(51.60)	(18.02)	(68.57)	

$R^2 = 0.9999$; DW = 1.56; A: $\chi_1^2 = 1.20$; B: $\chi_1^2 = 0.006$; C: $\chi_2^2 = 7.52$; D: $\chi_1^2 = 0.038$

		GROWTH RATES		
	φ_{wt}	φ_{rt}	ℓ_t	k_t
	0.384	0.584	0.370	0.610
	(17.28)	(20.78)	(8.18)	(30.02)

$R^2 = 0.985$; DW = 2.32; A: $\chi_1^2 = 0.74$; B: $\chi_1^2 = 2.30$; C: $\chi_2^2 = 11.15$; D: $\chi_1^2 = 5.72$

Notes: *t*-statistics in parenthesis. A: Lagrange Multiplier test for residual serial correlation; B: Ramsey's RESET test for functional form; C: Normality test; D: Heteroscedasticity test.
Source: see MICROFIT 3.2 (1991) for details.

of the wage and profit rates are. Are wage and profit rates correctly approximated by $w_t = \exp[\varphi_{1w}t + \varphi_{2w}t^2]$ and $r_t = \exp[\varphi_{1r}t + \varphi_{2r}t^2]$? For reference, the growth rate of the wage rate has a mean of 0.0393, a maximum value of 0.126, minimum of −0.61, and a standard deviation of 0.058. The corresponding values for the growth rate of the profit rate are −0.0378, 0.0983, −0.155, and 0.067. These values show a much larger variation than that of the factor shares. The estimation of these two paths is

$$\ln w_t = \quad 1.07 \; + \; 0.042\,t \; + \; 0.0002\,t^2 \qquad \ln r = -0.062 \; - \quad 0.095\,t \; + \; 0.002\,t^2$$
$$\quad (18.20) \quad (3.45) \quad\quad (0.40) \qquad\qquad (-1.16) \quad (-8.32) \quad\quad (4.80)$$

$$R^2 = 0.93 \quad\quad DW = 0.55 \qquad\qquad R^2 = 0.94 \quad\quad DW = 0.67$$

and in growth rates:

$$\varphi_{wt} = \; 0.032 \; + \; 0.00062\,t \qquad \varphi_{rt} = -0.10 \; + \; 0.005\,t$$
$$\quad (1.07) \quad\quad (0.27) \qquad\qquad\quad (-3.40) \quad (2.39)$$

$$R^2 = 0.004 \quad\quad DW = 1.70 \qquad R^2 = 0.24 \quad\quad DW = 1.69$$

The above results indicate that there is plenty of room for improving the approximation to the paths of the wage and profit rates (and hence of φ_t), and that this is the reason why the Cobb-Douglas with linear and quadratic trends in Table 1 is not equivalent to the identity, and leads to such different results from those in Table 2. In other words, while factor shares are sufficiently constant, and thus the Cobb-Douglas should work well, the approximation of φ_t (the weighted average of the growth rates of the wage and profit rates) with the time trends is incorrect (see Figure 2), and affects the overall results. This is simply a

Figure 2   Weighted Average of the Growth Rates of the Wage and Profit Rates
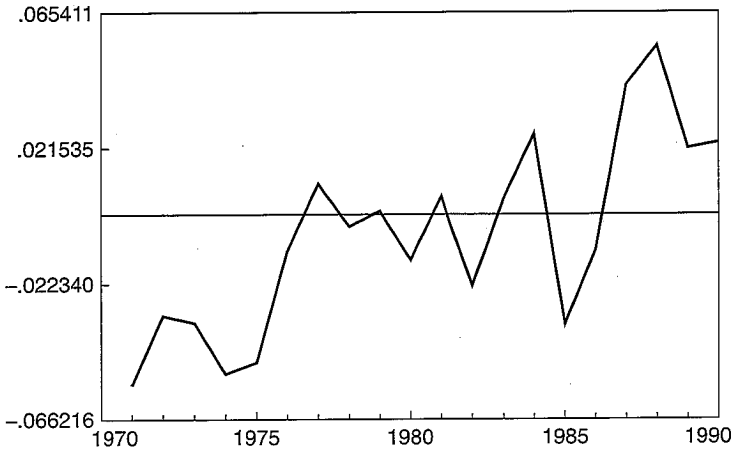
problem of misspecification of the identity when written and estimated as an aggregate production function.

Therefore, what is the exact Cobb-Douglas? In practice it would be extremely labour and computer-intensive to find it out, for we would have to identify the exact path of φ_t (which looking at Figure 2 seems to be a rather difficult task).[9] But the fact that in general we do not know it, does not mean that it does not exist, and does not undermine the arguments.

IV.4   Profit Maximization and Competitive Markets

Under the assumptions of profit maximization and competitive markets, the production function gives rise to the marginal theory of factor pricing. This analysis, which is strictly microeconomic, has been equally extended to the macro level in the form of a distribution theory. The first-order condition for labour in this model states that the wage rate equals the marginal product of labour, i.e., $w = \dfrac{\partial Q}{\partial L}$. However, if one looks at the accounting identity Equation (1), it follows that $w = \dfrac{\partial Q}{\partial L}$. How can we pose this as a testable proposition?

The arguments in Sections II and III indicate that if the translog were the best approximation to the identity, one would not be able to reject statistically the first order conditions, Equations (11a) and (11b). However, what we saw above is that in fact factor shares were (sufficiently) constant in Singapore during the period under consideration. This implies that the Cobb-Douglas first-order conditions should not be rejected, as indeed is the case. The marginal productivity

9.   See Shaikh (1980).

conditions in the case of the Cobb-Douglas production function are $w = \alpha (Q/L)$ and $r = \beta (Q/K)$ where α, β, are the estimated labour and capital elasticities (factor shares under profit maximization, the null hypothesis to test), and w, r, are the wage and profit rates, respectively. The OLS estimation of these two expressions yields $\alpha = 0.40$ (t-statistic = 48.65) for the labour first-order condition; and $\beta = 0.61$ (t-statistic = 77.38) for capital. Both elasticities are equal to the factor shares (the estimates in Table 2).

To complement the analysis we can also perform a joint test for profit maximization with respect to both labour and capital using the general Cobb-Douglas, Equation (4a). The test is carried out as follows. Following Chen (1991) we can construct the auxiliary variable Y as

$$Y = \frac{wL\ln L + rK\ln K}{Q} = \alpha \ln L + \beta \ln K \tag{12}$$

which is an identity if the two marginal productivity conditions hold. Then, we extend Equation (4a) above and we regress

$$Z = c + \gamma_1 \ln w_t + \gamma_2 \ln r_t + \gamma_3 \ln L_t + \gamma_4 \ln K_t \tag{13}$$

where $Z = \ln Q - Y$. It is clear that if the two marginal productivity conditions hold (i.e., $\alpha = a$, $\beta = 1 - a$), then $\gamma_3 = \gamma_4 = 0$, which is the null hypothesis to test in Equation (13). In this and the following test, the parameters α and β used to construct the variable Y in Equation (12) are the estimated elasticities. In this case, $\alpha = 0.354$ and $\beta = 0.613$ (levels estimates of Equation (4a). See first part of Table 2). The results are:

$$Z = \begin{matrix} -0.144 + & 0.387 \ln w_t + & 0.585 \ln r_t + & 0.0009 \ln L_t - & 0.00004 \ln K_t \\ (-10.17) & (45.26) & (51.60) & (0.05) & (-0.004) \end{matrix}$$

and the test for the null hypothesis $H_0 : \gamma_3 = \gamma_4 = 0$ takes on a value $F(2, 16) = 0.11$, indicating that it cannot be rejected, as it must be. And even if we use the Cobb-Douglas with the time trends ($\alpha = 0.86$ and $\beta = 0.43$. See Table 1):

$$Z = \begin{matrix} 0.188 - & 0.037\,t + & 0.0015\,t^2 - & 0.00021 \ln L_t + & 0.0024 \ln K_t \\ (1.60) & (-2.91) & (6.21) & (-0.002) & (0.04) \end{matrix}$$

the null hypothesis cannot be rejected either, $F(2, 16) = 0.84$. But the important point to remember is that this exercise cannot be taken to be a test for profit maximization and competitive markets. The first-order conditions are non-refutable hypotheses, given that one has identified the correct 'production function' as a transformation of the accounting identity.

If the same test is carried out using the estimated translog (Table 1), one obtains a rejection of the null hypothesis (result available upon request). This is simply because the translog is not Singapore's production function.

We are now in a position to reevaluate Kim and Lau's (1994) findings in their analysis of the role of technical progress in East Asia, and understand why they

Table 3   Tests for Non-Nested Regression Models. Translog against Cobb-Douglas Identity (4a)

	H_0 against H_1 (p-values)	H_1 against H_0 (p-values)
N-Test	0.00	0.513
NT-Test	0.00	0.501
W-Test	0.00	0.475
J-Test	0.00	0.591
JA-Test	0.00	0.524
Encompassing	0.00	0.879

Akaike's Information Criterion of H_0 versus H_1: Favours H_1
Schwarz's Bayesian Information Criterion of H_0 versus H_1: Favours H_1

Notes: H_0: Translog; H_1: General Cobb-Douglas
       N-Test: Cox; NT Test: Adjusted Cox; W-Test: Wald; J-Test: MacKinnon; JA-Test: Fisher
       and McAleer; Encompassing Test: Deaton, Dastoor.
Source: see MICROFIT 3.2 (1991) for details.

presumably rejected the hypotheses of linear homogeneity, profit maximization and perfect competition. They simply chose the *wrong* functional form. However, finding the exact approximation to the identity (as a production function) with Kim and Lau's data set, where they pooled data for nine countries, is virtually impossible. But this does not undermine the essence of the argument. I suspect that Equation (4a) will fit for the other eight countries Kim and Lau considered at least as well as for Singapore (surely factor shares are sufficiently constant). The question, once again, will be to find the adequate approximation to the weighted average of the growth rates of the wage and profit rates. Pooling data for nine countries and fitting a Cobb-Douglas like Equation (4a) might not work if factor shares, despite being approximately constant within each country, are very different across countries (suppose the average labour share for the G-5 countries is around 0.7 and for the NIEs around 0.4).

Summing up. This analysis indicates that one can always fit a 'very good' production function from the standard econometric point of view, and be able to reject the neoclassical hypotheses. This shows that there exists an inverted U-shape relationship between the statistical rejection of these hypotheses and R^2. When the latter is very low and parameters are poorly estimated (because the approximation to the identity is very bad), no hypothesis will be rejected. When R^2 improves because we begin approaching the identity, we will enter a region where rejections will increase (this is the region where Kim and Lau are). Finally, when we get sufficiently close to the identity, rejections will decrease (the hypotheses are embedded in the identity).

Lastly, I have fitted the translog and compared it to Equation (4a), the Cobb-Douglas. I have run a battery of non-nested tests of linear regression models. The p-values for the rejection of the first model (null hypothesis) are shown in Table 3 (the translog includes linear and quadratic trends). The tests clearly

favour the general Cobb-Douglas, Equation (4a). The first column tests H_0 (translog) against H_1 (Cobb-Douglas). All tests reject H_0. The second column tests H_1 against H_0. The tests indicate that H_1 cannot be rejected. Therefore, this analysis leads us to conclude that the translog is not the best approximation to Singapore's data set (i.e., the value-added identity).

V. Growth Accounting Exercises

In this section I review the results provided by growth accounting. If instead of estimating the production function one assumes perfect competition and competitive markets, as Young (1992, 1995) did, then one can derive the standard growth accounting equation by differentiating the production function $Q_t = A_t F(L_t, K_t)$ where A_t is the level of TFP. However, there is no need to do so. Recall that from Equation (2) we can obtain an expression equivalent to the Solow residual. Equation (3) indicates what the Solow residual must be, namely, the weighted average of the growth rates of the wage and profit rates.

I have calculated the residual using Equation (3). Table 4 summarizes the results. My data set, like those of Young, indicates that Singapore's total factor productivity growth is very low. The question is: what do we make out of these results for the analysis of technical progress in Singapore? Given the discussion in Section III, the answer is not much. A zero TFP implies that $a_t \varphi_{wt} + (1 - a_t)\varphi_{rt} = 0$, or $a_t \varphi_{wt} = -(1 - a_t)\varphi_{rt}$. Furthermore, suppose the labour share is around 0.5 (as in Young (1992, 1995) for Singapore). This implies $\varphi_{wt} = -\varphi_{rt}$, that is, the growth rate of the wage rate is matched by an equal decline in the growth rate of the profit rate. It would be erroneous to infer from this that there was no technical progress in the city-state during the two decades considered. The reason is, as argued above, that *if* there is no true underlying aggregate production function, and the relationship $a_t \varphi_{wt} + (1 - a_t)\varphi_{rt}$ reflects merely the accounting identity, then it can be interpreted unambiguously only as a measure of distributional changes.

Table 4 Growth Accounting. Averages for The Period

	TFP	$\bar{a}$	φ_{wt}	φ_{rt}	$a_t \varphi_{wt}$	$(1 - a_t)\varphi_{rt}$	q	ℓ	k
1970–90	−0.006	0.390	0.039	−0.038	0.016	−0.022	0.077	0.037	0.115
1970–80	−0.024	0.367	0.029	−0.055	0.011	−0.035	0.086	0.051	0.145
1981–90	0.010	0.423	0.049	−0.020	0.021	−0.010	0.068	0.023	0.085
1970–75	−0.044	0.362	0.019	−0.080	0.007	−0.050	0.090	0.044	0.188
1976–80	−0.003	0.374	0.039	−0.030	0.015	−0.018	0.081	0.058	0.102
1981–85	−0.004	0.436	0.098	−0.084	0.042	−0.047	0.060	0.008	0.109
1986–90	0.026	0.410	0.001	0.044	−0.0002	0.026	0.076	0.039	0.060

Note: The rate of profit (r_t), necessary to calculate $TFP = a_t \varphi_{wt} + (1 - a_t)\varphi_{rt}$ was inferred directly from the accounting identity Equation (1) as $r = \Pi/K$, where Π are accounting profits.

Figure 3   Growth Rates of the Wage and Profit Rates
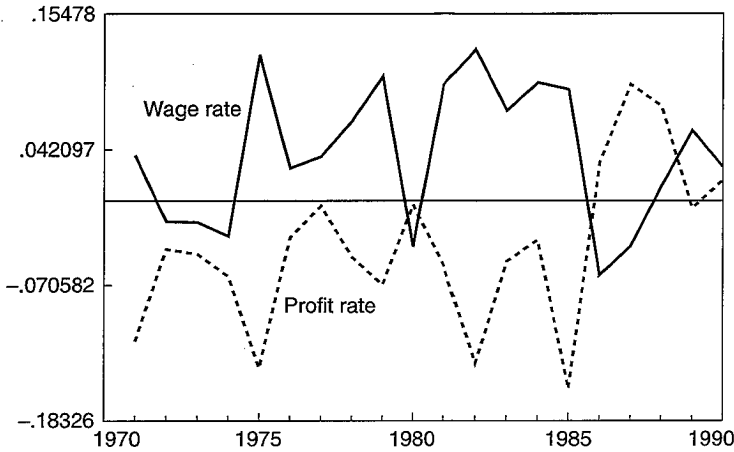
There is an additional issue. Singapore's accounting profit rate in my data set decreased at an annual rate of 4.2% (a total decrease by 50% from the beginning to the end of the period). Maybe Singapore's statistics are wrong, and likely the growth rate of output was higher, and that the growth rate of the stock of capital was lower. However, it is a fact of market economies that the average profit rate tends to display a decreasing trend (Felipe, 2000). And this is not inconsistent with observing large inflows of foreign investment, as in Singapore. Given that in general the growth rate of the wage rate is positive, a zero or negative TFP growth is the result of a negative growth rate of the profit rate. If for an economy the profit rate happens to be roughly constant (i.e., zero growth rate), the growth of TFP is approximately equal to the product of the labour share times the growth rate of the wage rate, i.e., $a_t \, \varphi_{wt}$. But this follows from the identity. The reason why Hsieh (1999) obtained a positive rate of TFP for Singapore using the 'dual' is that he estimated an approximately constant rental price of capital. Then, his estimate of TFP growth was approximately the product of the labour share times the growth rate of the wage rate $(a_t \, \varphi_{wt})$, around 1.6%, similar to the figure with my data set (Table 4). Naturally, the question here is whether his estimate of the rental price of capital is the correct one. This is relevant because Young (1992) had also calculated the rental price of capital for Singapore. Young's rental price of capital, however, displays a declining path similar to that of the average profit rate. This is just another example of what I have described elsewhere (Felipe, 1999) as a 'war of figures.'

Let us also mention that it has been claimed that Singapore's total factor productivity growth has increased recently (Collins and Bosworth, 1997). This is true, and Figure 2 corroborates it. But again, the evolution of this magnitude has no implications whatsoever for the analysis of technical progress in Singapore. As the estimates in Table 4 for different subperiods show, this is the result of the

combined variations in the growth rates of the wage and profit rates, as well as in the factor shares, all of which could be due to a multiplicity of reasons. The residual increased sharply from the first to the second decade, and particularly during the period 1986–90. Unlike in previous subperiods, wages did not grow during 1986–90 (the product $a_t \, \varphi_{wt}$ is even slightly negative), and the growth in TFP was mostly the result of an increase in the growth rate of the rate of profit (φ_{rt}) (Figure 3).

VI. Concluding Remarks

This paper has revisited the 'Singapore's zero-productivity puzzle.' The thesis put forward is that previous analyses, which concluded that productivity growth was zero, suffer from serious methodological problems and, therefore, are unconvincing. The argument has two parts. The first is the acknowledgment of Fisher's work, namely, that aggregate production functions are an invention. The second part of the argument is to show that Cobb-Douglas and translog aggregate production functions can be derived as particular parameterizations of the value added accounting identity under appropriate assumptions about the paths followed by the factor shares and the weighted average of the growth rates of the wage and the profit rates. As such, no behavioural content can be attached to them. What surfaces is a serious methodological problem since no proposition regarding the production function (e.g., the form of the production function, the degree of returns to scale, the elasticity of substitution, the interpretation of the parameters, the estimation of the first-order conditions and tests of the hypotheses of profit maximization and competitive markets and the role of technical progress) can be tested and potentially refuted. The conclusion is that the exercise of estimating a putative aggregate production function is simply a search for the best approximation to this identity. We have also shown that the Solow residual derived from a production function is equivalent to the weighted average of the growth rates of the wage and profit rate.

The paper also provides empirical evidence. I have fitted a production function for Singapore and shown that while standard analysis leads to conclude that Singapore's aggregate technology is best described by a translog with varying returns to scale, the isomorphism between the production function and the value-added accounting identity indicates that a general Cobb-Douglas with constant returns to scale performs better and encompasses the translog. All these results, however, are derived from the manipulation of the income accounting identity, and thus do not permit any inference about the alleged aggregate technology. This has allowed me to reinterpret the exercise, to deprive it of any significant meaning, and to question its policy implications.

I conclude that serious doubts arise from the standard analyses about the importance of disembodied technical change in Singapore. This is not to say that its role was more or less prominent than authors have estimated; rather, that this type of aggregative analyses cannot answer the question at hand. Or, perhaps,

that even the question itself is incorrectly posed, in so far as probably there is no such thing as the *aggregate technology* of a country as represented in the so-called aggregate production function. From here it follows that the notion of the aggregate rate of technical progress is also a concept devoid of clear empirical content. The notions of substitution, technical progress, and productivity, as well as the marginal theory of factor pricing, are microeconomic (as all neoclassical production theory is), and make sense at the firm level, but do not have an extension to the macroeconomic level (Fisher, 1971b; Robinson, 1971b).

Naturally one can disregard the arguments in this paper and simply work in the world of the hypothetical, and interpret these exercises 'as if' the production function existed, and the latter were undoubtedly what econometric estimation of production functions and growth accounting reflect, instead of the identity. But if work on the East Asian miracle is to have any policy relevance for development and growth, this methodological position cannot be accepted. And in the particular case of Singapore, this type of evidence contradicts the one found using case-studies such as the detailed, insightful, and truly microeconomic analysis of Hobday (1995).

Unfortunately, zero TFP growth in the context of Singapore has been associated with lack of 'creativity,' and scholars have implicitly established a relationship between political liberties and originality. Trivial and unfounded associations of this type can do more harm than good from a policy perspective. The real danger is that speaking about productivity in terms of the rate of TFP growth at the national level could result in the wasteful spending of Singapore's SPSB money to enhance 'a number' with unclear interpretation.

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