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INDIAN MANUFACTURING INDUSTRY: ELEPHANT OR TIGER? NEW EVIDENCE ON THE ASIAN MIRACLE

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Indian Manufacturing Industry: Elephant or Tiger? New Evidence on the Asian Miracle
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ABSTRACT

We estimate the rate of total factor productivity growth in Indian manufacturing industry for the period 1973-1992, and compare the results to those obtained by Young for the East Asian Tigers. We then interpret our results in light of Krugman's hypothesis that, because the Asian Miracle was driven by capital formation under diminishing marginal returns, it is not sustainable. We suggest a reinterpretation of the sustainability problem that recognizes the true role of TFP as a motive force in output growth. Past studies have compared the TFP residual to the growth rate of output and used this ratio as a measure of the importance of TFP as a source of growth. We argue that this is an erroneous way of assessing the role of TFP, because it ignores the additional capital formation made possible by an increase in productivity and therefore understates productivity's true importance. Our estimates suggest that the understatement may be quite large, and that one might better ask if the growth rate of TFP, rather than capital growth, is sustainable.

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I. Introduction

Young starts his 1995 paper on East Asian total factor productivity (TFP) with the statement "This is a fairly boring paper, and is intentionally so." This "boring" subject has, however, energized one long-standing debate and started another. The older debate deals with the question of whether economic reform and trade liberalization promote economic growth and increase productive efficiency. The new debate, triggered by Young (1992,1995) and Krugman (1994), concerns the sustainability of rapid economic growth, driven primarily by capital accumulation rather than TFP.

The analysis of the Asian Miracle has largely ignored India, just as the Asian Miracle itself has largely missed it. India remains a very poor country (though its prospects have improved somewhat in recent years), and the debate about Indian growth has naturally tended to emphasize policy failure rather the sustainability of success. Critics of India's less-than-miraculous growth (the disparaged "Hindu" growth rate) have attacked the country's central planning system, with its policy of import substitution and dirigisme of the economy. Bhagwati (1998) blames import substitution for India's poor performance relative to the Tigers, who followed the opposite policy of export promotion. Sen (1998) likens India's export-import polices to the practice of "shooting oneself in the foot (page 81)." The industrial licensing framework, established in 1951, has also been identified as a factor retarding productivity growth.[1]

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[1] Ahluwalia (1991) argues that the industrial licensing system was "... the principal instrument for channeling investments in the industrial sector in 'socially desired directions.' It controlled not only entry into an industry and expansion of capacity, but also

If this critique is correct, and it certainly has intellectual weight behind it, over-regulation and import-substitution must have exacted a penalty in terms of growth and productivity, one that is evident in a comparison of the industrial sectors of India and the East Asian Tigers. But how large a penalty? And, did the penalty diminish as a result of the recent movement toward reform and trade liberalization? These are the questions addressed in this paper. We start by estimating the rate of TFP growth for Indian manufacturing industry. This is an area where the tyranny of numbers has asserted itself with great force, and the literature has bogged down in a dispute over the appropriateness of various price deflation techniques. We approach the problem using new price deflators for output and intermediate input.

We then interpret our results within the hypothesis that, because the Asian Miracle was driven by capital formation, it is not sustainable because of diminishing returns to capital. We suggest a reinterpretation of the sustainability problem that recognizes the true role of TFP as a motive force in output growth. Past studies have compared the conventional Hicks-Solow TFP residual to the growth rate of output and used this ratio as a measure of the importance of TFP as a source of growth. We argue that this a fundamentally erroneous way of assessing the role of TFP, because this ratio understates the true importance of productivity by ignoring the additional capital formation

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technology, output mix, capacity location and import content (page 4)." It enforced barriers to exit and employee redundancy, favored smaller enterprises and regional dispersion. She goes on to state that licensing "had become more and more regulatory and less and less developmental, thus belying the promise of 'channelling' growth in desired directions ... (page 5)." Bhagwati (1998) calls the system "Kafkaesque."

made possible by an increase in productivity. We suggest an alternative measure of the importance of innovation based on the Harrodian conception of technical change. Our estimates suggest that the understatement of the role of innovation/assimilation may be quite large, with the implication that the playing out of assimilation possibilities may ultimately be a larger problem for successful economic development than diminishing returns to capital. In other words, convergence to the world frontier may be the real limit to rapid economic growth; one might better ask if the growth rate of TFP in the Asian Tigers is sustainable, rather than Asian capital growth.

II. Tiger or Elephant?

Cross-country comparisons of growth are always problematic. Differences in the definition of variables, sectoral coverage, and sampling procedures, can lead to a wide variation among results even for different studies pertaining to a single country (see, for example, BLS (1983) for methodological differences among studies of U.S. economic growth). These problems are generally aggravated in comparisons of different countries, which have different statistical bureaucracies, and are likely to be particularly severe for developing countries. Comparative international data must therefore be approached with caution.

This said, if the industrial performance of the Asian Tigers and the Indian "elephant" are as starkly different as conventional wisdom suggests, the difference should be apparent even through the fog of international statistics. We have therefore combined our results for Indian manufacturing with estimates drawn from the Young 1995 study. Our estimates of real value added, which are based on the Indian Annual Survey of Industries (for the "registered" segment of manufacturing firms) for various years, are shown in Table 1, along with the conventional sources-of-growth decomposition of this "output" variable into its constituent components: the growth rate of total factor productivity and the inputs of capital and labor. Details of sources and methods are given in the Technical Appendix, and more will be said about the implications of this decomposition in subsequent sections.

We have omitted country names and labelled the columns of Table 1 with letters in order to emphasize the point we wish to make. These letters correspond to our estimates for Indian manufacturing; Young's estimates for the manufacturing sectors of Singapore, South Korea, and Taiwan; and two other examples drawn from the Pacific rim. Results are displayed across columns in descending order of value-added growth. The reader is invited to pick out the elephant.

The first two columns show economies with double-digit growth in manufacturing real value added. These are indeed Tigers: South Korea and Taiwan. The last two columns are better candidates for the role of elephant, given their distinctly slower growth rates. But these columns belong to the 500 pound gorilla of the Pacific rim: the U.S. manufacturing sector from 1950 to 1973, and again from 1974 to 1994. India is in the middle of the table with Singapore. These two columns look very similar, which is the point we want the table to convey: the manufacturing sector of India, which happens to be column D, is not obviously out of place in a list of the manufacturing industries of some of the main Asian Tigers. The first line of Table 2 makes this case even more forcefully. The growth in "raw" labor productivity -- i.e., the ratio for real value added to labor inputs unadjusted for quality differences -- is stronger in India than in Singapore and equal to Taiwan.

Put provocatively, if larger-scale Indian manufacturing industry could be isolated and extracted from the Indian subcontinent and relocated to an island or peninsula of its own, it too might well be considered part of the Asian Miracle.

Real value added growth in manufacturing of 7.1 percent over twenty years may not be as impressive as Korea's 14.1 percent, or Japan's eye-popping 17.0 percent during its high growth period of 1955-71 (Nishimizu and Hulten (1978)). Still, an annual growth rate of real value added in excess of seven percent compounded over twenty years can hardly be called a failure.

By comparison, the rest of the Indian economy grew at roughly half the rate of the manufacturing sector (which only accounted for roughly one-sixth of Indian GDP over the sample period, and a smaller share of employment). According to recent World Bank estimates, Indian income per capita was still only $370 in 1997 ($1,599 when corrected for purchasing power parity), compared with $10,550 in South Korea (PPP $13,430) and $32,810 Singapore (PPP $29,230). The Indian economy as a whole is decidedly not part of the Asian Miracle, despite a relatively successful performance by the manufacturing sector (note, however, the relatively untigerish growth in employment in Indian manufacturing). Sen (1998) remarks that the industrial and trade policy reform may have been necessary, but it was not sufficient.[2] Indian manufacturing industry is not on an isolated island or peninsula of its own.

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[2] "...Jean Drèze and I have argued, in our joint book (Drèze and Sen (1995)), that the success of liberalization and closer integration with the world economy may be severely impaired by India's backwardness in basic education, elementary health care, gender inequality and limitations of land reform. While [the reforms] did initiate the correction of governmental over-activity in some fields, the need to correct under-activity in other areas has not really been addressed (Sen, page 82)."

III. Perspiration versus Inspiration

Table 1 carries another message about the Asian miracle and the role of government intervention. Young's research focused attention on the relative contributions of capital formation and total factor productivity in explaining the high rate of Asian economic growth, and found that the success of the Asian Tigers was due largely to the accumulation of capital with only a minority contribution from TFP growth. Kim and Lau (1994) arrived at much the same conclusion, as do Nadiri and Kim (1996), Nadiri and Son (1998), and Collins and Bosworth (1996) for a collection of other countries. While there is room for debate (see, Hsieh (1999) about the case of Singapore and also the discussions in Collins and Bosworth (1996), Chen (1997), and Rodrik (1998)), we conclude that conventional growth accounting procedures imply, in Krugman's (1994) colorful terminology, that it was "perspiration" and not "inspiration" that powered the Asian Miracle.

This result has important implications for the maintenance of the East Asian miracle, because growth driven by "perspiration" is not sustainable if capital is subject to diminishing marginal returns, whereas costless gains in productivity may continue as long as inspiration (or imitation) permits. The distinction between "perspiration" and "inspiration" is also important because it is, in a different form, a central point of contention in the development/growth literature. Nelson and Pack (1998) describe two competing paradigms of the development process: the "accumulationist" view, which places primary emphasis on capital formation (human and knowledge, as well as physical) as the driving force behind successful development; and, the "assimilationist" view, which sees institutional barriers to adopting and operating advanced technology and management practices as the essential barrier. In the assimilationist paradigm, developing economies tend to start off below the best-practice frontier of world technology, and thus have the possibility of appropriating the technology developed elsewhere at prices below the cost of production. Once an economy begins to innovate, the process of assimilation should lead to a surge in TFP growth followed by convergence to the best-practice rate of growth.

The minority role of TFP found in much of the empirical growth literature, and apparent in Tables 1 and 2, does not offer much encouragement to the assimilationist/inspirationist point of view. Rather, it appears that accumulation is indeed the driving force of Asian growth, with only some help from TFP. Krugman drives home this point with the provocative analogy between the early success of Soviet economic planning and the more recent success of Singapore. Both are portrayed as situations in which dirigiste governments boosted output growth by increasing the rate of investment but not TFP. By implication, the Asian Miracle may go the way of the Soviet Miracle of the 1950s.

Krugman's equation of Soviet-style planning with the Asian Miracle makes no mention of India. However, some observers have suggested that India's early economic policy had a distinctly Soviet personality.[3] Thus, from an

[3] Desai (1998, page 45), in discussing the "Bombay" alternative to the Mahalanobis model that informed the Indian planning system, states "The mid-1950s were heady days when Nehru persuaded the Congress Party to accept the "Socialist Pattern of Society" as its aim. There was also a growing friendship with the Soviet Union. Things Soviet were in fashion. In any battle between a machine goods oriented Feldman-Stalin Plan [Mahalanobis] against a consumer goods oriented Bukharin Plan [Bombay], victory was guaranteed for the former. Bombay lost." Also, Bhagwati (1998, page 34): "We had clearly reproduced beautifully the disadvantages of communism, without any of its benefits!"

analytical perspective, India's growth experience offers a natural experiment for the Krugman's hypothesis.

A glance at Table 1 reveals a pattern for Indian manufacturing that is similar to the Asian Tigers. Total factor productivity growth accounted for 31 percent of RVA growth in India and slightly less in South Korea and Taiwan. Singapore exhibits negative TFP growth in the sector.[4] Krugman's objection about the sustainability of investment-driven growth thus applies to India. Indian manufacturing growth relied heavily on perspiration (the growth of capital per worker, shown on line 2 of Table 2), though not so heavily as the Tigers. If diminishing returns to scale is operative, India can expect a slowdown in manufacturing output growth, all else equal. In other words, the good news is that Indian manufacturing is like a tiger, not an elephant. The bad news is that tigers do not live as long as elephants.

IV. An Assimilationist Reinterpretation

The preceding analysis is based on the TFP model developed by Solow (1957), Jorgenson and Griliches (1967), and others (for a brief history, see Hulten (1998)). Conventional TFP measures the shift in the implied production function and is accurate under the assumptions of the TFP model. There are many potential problems with the maintained hypotheses of the TFP model, but

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[4] However, it must be noted that Young warns about the quality of Singapore's manufacturing data. Moreover, Young makes an adjustment for the quality (composition) of the factor input, whereas our estimate for India is based on raw employment growth. In order to make the comparison of TFP more meaningful, line 3 of Table 2 restates the TFP residuals so that they exclude the various quality adjustments. Again, the Indian "elephant" is by no means out of place among the Tigers in this table. Hsieh (1999) raises questions about the aggregate result for Singapore, as well.

this is generally true of the maintained hypotheses of all empirical growth models.[5] One can find trouble everywhere, but if one is looking for trouble in conventional TFP analysis, the model's assumptions are not the first place to look. A much bigger problem lies in the interpretation of the results.

A key problem arises when using the TFP residual to assess the causes of output growth: the residual is derived from a production function that is but one equation in a larger system determining the growth rate of output. Once the problem is formulated within a more complete model, it is clear that capital is an endogenous variable. In the neoclassical class of growth models, capital per worker depends on the rate of growth of labor, the rate of innovation, and either the rate of saving or the rate of time preference (all assumed to be exogenous to the growth process). An increase in the rate of innovation will thus have the effect of increasing the quantity of capital, and the additional output made possible by a shift in the production function leads to more saving and investment.

This endogenous response in capital, termed "induced accumulation" in Hulten (1975), has an important consequence for the analysis of the preceding sections.[6] A conventional sources-of-growth accounting exercise like Table 1 will register significant amounts of capital accumulation that are, in fact, driven by the shift in the production function. When combined with autonomous changes in the rate of investment, capital formation may erroneously appear to

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[5] For a discussion of these assumptions, and a description of the potential pitfalls in the TFP model, see Hulten (1998) and the brief remarks in the Technical Appendix of this paper. The questions raises by Rodrik (1998) are, in part, due to path dependence rather than overt bias, and in part to the induced-accumulation problem discussed below.

[6] The Technical Appendix provides a more detailed treatment of the induced-accumulation effect, as well as the difference between the conventional TFP approach and the approach advocated in the section.

be the dominant cause of growth and TFP the minority cause, as per Young and others. However this pattern gives false encouragement to the accumulationist view of growth. A correct accounting for the causes of growth should reassign the induced-accumulation effect to the assimilationist side of the growth ledger.

In other words, inspiration gives rise to more perspiration, and conventional estimates of TFP miss this fact. Estimates in Hulten (1975) suggest that the miss may be quite large. Where the conventional TFP residual accounted for 34 percent of U.S. output growth over the period 1948 to 1966 (annual output growth was 4.15 percent and the residual was 1.42 percent), innovation was actually responsible for 64 percent of the growth in output when the induced-capital accumulation effect was taken into account. Hulten and Nishimizu (1980) deploy a variant of the Harrodian framework from Hulten (1978), and found a similar pattern in their study of nine industrialized countries for the period 1960-73.[7] Conventional TFP accounted for an average of 45 percent of output growth in the nine countries, while the accumulation-adjusted measure of innovation was found to be responsible for 84 of growth in output. For Japan, the adjustment for induced accumulation boosted the relative importance of innovation from 41 to 77 percent of growth, and from 41 to 58 percent for South Korea.

A closely related alternative can be used to obtain an accumulation-adjusted measure of TFP for the Asian macro economies studied by Young. This alternative to based on the Harrod-Rymes variant of the TFP residual instead of the conventional Hicksian TFP of Tables 1 and 2 (see Rymes (1971) and

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[7] The countries studied include Canada, France, West Germany, Italy, Japan, South Korea, the Netherlands, the United Kingdom, and the United States.

Hulten (1975)). The Harrodian concept of TFP measures the shift in the production function along a constant capital-output ratio, instead of the constant capital-labor ratio of the conventional Hicks-Solow measure (A_t) of the preceding sections. Since the capital-output ratio is held constant when costless innovation occurs, the Harrodian measure assigns part of the observed growth rate of capital to the shift in the production function.

The Harrodian TFP residual can be calculated from the conventional Hicks-Solow residual by dividing the latter by labor's share of income. Dividing the Harrodian residual by the growth rate of output then gives an approximate indicator of TFP's true importance, even though the costless technical change may not be Harrod neutral. The impact of this computation on Young's 1995 aggregative sources-of-growth estimates are shown in Table 3. For the three economies for which the conventional estimate of TFP is relatively non-controversial (the vexed case of Singapore is omitted), TFP is clearly the minority source of growth, with an average "importance" of 32 percent. Input growth drives output in this reading of the data. Note, however, that innovation/assimilation is the dominant source of growth in output per worker, even under the conventional interpretation. Under the Harrodian interpretation, TFP becomes the primary driver of the growth process.

The critical importance of the induced-accumulation effect at the economy-wide level carries over to the industry level: a costless improvement in output per unit of input (i.e., TFP) generates surplus funds that can be used to finance additional investment, and at the same time, the shift in the production function tends to raise the marginal product of capital at the prevailing level of inputs. When the Harrodian framework is implemented for the manufacturing sectors of the Table 1 economies (absent Singapore), TFP is again seen (in Table 4) to be the prime driver of both output and labor-productivity growth. Even in India, where the conventional Hicksian estimates assign a very large role to capital formation, correction for the induced-accumulation effect radically alters the picture in favor of innovation and assimilation.

Is Krugman's pessimism about the sustainability of Asian growth then unwarranted? Not necessarily. Instead of a diminishing-returns-to-capital problem, there may be a diminishing-rate-of-TFP-growth problem. TFP is the costless part of innovation, and in developing countries, it reflects opportunities to assimilate technology from abroad as well as gains from reducing productive inefficiency at home. If a developing country takes advantage of the assimilation possibilities, one might expect it to converge to a target rate of TFP growth defined by the best-practice economies. But convergence implies a slowing rate of TFP growth as the target is approached. Moreover, there is evidence that the target may be diminishing: TFP growth in advanced economies has slowed in recent years (Nadiri and Prucha (1997)), and may be headed to zero growth (Jorgenson and Yip (1999)). If the TFP growth of the Asian Miracle economies is trending toward that of the G-7 economies, it may disappear altogether (along with the output effects that leverage TFP growth). This is certainly a cause for concern, if not outright pessimism.

V. Did Indian Reforms Affect Manufacturing Productivity? The Policy-Endogeneity of TFP

The preceding sections have treated productivity as an exogenous factor in the growth process. Endogenous growth theorists may take issue with this assumption, as may those who believe in the importance of capital-embodied technical change. From either standpoint, capital formation is a necessary ingredient in the process of innovation. Capital formation may interact with the induced-accumulation effect to create a complicated two-way interaction, making it empirically hard to sort out the separate effects of inspiration and perspiration. However, this does not necessarily invalidate the estimates of the preceding sections, because it is important to distinguish between productivity and technical change. TFP is, at best, the costless part of innovation and productivity may increase for reasons other than technical innovation (e.g., improvements in the allocation of resources). Opening the economy to foreign trade and reducing regulation may allow developing economies to begin the process of assimilating technology and management procedures from abroad, thereby raising the rate of TFP growth. This may or may not require capital formation to accomplish, but even when it does, the prevailing rate of investment may be sufficient for the purpose.

Put differently, the assimilationist view sees TFP growth in developing economies as governed more by institutional and historical factors than by economic factors like capital formation and relative prices. TFP can therefore be treated as a partially exogenous factor, with the induced-accumulation effect as an added bonus to the successful assimilation of foreign practices. The estimates of Tables 3 and 4 are thus relevant for the analysis of the causes of growth. There is, however, a sense in which TFP is endogenous: the perception of poor economic performance gives rise to dissatisfaction with prevailing policies; the pressure for change may lead to policies of deregulation and openess that enhance TFP growth.

This seems to have happened in India. A reaction to the defects of the "Kafkaesque" planning system began to influence policy during the 1970s. A number of committees were set up during the Fifth Five Year Plan (1974-79), which led to a reorientation of policy beginning in the late 1970s and 1980s that began the gradual process of loosening direct control over the economy (Ahluwalia (1991)). However, the main era of liberalization began in 1991 and unfolded in stages: for example, the rupee was made convertible for most current account transactions in March 1993, invisibles were added in 1994, and reductions in tariffs were phased-in over the decade of the 1990s (Gulati (1998)).

Our Table 1 and 2 estimates for Indian manufacturing reveal a distinctly tigerish rate of TFP and labor-productivity for the 1973-1992 period as a whole, but give no indication of whether or not this was accomplished toward the end of the period as a result of the reform process. This is, indeed, an issue that has been much debated. The 1991 book by Ahluwalia presents annual estimates of manufacturing TFP that suggest a mildly accelerating pattern of TFP growth after the reforms began in the late-1970s, but no net growth over the entire sample period, 1959-60 to 1985-86. However, these estimates have been challenged by Balakrishnan and Pushpangandan (1994) and Rao (1996a), who criticized the way Ahluwalia measured the price of intermediate inputs. Ahluwalia used a "single-deflation" procedure which assumed that the price of output and intermediate inputs grew at the same rate. The new studies used a "double-deflation" method with a separate estimate of the intermediate-goods price, and found a very different pattern of TFP growth: instead of rising during the period of liberalization, the new estimates show that TFP growth appears to have collapsed.

The alternative Balakrishnan-Pushpangandan-Rao (BPR) price indexes are theoretically superior, but the associated estimates of TFP shown in Figure 1 reveal an improbably large decline in manufacturing productivity after 1983. The estimate of TFP increases rapidly and peeks at 196.0 in 1982-83, remains near that level for two years, and then plummets to 127.1 by the end of the sample period. Taken at face value, this last result means that the average Indian factory became very much less efficient after 1985: if the labor and capital in the typical Indian factory could produce 100 widgets in 1982-83, it could only produce 65 widgets from the same quantities of labor and capital ten years later.

The decline in the level of TFP is too abrupt to be attributed to convergence, which implies that TFP growth should gradually slow over time, not turn steeply negative. The decline is also too abrupt to be attributed to short-run fluctuations in output growth, which may cause negative TFP growth, but only for a short period of time.[8] The implausibility of strongly negative TFP growth rates over an extended period points to either the

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[8] Rao (1996b) justifies that precipitous drop in TFP growth (around -4 percent per year after the mid-1980s) by arguing that the Solow residual does not reflect supply-side considerations alone. He argues that demand-side factors operated through Verdoorn's Law, and that the Law weakened in the 1980s. However, he does not document the presence of Verdoorn effects nor indicate why the weakening occurred.

This said, it must also be acknowledged that it is all too easy to criticize empirical studies that struggle with inadequate data. The progression of papers in this area defines a steady line of advance, and if there is to be criticism, it should be directly primarily at the adequacy of the data.

omission of an important variable or a mismeasured data series. In this light, the skepticism of Ahluwalia (1994) and Dholakia and Dholakia (1994) about the Balakrishnan-Pushpangandan-Rao double-deflation method seems not unjustified. Indeed, a reading of the literature reveals that different procedures and weighting schemes have produced so much variation in outcomes that it is dangerous to conclude that TFP growth has either decreased or increased.

Perhaps the matter should be left where it currently stands, awaiting improvements in the statistical series and perhaps a longer time frame that includes the post-1991 reform period. However, to leave the debate here would essentially suspend the use of Indian manufacturing data for productivity comparisons like those presented in Tables 1 through 4, or, indeed, for any purpose requiring estimates of real value added or real material input. We therefore propose the following two modifications to the current literature. First, we develop a new index of gross output price in which the value weights are allowed to change every year. This index has three virtues: (1) it is based on the same Tornqvist-Divisia procedures used to compute the rate of TFP growth; (2) it is less subject to substitution bias implicit in the fixed-weight Laspeyres-type price indexes of previous studies; (3) it reduces the adverse effects of distorted prices implicit in a fixed-weight index based in a pre-reform year.

We also propose a way around the problem of measuring material input (a term we will use synonymously with intermediate input even though the latter includes, among other things, purchases of energy). Our procedure assumes that capital and labor are not easily substituted for intermediate inputs, particularly material inputs, as relative input prices change. We adopt the strong assumption that the ratio of intermediate input to output is constant within each two-digit manufacturing industry. We then construct a Tornqvist-Divisia index of input price for total manufacturing by weighting the implied two-digit materials prices using the corresponding value shares.

The result of these changes is shown in Table 5. A comparison of the new deflators with those used by Rao (1996a) reveals that there is essentially no difference between the two studies for the sample period as a whole. Thus, the estimates of Indian manufacturing growth shown in Tables 1 through 4 are robust to changes in the price deflators. However, there are major differences in the two decadal subperiods. Where the output price index used by Rao accelerates from the first half of the sample period to the second half, the Tornqvist-Divisia output price index used in this paper decelerates. The growth of real output shows the reverse pattern.[9]

Table 5 reveals that the price index for material inputs is also similar in the two studies over the entire sample period. The big difference is, again, in the sub-periods. The fixed-weight input price index used by Rao shows a more rapid deceleration between the two decadal subperiods than the input price index used in this paper. This results in a slower growth rate of material input in our study during the first half of the period than in Rao's work.

Other things equal, these patterns should translate into indexes of TFP that start and end at almost the same point, but which reach the endpoint by a very different path. This is exactly the pattern seen in Table 6, and in

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[9] Note, here, that the value of output is equal to price times quantity, and that the value of output is basically the same in the two studies. Thus, output quantity will grow appreciably faster in the first half of the period in Rao's study since output price is growing more slowly than in this paper.

Figure 1 (fluctuations in gross output around its growth trend are also shown, since they tend to propagate fluctuations in TFP growth). It is evident from this figure that the new price indexes proposed in this paper, which can be justified on their own merits, have the effect of smoothing the path of TFP and avoiding the improbable inflection point of the Balakrishnan-Pushpangandan-Rao estimates.

The calculations reported in Table 6 reveal a general pick-up in RVA growth and capital formation during the second decade of the sample period. On the other hand, employment growth was cut in half. As a result, capital per worker more than doubled, and gross output per worker (labor productivity) increased from an average growth rate of 4.4 percent to 6.1 percent. Table 6 also reveals that there was essentially no TFP growth between the two decadal subperiods, and that TFP growth accounted for less than a third of RVA growth in both periods.

The first wave of reforms does not appear to have raised TFP growth, contrary to some expectations. However, the possibilities of economic reform may extend beyond TFP growth. The surge in investment may reflect confidence in the reform process, and the slowing of employment growth may be the result of less interference in labor markets, particularly with regard to redundancy (Gangopadhyay and Wadhwa (1998)). The strong performance of labor productivity and capital per worker may, indeed, may be the leading indicators of successful reform.

These conclusions hold up when under a Harrodian view of the process. As in Table 4, the induced-accumulation effect promotes Harrod-adjusted TFP to the leading cause of growth (accounting for three-quarters of RVA growth in both sub-periods), with a corresponding reduction in the importance of capital. However, line 9 of table 6 reveals that the growth rate of Harrod-adjusted capital accelerates during the second decadal period, suggesting that capital formation accelerated independently of any induced-accumulation impetus. This reinforces the point about the need to recognize the role of capital in understanding the reform process. Moreover, contrary to the conventional Hicksian TFP estimates, the Harrodian rate of TFP growth is now seen to be an important contributor to the increase in RVA per worker. The adjusted estimate of TFP explains a third of the 2.1 percentage point increase in output per worker between the two subperiods, suggesting a possible impact of reforms not seen in the conventional approach.

IX. Final Remarks About Total Factor Productivity

The Indian experience is generally seen as a failure to participate in the Asian Miracle. The main point of this paper has been to show that this failure does not apply equally to all sectors of the Indian economy. Indian manufacturing industry is, in fact, perfectly at home in a table comparing the manufacturing sectors of the Asian Tigers. The rest of the story is an exercise in bad news/good news. The bad news is that conventionally-measured TFP not does not appear to be the driving source of output growth in either India or the East Asian Tigers, inviting the end-of-miracle scenario of the Young-Krugman literature. But the good news is that the conventional sources-of-growth analysis tends to understate the role of TFP in driving growth. There may be bad news if TFP growth in India and East Asia starts to decline as it converges to best-practice rates, which are themselves falling. But good news: our estimates of TFP in Indian manufacturing show no convergence effect. But this is also bad news, since convergence to the leaders is a sign of a successful development program.

There is also bad news and good news for those who expect pro-market reform and liberalization of the Indian economy to have a productivity pay-off. The bad news is that neither conventional TFP nor Harrod-adjusted TFP seem to have responded strongly to the reforms initiated in the late 1970s and 1980s. The goods news is that capital per worker and labor productivity did increase, as did Harrodian TFP. And there is hopefully more news to come, since the most important round of reforms began in 1991, toward the end of our sample period.

Abramovitz (1956) famously remarked that the residual is the "measure of our ignorance" about productivity. It lumps together wanted factors like costless improvements in technology and organization with unwanted measurement error and model misspecification. The uncertain accuracy of the price indexes used in past studies of Indian manufacturing industry increases the zone of ignorance. We have proposed new price deflators, but these can hardly be taken as the last word on the subject. Our results are similar to past studies for the period as a whole, thus lending some confidence to our conclusions about the relation of Indian manufacturing to the manufacturing sectors of the East Asian Tigers, and about the sustainability of growth. On the other hand, our results about the timing of TFP growth, and its relation to the process of economic reform, must be regarded as highly tentative.

A final word must be said about model misspecification. The TFP residuals computed in this paper and elsewhere assume that production takes place under constant returns to scale. If production actually takes place under diminishing returns, the value of output is greater than the marginal-productivity value of the inputs, and the TFP estimates are potentially biased downward. In others words, conventional estimates of TFP may understate the true size of the productivity effect even without considering the induced-investment effects. Our preliminary analysis of the data does suggest a tendency toward diminishing returns to scale (DRTS) in Indian manufacturing industry. Mitra et. al. (1998) also report DRTS in eight of the seventeen manufacturing industries studied, constant return in eight others, and increasing returns in one. A similar result is reported by Singh and Ajit (1995). However, Fikkert and Hasan (1998) find evidence for constant returns in their sample of manufacturing firms. This is an issue that bears further investigation.

TABLE 1

FIND THE ELEPHANT

Sources of Growth In India and Various Pacific Rim Manufacturing Industries (Average Annual Rates of Growth)

		(A)	(B)	(C)	(D)	(E)	(F)
1.	Output (RVA)	14.1%	10.8%	8.5%	7.1%	4.5%	1.8%
2.	Labor*	7.4%	6.3%	11.2%	2.1%	1.4%	-0.3%
3.	Capital*	15.1%	13.0%	7.0%	6.8%	4.0%	3.2%
4.	Tot. Factor Input	11.1%	9.1%	9.5%	5.0%	2.1%	0.6%
5.	Tot. Fact. Prod.	3.0%	1.7%	-1.0%	2.2%	2.4%	1.2%
6.	TFP as % of RVA	21%	16%	(neg)	31%	53%	72%

* Growth rate not weighted by factor share. Detail may not add due to rounding error.
Sources: Young (1995), BLS, results of this paper.

TABLE 2

Manufacturing Industry Sources of Growth
Additional Statistics
Labor and Capital Not Corrected for Quality
(Average Annual Rates of Growth)

		Singapore 1970-90	South Korea 1966-90	Taiwan 1966-90	India 1973-92
1.	Output (RVA) per Worker	3.1%	7.8%	4.9%	5.0%
2.	Capital per Worker	5.3%	8.8%	6.9%	4.7%
3.	Tot. Factor Prod. w/o Qual. Corr.	-0.1%	3.6%	2.0%	2.2%
4.	Labor's Share of Value Added	40.4%	52.1%	57.9%	40.7%

Source: Young (1995), and estimates of this paper. Detail may not add due to rounding error.

TABLE 3

Percentage Contribution to Output Growth
Young's Aggregative Tyranny of Numbers Results
With and Without Induced Accumulation Effect

% Contri-bution	South Korea 1966-90	Taiwan 1966-90	Hong Kong 1966-91
Labor	37%	36%	22%
Capital	37%	32%	39%
TFP	26%	31%	38%
TFP/[Q/L]	54%	62%	59%
Harrodian Adjustment for Induced Accumulation			
Labor	37%	36%	22%
Adj. Capital	26%	21%	17%
Adj. TFP	37%	42%	61%
Adj TFP/[Q/L]	77%	83%	95%

Detail may not add due to rounding error.

TABLE 4

Percentage Contribution to Output Growth
Table 1 Manufacturing Industry Results
With and Without Induced Accumulation Effect

% Contri-bution	South Korea 1966-90	Taiwan 1966-90	India 1973-92
Labor	23%	32%	12%
Capital	51%	50%	57%
TFP	25%	19%	31%
TFP/[Q/L]	46%	41%	44%
Harrodian Adjustment for Induced Accumulation			
Labor	23%	32%	12%
Adj. Capital	28%	36%	12%
Adj. TFP	49%	32%	76%
Adj TFP/[Q/L]	88%	71%	108%

Detail may not add due to rounding error.

TABLE 5

Price Indexes for Indian Manufacturing Output and Input
Comparison of Alternative Procedures
(Average Annual Rates of Growth)

		1973-93	1973-82	1983-92
1.	Gross Output (Rao)	7.8%	7.5%	8.1%
2.	Gross Output (TD*)	7.9%	8.1%	7.7%
3.	Int. Input (Rao)	8.1%	9.4%	6.7%
4.	Int. Input (TD)	8.2%	8.4%	7.9%

Source: Rao (1996a), * TD is Tornqvist-Divisia from this paper.

TABLE 6

Sources of Growth of Gross Output
In Indian Manufacturing Industry
Using New Price Deflators
(Annual Rates of Growth)

		1973-92	1973-82	1983-92
1.	Real Value Added	7.1%	6.8%	7.5%
2.	Labor	2.1%	2.8%	1.4%
3.	Capital	6.8%	5.9%	7.7%
4.	Tot. Factor Input	5.0%	4.6%	5.3%
5.	Tot. Factor Prod.	2.2%	2.2%	2.1%
6.	Ratio TFP/RVA	31%	32%	28%
7.	Labor's Share	41%	44%	37%
8.	Capital's Share	59%	56%	63%
9.	Adj. Capital	1.4%	0.9%	2.0%
10.	Adj. TFP (Harrod)	5.4%	5.0%	5.7%
11.	Ratio Adj. TFP/RVA	76%	74%	76%

Source: This paper. Detail may not add due to rounding error.

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TECHNICAL APPENDIX

The non-parametric (index number) approach to measuring total factor productivity (TFPG) used in this paper is based on the assumption of a constant-returns-to-scale production function in which output (Q_t) depends (in the case of manufacturing industry) on inputs of labor (L_t), capital (K_t), and materials (M_t). Output is also assumed to depend on the productivity of the inputs, represented by Solow by the Hicks-neutral technical efficiency index A_t. The resulting production function has the form:

$$Q_t = A_t F(L_t, K_t, M_t) \tag{1}$$

Logarithmic differentiation of the production function with respect to time expresses the growth rate of output as equal to the growth rate of the total factor productivity index, A_t, plus the output-elasticity-weighted sum of the inputs. If the inputs are paid the value of their marginal products, the output-elasticities can be replaced with value shares, yielding the expression:

$$TPG = g_Q - s_L g_L - s_K g_K - s_M g_M = g_A \ . \tag{2}$$

This is the Solow-Jorgenson-Griliches residual.[10] The notation g_X to denotes the growth rate of variable X, and s_X the share-weight. The residual represents a shift in the production function holding inputs constant, and captures costless improvements in output per unit of input. The weighted sum of the inputs represents a movement along the production frontier holding productivity constant.

The data required to implement this model for Indian manufacturing industry are obtained from the Annual Survey of Industry (ASI), supplemented by price data based on the Wholesale Price Index (WPI). The ASI organizes its data using the conventional accounting identity:

$$p_t Q_t = w_t L_t + r_t K_t + q_t M_t \ . \tag{3}$$

[10] A Tornqvist approximation is typically used when implementing (2) with discrete-time annual data (Diewert (1976)). In this approach, the continuous growth rate of each variable, g_X, is replaced with discrete change in the natural logarithm of X: $\ln X_t - \ln X_{t-1}$. The share of X is replaced by the average of this year's value and the value in the preceding year: $(s_{X,t}+s_{X,t-1})/2$.

The price of output is denoted here by p_t, and the price of inputs by w_t, r_t, q_t. Under constant returns to scale in production and marginal productivity pricing, this identity follows from the production function (1) by Euler's Theorem. Separation of prices and quantities yields the data needed to compute the TFP residual.

Our focus is on the registered manufacturing sector of Indian "industry." The ASI yields the following data. For the value of output (p_tQ_t) we use the current price "value of [production or shipments]", for the value intermediate inputs (q_tM_t) we use "inputs," we use employment as our measure of labor input (L_t) and "total emoluments" as our labor compensation variable (w_tL_t). Our capital stock estimation procedure follows Balakrishnan and Pushpangandan (1994), as modified by Rao: current price investment in productive capital stock is obtained from ASI and deflated using a WPI price index. The result is added to a benchmark value of the initial level of capital ultimately obtained from Balakrishnan and Pushpangandan (1994). Our contribution is to use a four percent rate of depreciation in this "perpetual inventory" calculation (the previous work had assumed zero depreciation). In compiling our estimates, we removed the non-manufacturing components of the total industry sector.

These procedures follow Rao rather closely, except in our treatment of depreciation and the "exponential" method we use to convert Divisia growth rates to level indexes. The main difference from past work lies in our treatment of output and material price deflators. Three solutions have been proposed in previous studies. The first uses the "single deflation" method (Ahluwalia (1991), Gangopadhyay and Wadwa (1998)). Under this approach, the value of intermediate inputs (q_tM_t) is first subtracted from the value of gross output (p_tQ_t) to obtain nominal value added, and the result is deflated using the price of output. This solution essentially assumes that the price of output and intermediate inputs grows at the same rate. Balakrishnan and Pushpangandan (1994) opt for an independent estimate of q_t and can thus deflate q_tM_t and p_tQ_t separately to arrive at an alternative estimate of real value added (RVA). This is the double deflation method, which yields fixed-base-year price deflators. Finally, Rao (1996a) argues for the use of Divisia-Tornqvist procedures, which avoid the potential substitution bias implicit in fixed-base-year price indexes.

We propose a different approach to the problem of computing price deflators for output and material input. Our gross output price deflator is a flexible index in which the value weights are allowed to change every year. We start with WPI output price deflators at the two-digit industry level of detail, and apply the Tornqvist-Divisia procedures described above. For each industry, the growth rate of the output price, p_i, is weighted by the industry's value share, v_t, and summed to the all-manufacturing total:

$$g_p = \sum_i v_i g_{p_i} \qquad (4)$$

This method of estimating output price is symmetric with the Tornqvist-Divisia approach used to calculate TFPG.

A similar procedure is used for the materials' price deflator (we use "materials" synonymously with "intermediate inputs" even though the latter includes, among other things, purchases of energy). We start with the assumption that capital and labor are not easily substituted for intermediate inputs. We assume that the ratio of intermediate input to output is constant within each two-digit manufacturing industry. For each industry, we observe the input value share, which is the ratio of the value of input to the value of output. We observe the quantity of output and input in every industry, as well as the price of output, so the price of intermediate inputs is defined implicitly for each industry. This gives us the growth rate needed for the material-input variant of (4). We can also compute the share of each industry's material input in the total value of intermediate inputs for all industries. This gives us the share-weight for (4). Once we have estimated the input price for each industry, we aggregate the results by summing the share-weighted growth rates of the individual price to obtain a Tornqvist-Divisia price index for the all-manufacturing level, as in (4).

Together, these new price indexes have the effect of flattening the problematic spike in the mid-1980s apparent in Rao's estimate of TFP. However, it is worth emphasizing that the price indexes for gross output and material inputs are similar in the two studies <u>over the entire sample period</u>. The big difference is in the sub-periods. The fixed-weight material input price index used by Rao now <u>de</u>celerates from 9.4 percent in the first half of the sample period to 6.7 percent in the second half, while the Tornqvist-Divisia input price index used in this paper decelerates only from 8.4 percent to 7.9 percent. This means that the growth rate of the quantity of material input in the first half of the period will be appreciably slower in Rao's study than in this study. As for the output price deflator, the fixed-weight output price index used by Rao accelerates from 7.5 percent in the first half of the sample period to 8.1 percent in the second half, while the Tornqvist-Divisia output price index used in this paper decelerates from 8.1 percent to 7.7 percent. Thus, output growth in the first half of the period will be appreciably faster in Rao's study. These timing differences in the growth of output and input translate into differences the pattern of TFP growth observed in Figure 1, and the estimates summarized in Appendix Table 1.

This discussion has focused on the problem of estimating productivity using real gross output as the measure of manufacturing product. The resulting productivity estimates are appropriate for industry analysis, since it is real gross output that is observed leaving the factory door. On the other hand, the TFP estimates presented in the body of the paper, and in the associated literature, are based on real value added as the measure of product. The two measures of productivity are closely related but not identical. The valued-added based total factor productivity residual is defined as the growth rate of real value added not explained by the growth rates of labor and capital alone (without intermediate input), each weighted by its share in total value added: $TFPG = g_V - \nu_L g_L - \nu_K g_K$.[11] A little algebra reveals that this measure of productivity is related to the gross-output based total productivity (TP), as defined in (2) above, via the expression $TFP = TP/(1-s_M)$. TFP is simply TP grossed up by the proportion of value added in the total value of output.

Which of the two concepts is the more accurate? If the issue at hand involves industry productivity, TP is the correct estimate given the production function (1). There are, however, two situations in which the use of TFP is appropriate. First, if the production function (1) is weakly separable into a function of labor and capital and productivity gains affect only labor and capital, and not materials, it can be expressed as $Q_t = F(M_t, B_t G(L_t, K_t))$. The index B_t acts, here, as the productivity shifter and $G(\bullet)$ the aggregator function. RVA is defined as $V = BG(L,K)$, and TFP has a clear interpretation as the shift in the aggregator function. However, industry productivity is still defined by the shift in (1), so TP still measures productivity, but not, in this case, the parameter B_t causing the change in productivity. This is yet another case in which there is a wedge between productivity and innovation.

The second situation in which the value-added TFP residual is of interest occurs as a result of the aggregation of industries into an economy-wide average productivity growth (i.e., when measuring the shift in the economy's production possibility frontier). This arises because aggregate productivity growth is both the weighted sum of TP and the weighted average of TFP (e.g. Hulten (1998)). Thus, TFP is a valid indicator of manufacturing industry's contribution to productivity growth at the economy-wide level. Since the focus of the analysis in this paper is economic development, the TFP statistic is the statistic reported in the body of the text. The two measures yield essentially the same conclusions about the pattern of Indian manufacturing productivity, and allowance is made for the difference is scope, that is, for the fact $TFP = TP/(1-s_M)$.

The Induced Accumulation Effect

The conventional interpretation of the TFP residual defined in equation (2) is illustrated in Figure 2. Output per worker is shown as increasing from q_0 to q_1, while capital per worker grows from k_0 to k_1, and the TFP parameter increases from A_0 to A_1. Under the increase in output per worker attributable to TFP is the difference between q_0 and q'_1 (the vertical distance ac at the initial capital-labor ratio, k_0. The rest of the change in output, from q'_1 to q_1, is the result of the change in capital from k_0 and k_1 (the vertical distance cd or, equally, the movement along the production function at the new

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[11] The Divisia index of RVA is derived from the accounting identity above by noting that $g_Q = (1-s_M)g_V + s_M g_M$, solving for g_V. The value-added are ν_L, which is labor's share of value added (equal to $[s_L/(1-s_M)]$), and ν_K, which is capital's value-added share (equal to $[s_K/(1-s_M)]$).

level of productivity from c to b). For Indian manufacturing, Table 2 indicates that q_t increased at an average annual rate of 4.9 percent over the years 1973-1992, of which 2.2 percent was due to TFP and the rest to the growth rate of k_t.

This figure reads differently from the perspective of growth theory. The points a and b are on the steady-state growth path 0S, and all of the change in output is the result of innovation (if we assume that the production function has the Cobb-Douglas form, we can engage in the small expositional cheat of having innovation be both Hicks and Harrod neutral). The apparent increase in capital is caused by the jump in TFP, which leads to more output at prevailing levels of capital per worker (q_0 and q'_1). Some of this additional output is saved, given the prevailing (constant) rate of saving and this causes the increase in capital from k_0 and k_1. This is "induced accumulation" discussed in the body of the paper, and the resulting corresponding increase in output (q'_1 to q_1) is the "induced-accumulation effect."

By way of a numerical example, suppose that q_t and k_t in Figure 2 grow at a rate of technical change of 6 percent per year, and that capital's income share is 1/3 of GDP. A conventional sources-of-growth approach (like Table 2) would record the growth rate of q_t as 6 percent , and allocate 2 percent to capital per worker and 4 percent to TFP. Observed capital formation seems to explain one-third of the growth in output per worker. However, its true contribution is shown in Figure 1. Thus, the correct sources-of-growth analysis would record a 6 percent growth rate of q_t allocated in the following way: 0 percent to capital per worker and 6 percent to productivity.

The induced accumulation effect operates when the economy is not in steady-state growth or technical change is not Harrod neutral. The line 0S defines a constant capital-output ratio at the initial point a. The Harrodian rate of technical change is defined as the shift in the production function measured along 0S. Thus, an induced capital effect is included in the Harrodian measure, whereas the Hicksian definition measures technical change at a constant capital-labor ratio (k_0 in Figure 2) and thereby picks up only the shift from a to c. When technical change is not Harrod neutral, the economy may find other point than b on the new production function. In this case, there actually may be more or less capital per worker than k_1.

APPENDIX TABLE 1

Sources of Growth of Gross Output
In Indian Manufacturing Industry
Using New Price Deflators
(Annual Rates of Growth)

		1973-92	1973-82	1983-92
1.	Gross Output	7.3%	7.2%	7.5%
2.	Materials	7.4%	7.3%	7.5%
3.	Labor	2.1%	2.8%	1.4%
4.	Capital	6.8%	5.9%	7.7%
5.	Total Input	6.8%	6.7%	7.0%
6.	Total Productivity	0.5%	0.5%	0.5%
7.	Material's Share	77.9%	77.2%	78.6%
8.	Labor's Share	9.0%	10.0%	8.0%
9.	Capital's Share	13.1%	12.8%	13.4%

Source: This paper. Detail may not add due to rounding error.

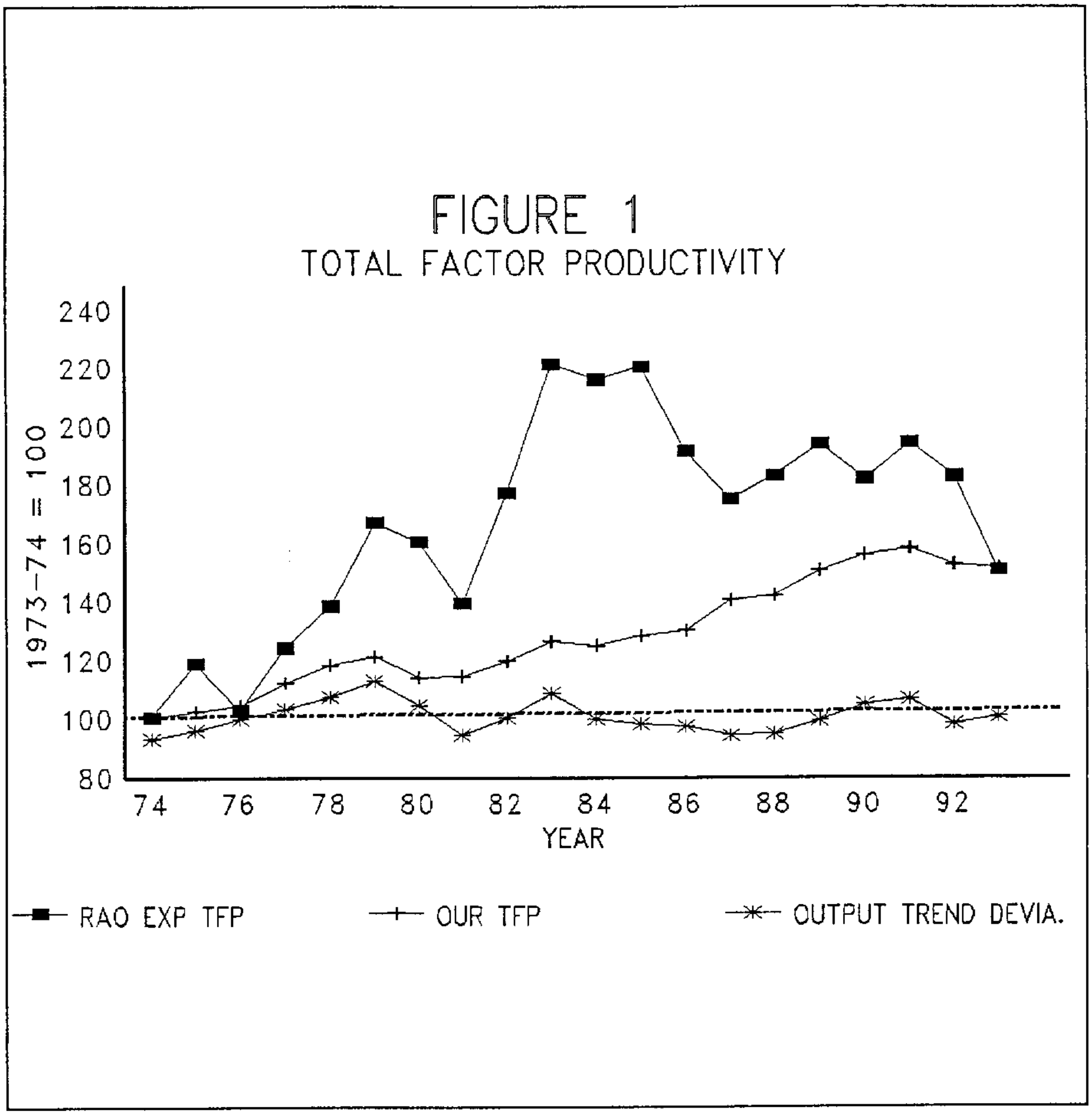
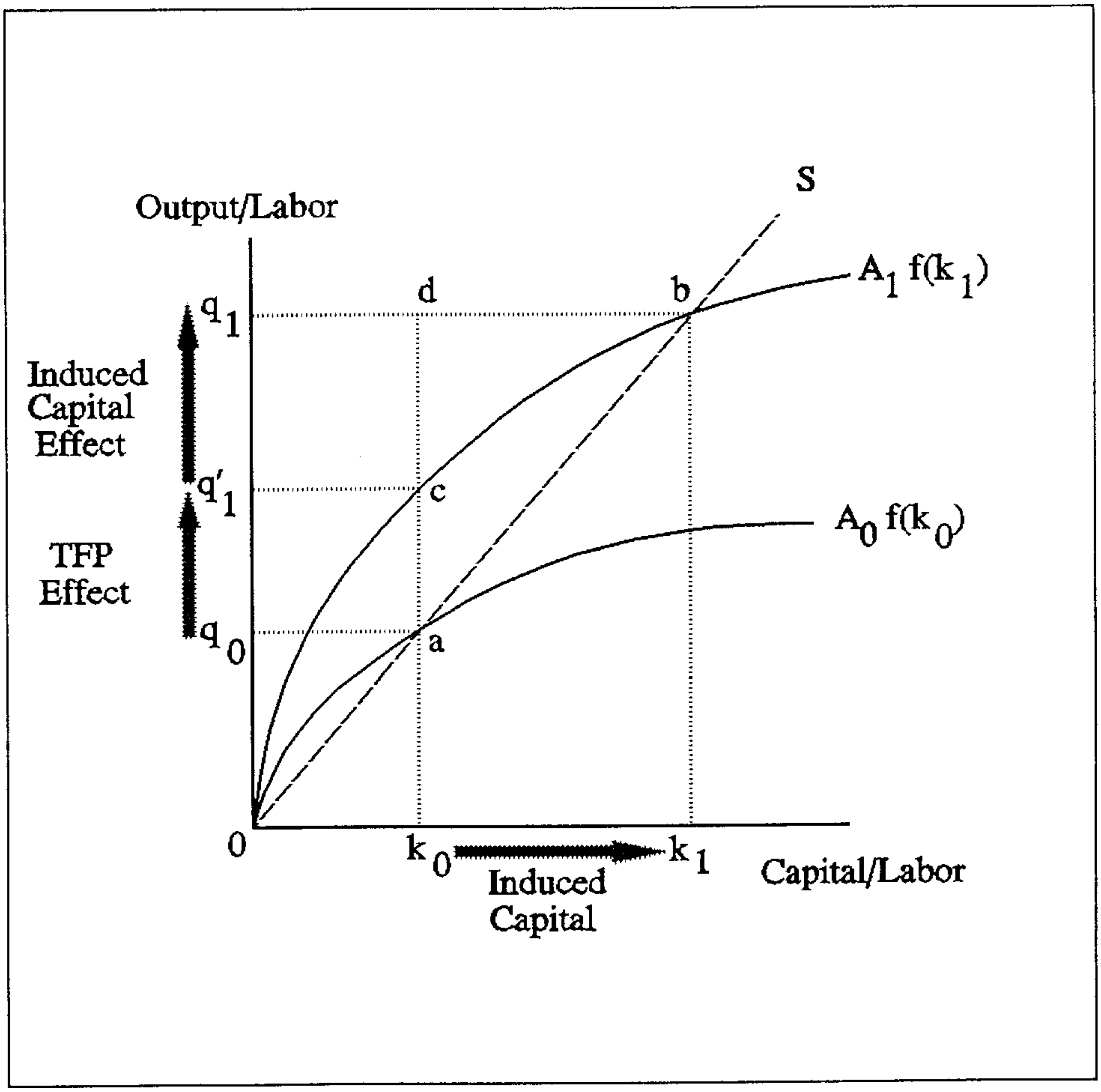


FIGURE 1
TOTAL FACTOR PRODUCTIVITY
1973–74 = 100
240
220
200
180
160
140
120
100
80
74
76
78
80
82
84
86
88
90
92
YEAR
RAO EXP TFP
OUR TFP
OUTPUT TREND DEVIA.

FIGURE 2


S
Output/Labor
d
b
$A_1 f(k_1)$
q_1
Induced Capital Effect
q'_1
c
$A_0 f(k_0)$
TFP Effect
q_0
a
0
k_0
k_1
Capital/Labor
Induced Capital