TFPG in Manufacturing Industry

P Balakrishnan
K Pushpangadan

IN the light of at least one [Sastry 1995] response to our original article that appeared since our last [Balakrishnan and Pushpangadan 1995] note we would first like to offer some observations on the question of the plausibility of our estimates of TFP growth in Indian manufacturing industry in recent years. Next, we reply in detail to the most recent comment of R and B Dholakia [Dholakia and Dholakia 1995]

I

In general, our point that double deflation is superior to single deflation as a procedure to arrive at real value added appears to have been well taken. However, there appears to be an unease among some at finding the consequent estimates indicating a slower growth of value added in the 1980s since this is widely, and correctly, perceived to be a period of expansionary macroeconomic policy. However, we see no problem, whatsoever, in reconciling our results with the recent trajectory of the Indian economy. The 1980s might well have seen a faster growth of production along with a slower growth of value added. In fact, in a period of a secular decline in the price of raw materials, as occurred in the 1980s,[1] this is exactly what would be the prediction when using a neo-classical production function.

Essentially, a scepticism regarding our results must be based on the conflation of output and value added, when these are not identical. Firms might well raise output in response to higher aggregate demand, but the growth in value added during the period depends on the firms' choice of technology, in particular, the use of raw materials. There is no requirement that output and value added need grow at the same rate. In the present case, since the 1980s were a period of declining raw material prices, technology permitting, we would expect firms to now use more raw material inputs per unit of output. *Ceteris paribus* this must lower the growth of value added.[2] This is easily demonstrated.

Write the expression for the change in production thus:

$$\dot{Q} = (1 - \beta)\ \dot{V} + \beta\ \dot{N} \qquad (1)$$

where Q is output, V is the value added and β is the share of materials in output. The dot over a variable denotes its rate of change. Assuming an industrywide production function of the CES-type we can[3] write:

$$\dot{N} = \dot{Q} - \sigma\ \dot{\pi} \qquad (2)$$

where N is the materials input, Q is output, π is the relative price of materials and σ is the elasticity of substitution between materials and value added. Substituting (2) into (1) and rearranging gives:

$$\dot{V} = \dot{Q} + \alpha\ \dot{\pi} \qquad (3)$$

where $\alpha = \sigma[\beta/1 - \beta]$. (3) may be suitably dated to yield:

$$\dot{V}_2 - \dot{V}_1 = [\dot{Q}_2 - \dot{Q}_1] + \alpha[\dot{\pi}_2 - \dot{\pi}_1] \qquad (4)$$

where the subscripts refer to time periods. Now it is easy to see from (4) that we can have $[\dot{V}_2 - \dot{V}_1] < 0$ and $[\dot{Q}_2 - \dot{Q}_1] > 0$ (that is, value added growth slows down even as output growth accelerates) so long as the decline in the relative price of materials is sufficiently great.

II

Dholakia and Dholakia (henceforth D-D) have written [Dholakia and Dholakia 1995] once again, this time following our reply to their original note. We shall keep our response precise.

(1) We find that the greater part of the comment by D-D stems from the misconception that the so-called 'substitution bias' is a feature peculiar to the procedure of double deflation. The substitution bias is the result of continuing to evaluate quantities at base-year prices even as relative prices change. Thus real value indices with a fixed base will reflect current quantities alright[4] but not the current relative price structure. It is easy to see that this is a hazard of using any fixed base index and, for that reason, the substitution envisaged could also occur in consumption and thus be reflected in the production index. Consider the calculation of GNP. When, in the attempt to estimate the real value of goods, current quantities are evaluated at base year prices the procedure tends to exaggerate the contribution of goods whose production might have increased due to a decline in their relative price leading to their being consumed in larger quantities. It is easy to appreciate that were these goods evaluated at prices closer to the current level than the base-year price their recorded value would be lower. A case that has long been noticed and remarked upon in the literature on national income accounting is that of computers in the US economy. This sector has witnessed a secular decline in its relative (and, a rare, decrease in the absolute) price accompanied by an expected increase in production that has been substantial. In the fixed base GNP value index for the US economy the real value of this line of production has got to be overestimated a bit and, with output a natural building block in the computation of productivity, so has the latter.

This brief account must help us focus our attention on the relative merits of the double deflation versus the single deflation method. Essentially the 'substitution bias', being the result of evaluating current quantities at unchanging base-year prices, is inherent in any procedure of deflation using fixed-base price indices and the single deflation methodology is no less susceptible to the 'substitution bias'. Thus the D-D preference for it on grounds that it is not is a *non sequitur*. Moreover, single deflation, as we have demonstrated [Balakrishnan and Pushpangadan 1994:2028, expression (2)], results in a measure of real value added that is not invariant with respect to the current level of the relative price of inputs. A real value index that is not independent of current prices defeats the very purpose for which it is devised. Given this deficiency of the single deflation procedure and the feature that it is no less subject to the substitution bias, the case for double deflation can be made on the no more complex understanding than that we ought to be using output prices to deflate output values and input prices to deflate input values.

With the intention of trying to slough off the issue of double deflation D-D produce the following quote from David: "To the extent that the clarity with which the results can be interpreted should be a criterion in selecting any measurement technique, the

TABLE : GROWTH OF TFP

Method	Period 1	Period 2
Piecewise regression:		
Chow: F(2, 15) = 6.57	4.9	−2.9
Kinked exponential curve:		
R^2 = .81 D − W=1.53	5.2	−1.1*

Notes: Dependent variable is log (TFP); * Indicates not (statistically) significant at the 5 per cent level; 'Period 1'' is 1970-71 to 1982-83 while 'Period 2' is 1982-83 to 1988-89; 'Chow' is a test for a structural break at the end of period 1; the data comes from (Table 2, column 5 in) Balakrishnan and Pushpangadan (1994).

difficulties inherent in the residual deflation method constitute a strong argument in favour of the alternative familiar approach to real national product directly from the expenditure side" [David 1962:154]. By 'residual deflation' David, of course, means double deflation. In the quotation David is suggesting the procedure of arriving at a measure of real value added by deflating nominal expenditure by exploiting the notion that, certainly in the aggregate, output equals expenditure which in turn equals value added in production. This is no recommendation of single deflation. In fact, on this procedure, David's verdict is precise and elegant: "In view of the potentially nasty index number problem raised by the residual deflation procedure, and the work involved in pursuing an expenditure-type deflation of industry income-originating, the simple device of employing an index of prices of an industry's (gross) output may take on momentary appeal. However, that procedure (unless adorned by a number of restrictive thoretical assumptions which need not be detailed here) in effect conceives of the payments to the factors being made in the commodities they produce, valued in prices of the base year. If one is content to assume that people do not exchange their income-in-kind for other goods, why not also assume that they would be content to retain the currency they receive, and thereby circumvent the entire problem of deflation?" [David 1962:155]. We reckon that in the face of such wit and wisdom no further judgment on the status of single deflation as a procedure would be necessary.

Following from the above discussion it is easy to see that while estimating real value added the substitution bias can be eliminated by a continuous shifting of the base year of the price index used for deflation. Note, once again, that this would be necessary whether one is using the single deflation or the double deflation procedure even though the consequences of not doing so are different to the extent that different real value categories are affected in each case. Quite simply, while in the case of single deflation only the nominal output deflator must be a chain index, in the case of double deflation so must be the input value deflator.

A shift in the base is effected when we use a chain index for prices. While the theory of a chain index is pretty well understood, the procedure is ruled out in practice due to the non-availability of indices based on every successive year in the sample under consideration, or more generally even. The only option therefore is to re-work the exercise of calculating real value added using price indices, subject to their availability, based on different years.

Now it is apparent too that the possibility of negative estimates of real value added arises from the comparison of current quantities of output and inputs at their respective base year prices even as relative prices have changed. This problem can be avoided, at least in theory, by a continuous updating of the base, as it were, so that it reflects the current relative price structure as closely as possible. Thus the cirticism[5] levelled against double deflation that it must be avoided because it does not preclude negative real values is not particularly forceful. It is indeed true that estimating real value added by the method of single deflation does not run into this problem but that is not particularly impressive a claim, for this is achieved by the, entirely untenable, elimination of input prices from the calculation altogether. Inputs in the single deflation procedure get to be evaluated at (base year) output prices. This is so absurd that it more than compensates for the feature that the single deflation procedure does not (ever) result in negative estimates of the real value added.

(3) To check for the possibility that our results might in any way have been influenced by the substitution bias, we had re-worked[6] the exercise of calculating real value added using deflators, for the values of output and input, respectively, based on another year. In addition, the input prices were weighted by input-output coefficients entailed in an year as close to the base year for prices. This had yielded results in consonance with our original conclusion that there is no basis for the view that TFP growth had accelerated since 1980. D-D do not refer to this. On the contrary, when they comment on our work "In their reply (B-P 1995) they have also repeated some results already reported in their original paper (B-P 1994) and claimed it to be substantial further work which strengthens their finding of no turn-around during the 1980s in the total factor productivity (TFP) growth in the Indian registered manufacturing sector" [Dholakia and Dholakia 1995:1786], they either reveal an ignorance of our work or set out to deliberately mislead the readership. But what finally disposes of the challenge from D-D is the demonstration [Balakrishnan and Pushpangadan 1995: Table 2] by us that our conclusion that there is no evidence for the acceleration of TFP growth needs no revision even when we use the input-value deflators proferred by them. They have chosen to remain silent on this. As we had observed [Balakrishnan and Pushpangadan 1995:462], that the use of the D-D deflators should make no difference could have predicted by simply eye-balling the data. However, we had chosen to give them the benefit of doubt even though it was clear that the method by which they had arrived at the data was not entirely acceptable. To recapitulate, D-D argue that the input-mix varies between the 'registered' and 'unregistered' segments of manufacturing and since our work uses ASI data in the construction of an index of input prices, we ought to use input-output coefficients for the 'registered' manufacturing sector. In their first response they actually proffer such an index and in their more recent piece provide an elaboration of their methodology. We quote from the latter in full "...the input mix essentially depends on the output-mix and (that) the output-mix differs between the registered and unregistered manufacturing sectors. Since the product-mix in the manufacturing sector is readily available from the National Accounts Statistics (CSO) for different years, the effect of the differing product-mix on the input-mix can be estimated by assuming that within each product category, the input structure remains the same in the registered and the unregistered manufacturing sectors. Although this is an empirical assumption, the state of data availability especially in the unregistered manufacturing sector in India does not allow its testing. On this assumption, which happened to be the best possible and evidently the most plausible one to make under the

present situation, we derived the break-up of the total input use as given in the CSO transactions matrix for 1973-74 between the registered and unregistered manufacturing sectors" [Dholakia and Dholakia 1995:1796]. Frankly, we find nothing "plausible" about this at all. In fact, to start out arguing that one ought to distinguish between the input mix in the two sectors of manufacturing and to then go about assuming that the input structure remains the same in the registered and unregistered manufacturing sectors is nothing short of pathetic. The D-D procedure appears to be something like this: letting x be a vector of outputs (the "output mix") and m the vector of inputs (the "input mix") we have $m^r = Ax^r$ and $m^u = Am^u$, where A is the "input structure" (by which D-D must mean the input-output coefficient) and the superscripts r and u stand for the registered and unregistered sectors of manufacturing, respectively. The absurdity of the procedure lies in the assumption that A is common to both sectors. However, the proof of the pudding we would have thought, lies in the eating and we are perforce to repeat that the use of these much-vaunted D-D deflators, allegedly reflecting the difference in the "input mix" between the two sectors, does not alter our original finding that there is no turnaround in TFPG starting 1980.

(4) D-D entertain a view on our having estimated separate trend lines for the periods prior to and after 1980 that is completely beside the point. We were not after the curve of best fit after all, but explicitly interested in testing the proposition that the 1980s mark a new phase of TFP growth, one of the most striking claims in Indian industry studies in recent years. To now harp on the choice of dates being "arbitrary" and that our procedure implies a discontinuity etcetera is to be completely out of synch with the proceedings. As an approach to measurement in the presence of structural change we find the advice of Poirier quite apt: "Discontinuous models of structural change are of course appropriate whenever the variable causing the parameter change is qualitative in nature. In such cases the familiar hypothesis testing techniques described in Chow (1960) and Fisher (1970) can be used" [Poirier 1976:2]. A switch in the policy regime would constitute an instance of qualitative change. Alas, D-D have allowed themselves to be misled by the D-W statistics reported by us. Moreover, in re-discovering the well known feature that polynomials will fit curves better than straight lines, D-D are hoist with their own petard! The curve they fit implies a deceleration in TFP growth starting the early 1980s with the point of inflexion occurring at sample point t=12, or in the year 1982-83. Taking a cue from this we decided on some further exercises. First following upon Poirier's suggestion, using intercept and slope dummies we tested for structural break. Finding no evidence to the contrary (see the Table), we undertake piecewise regression. Next, as a sop to the Dholakias, by imposing a linear restriction, we eliminate the discontinuity between the segments of the piecewise regression. This yields a kinked exponential function [Boyce 1986] which we fit to the data on TFP. Following upon the estimate presented by D-D we choose 1982-83 as the relevant year in both the regressions. The results are presented in the Table. Our verdict is brief. For the period that we have studied, there can no longer be any question of a positive turnaround in TFP growth in the 1980s.

In conclusion then, we might state that not only were we right in the choice of procedure in the context of testing for a break in the rate of growth since 1980 but also that D-D are plain wrong in the choice of theirs. The rationale for preferring fitted trends over the point-to-point growth-rate calculation is that it helps avoid falling prey to 'outliers'. This is only commonsense, really, but D-D will also find this argument in work cited by them [Boyce 1986:387].

(5) D-D make an egregious error when they state that the use of the double deflation procedure, by virtue of its requiring separability of the production function, is tantamount to ruling out substitution among inputs. This is false. Indeed there are two counts on which D-D must stand corrected.

Firstly, the concept of real value added *per se* requires that the production function is weakly separable in the contribution due to material inputs. This is so because value added is output less material inputs. However, notice that this requirement is, contrary to what D-D make of it, independent of the deflation procedure adopted in the computation of real value added. It is a conceptual issue. It has to do with the technical conditions of production that must be satisfied for real value added to be a valid category of analysis.

We reproduce here Arrow's masterly overview of the issue: "To assess more deeply the relative merits of alternative measures of real value added, it is necessary to ask what its economic meaning is, that is what we are trying to measure. I will argue first that the most natural meaning, indeed the only one I can think of, arises from the estimation of production functions. The output of any commodity is determined by the inputs of a number of commodities, of which some are primary factors and others are produced goods, which we will refer to as *materials*. The attribution of a special role to primary factors, capital and labour, and the construction of an aggregate for them can be justified only for the usual reasons: that their use in production is *separable* from that of the materials. If Q is output of the commodity, and K, L, and M stand for capital, labour and materials, respectively, a production function is a relation

$$Q = Q(K, L, M).$$

Here, K, L, and M appear to play a symmetric role, and there is no apparent reason to aggregate K and L rather than, say, K and M. The notion of real value added has meaning in a production function framework only if this relation can be assumed to take on the special *nested* form,

$$Q = Q[V(K, L), M].$$

As is well known, this is equivalent to requiring that the marginal rate of substitution between K and L in the production of Q is independent of M. Metaphorically, we can imagine capital and labour co-operating to produce an intermediate good, real value added (V), which in turn co-operates with materials to produce the final product. This is an empirical and refutable assumption about the nature of production functions... Without the separability assumption, however, it is hard to assign any definite meaning to real value added, and probably the best thing to say is that the concept should not be used when capital and labour are not separable from materials in production" [Arrow 1974:4-5, italics as in the original]. Notice that the deflation procedure (single versus double deflation) is entirely irrelevant to the more fundamental issue of the meaning of real value added that is considered here.

Now on to the question of substitution, raised *ad nauseum* by Dholakia and Dholakia. Separability of the production function does not prejudice the issue of the underlying technology and thus the possibility of substitution among inputs. It is conceivable that even in the presence of separability technology "is Leontief" but this is not necessary. Whether the production function is separable or not is quite independent of the specification of the technology. A simple example should suffice.

The production function $Q = g(X_1) + h(X_2)$ is additively separable in the two inputs X_1 and X_2. In the extreme form

$$Q = X_1 + X_2$$

it admits of perfect substitution between them. We may easily consider the two inputs to be value added and materials if need be.

(6) D-D had first started out by stating [Dholakia and Dholakia 1994] that double deflation should be done with appropriate deflators and, with this in mind, had put forward a price index that they claimed was appropriate. When it was demonstrated by us [Balakrishnan and Pushpangadan 1995] that the use of their input price index does

not alter the result of no turn-around in TFPG in the 1980s they resort to finding reasons [Dholakia and Dholakia 1995] for why single deflation is a better procedure. This about sums up their effort.

D-D are deluded when they commence thus: "In response to our comment (*EPW*, December 31, 1994) on the paper by Balakrishnan and Pushpangadan, the authors have sought a few clarifications on the numbers we have estimated using their data (see *EPW*, March 4, 1995)" [Dholakia and Dholakia 1995:1786]. As should be plain for anyone following this tedious interchange, we would not have had the need to make any further enquiries after having demonstrated that the numbers they put forward (the input-price deflators) do not require us to alter our original story!

III

There is a cogent argument for the double-deflation method of estimating value added. Not only is it widely used in the case of the major industrialised economies [Bruno 1984], its use has been recommended by the UN [United Nations 1968] and, what is surely of some import to those working with Indian data, is considered by the CSO to be "The ideal method for working out the constant price estimates... of value added [CSO 1980:26]. As far as we know, we have provided the first estimates of TFP in Indian manufacturing industry using double-deflated value added. The correspondence that this has evoked thus far does not impress us. We now invite some professional criticism from our peers.

Notes

[For research assistance we thank M Suresh Babu. For advice on various aspects of the issues considered here we are grateful to Satya P Das, Dipankar Dasgupta, Ajit Kumar Ghose, T N Krishnan, Dilip Mookherjee, Bharat Ramaswami, B P Vani and, above all, Arunava Sen. Errors can only be ours.]

1 See Figure in Balakrishnan and Pushpangadan (1994).

2 In this context we would like to draw attention to the work of Nambiar and Tadas where in an estimate of the growth of value added over the period 1975-76 to 1991-92 the rate of growth slows down after 1984-85, the year they treat as marking the onset of liberalisation. Admittedly the coefficient of the slope dummy in the Nambiar and Tadas estimates is not statistically significant but it is negative in sign. We see their work essentially as evidence that the view that the 1980s mark a phase of higher growth in value added in manufacturing may be somewhat presumptious yet. See Nambiar and Tadas (1994).

3 It is a property of the CES production function that "...the intensity of use of each factor is a decreasing function of its real cost to the producer", Taylor (1983), p 29. Expression (2) also appears in the study by Bruno (1984) of the impact of changes in the price of raw materials on productivity growth. See Desai (1976), p 126, for its derivation.

4 This is emphasised because many, especially those who have written-in in response to our original estimates, harp on the point that double deflation does not take into account substitution in production. For a confirmation that this is an absurd suggestion you are referred to our original article. See Balakrishnan and Pushpangadan (1994), p 2028, expression (3).

5 As always Arrow's comments cut through decisively and we feel that we can do no better than quote him: "...as David (1962) has cogently pointed out, it is by no means impossible that the double-deflation measure of real value added can lead to a negative measurement. To be sure, Sims (1969) has recently pointed out that the double-deflation approach can be given a reasonable foundation if Divisia price indices rather than fixed-base indices are used for the two deflations. In effect, only small changes are considered, so that negative values cannot occur (since the value added was necessarily positive in the base period)." Arrow (1974:4).

6 Balakrishnan and Pushpangadan (1995) Table 1. For this suggestion we are grateful to Michael Bruno.

References

Arrow, K J (1974): 'The Measurement of Real Value Added' in P A David and M W Reder (eds), *Nations and Households in Economic Growth – Essays in Honour of Moses Abramovitz*, The Academic Press, New York.

Balakrishnan, P and K Pushpangadan (1994): 'Total Factor Productivity Growth in Manufacturing Industry: A Fresh Look', *Economic and Political Weekly*, July 30.

– (1995): 'Total Factor Productivity Growth in Manufacturing Industry', *Economic and Political Weekly*, March 4.

Boyce, J K (1986): 'Kinked Exponential Models for Growth Rate Estimation', *Oxford Bulletin of Economics and Statistics*, 48, 385-91.

Bruno, M (1984): 'Raw Materials, Profits and the Productivity Slowdown', *Quarterly Journal of Economics*, 99, 1-29.

Central Statistical Organisation (1980): 'Sources and Methods', *National Accounts Statistics*, New Delhi.

David, P (1962): 'The Deflation of Value Added', *The Review of Economics and Statistics*, 44, 148-55.

Desai, M (1976): *Applied Econometrics*, McGraw Hill Book Company, San Francisco.

Dholakia, B and R Dholakia (1994): 'Total Factor Productivity in Indian Manufacturing', *Economic and Political Weekly*, December 31.

Dholakia, R and B Dholakia (1995): 'Total Factor Productivity Growth in Indian Industry', *Economic and Political Weekly*, July 15.

Nambiar, R G and G Tadas (1994): 'Is Trade Deindustrialising India?', *Economic and Political Weekly*, October 15.

Poirier, D J (1976): *The Econometrics of Structural Change*, North Holand, Amsterdam.

Sastry, D U (1995): 'TFPG in Manufacturing Industry', *Economic and Political Weekly*, January 1995.

Sims, C A (1969): 'Theoretical Basis for a Double Deflated Index of Real Value Added', *The Review of Economics and Statistics*, 51, 470-71.

Taylor, L (1983): *Structuralist Macroeconomics*, Basic Books, New York.

United Nations (1968): 'A System of National Accounts', *Studies in Methods*, Series F, No 2, Rev 3, United Nations, New York.