Labour or Total Factor Productivity: Do We Need to Choose?

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I.   Introduction

Which productivity measure is the 'best' has recently been the subject of some debate in academic and policy circles. On the one hand there are those who argue that total factor productivity (TFP)[2] is the appropriate measure of productivity growth, and that labour productivity is a much cruder measure.[3] On the other hand, there are those who argue that TFP depends too much on arbitrary assumptions, and that labour productivity is more closely related to current living standards, which is what society ultimately cares about. In this note, we shall argue that both measures have their place, and that neither tells the whole story.

II.   The Basic Neoclassical Model of Productivity

In the basic neoclassical model, output is assumed to depend on the quantity of labour employed, the level of the capital stock, and the level of TFP, a parameter that governs the relation between the inputs, capital and labour, and output. TFP is commonly identified with the level of technology but it actually incorporates a wide variety of factors, such as the internal organization of firms and the level of worker effort. Growth in TFP is usually calculated as a residual, by subtracting the relative contributions of the growth in labour input and capital input from output growth.

When using this framework, one important consideration to keep in mind is that in the neoclassical model growth in the capital stock is not an exogenous determinant of growth in the long run. Rather, it is an endogenous variable that depends on TFP growth. In the long run, if TFP were to stop growing, capital intensity would also stop growing, and there would be no further labour productivity growth and ultimately no further improvements in standards of living.

Thus by adopting the neoclassical model of TFP growth, one is more than just calculating the relative importance of capital in explaining labour productivity growth, one is adopting a *theory* of growth, and one in which causation runs *from* TFP growth *to* capital stock growth.[4] This matters for which measure of productivity growth is most useful, because it means that, in the long run, capital stock growth will tend to follow TFP growth, and not the other way around.

III. Capital-Embodied Technical Change

Models of capital-embodied technical change, such as that of Solow (1960), postulate that much of productivity growth can be attributed to increases in the *quality* of capital goods. In these models technological change is said to be *embodied* in new capital goods.[5]

Incorporating capital-embodied technical change into the neoclassical model provides an additional source of growth. In the long run, labour productivity growth depends on both disembodied technological change and capital-embodied technical change. As with the basic neoclassical model, the rate of capital accumulation should not be thought of as an exogenous determinant of productivity growth. Rather, it is determined by the rate of technological change, both embodied and disembodied. This is because there are still diminishing returns to capital. Even though the quality of new capital goods is increasing, this is a purely exogenous process, and is not affected by an increase in investment.

How should we interpret standard measures of TFP when there is capital-embodied technical change? The answer depends crucially on the extent to which capital stock measures are adjusted by statistical agencies for quality changes. In the case where there is no adjustment made for quality changes, measured TFP growth will pick up both the disembodied portion of technological change and the embodied portion. Thus the conventional growth accounting procedure gives the relevant measure of productivity growth for understanding long-run changes in labour productivity growth. What it does not do is give the portion of long-run growth that is due to capital-embodied technical change.[6]

IV. Productivity in New Growth Models

While the neoclassical model assumes TFP to be essentially determined outside the model, 'new' growth theory, or endogenous growth theory, attempts to explain the evolution of TFP. All new growth theories stress the importance of ideas as the underlying 'engine' of growth. However, they differ in what is posited to be the primary determinant of ideas: some authors stress investment in human capital, others stress investment in new capital goods, or spending on research and development.

What does new growth theory imply for growth accounting? If we assume that TFP depends on investment in human capital, or on that part of spending on R&D not measured as investment, then the standard growth accounting framework largely carries through.[7]

The situation is different if TFP growth depends on capital accumulation, as in Romer (1987), where greater capital accumulation leads to a greater variety of capital goods and thus greater capital quality. If we apply the standard growth accounting procedure in the context of Romer's growth model, we find that TFP depends on both disembodied technological change and the rate of increase of the variety of capital goods. Because the latter is endogenously determined by the resources society devotes to saving, this means that TFP now follows capital accumulation, rather than being a cause of it. As a result, TFP is no longer a better guide to long term trends in productivity than labour productivity.

V.   Conclusions

What then do we believe to be the most appropriate measure of productivity growth, TFP or labour productivity? Our view is that the choice should depend on several factors, including the time period of interest, the quality and comparability of the capital stock data, and the growth model assumed.

The Time Period of Interest

In most models of growth, diminishing returns to capital accumulation implies that capital intensity cannot grow faster in the long run than (adjusted) TFP growth. Any tendency for labour productivity to grow faster than TFP is merely a temporary phenomenon. Nevertheless, this adjustment to the long run could well be prolonged, and it is possible for capital intensity to grow more quickly than adjusted TFP for a considerable period of time. So if the intent is to examine trends in the economy over a period of less than a decade or so, then labour productivity is a better guide. If the intent is to examine long run trends in the economy, then TFP may well be a better choice than labour productivity.

The Quality and Comparability of the Capital Stock Data

If there are important biases in the estimates of the capital stock used to construct measures of TFP growth, then it will clearly be better to rely on measures of labour productivity, which are estimated directly using readily available estimates of value added and labour inputs. This is especially relevant when making cross-country comparisons, because the procedures used by different statistical agencies to deal with, for example, depreciation and aggregation, may be quite different.[8]

What the Underlying Model of Productivity Growth Is Assumed to Be

Most attempts to measure TFP involve an implicit assumption about the underlying model of growth. This means that simply estimating TFP growth is not enough: one needs to know how to interpret the resulting time series:

- In the *neoclassical model of growth*, when no adjustments are made for changing capital quality, measured TFP growth reflects both disembodied and embodied technological change, and remains the best guide to long-run trends in productivity. When adjustments are made to the capital stock, measured TFP only reflects disembodied technological change, and additional data are required to construct a measure of embodied technological change.

- In *new growth models in which physical capital accumulation is the engine of growth*, capital intensity drives TFP growth, not the other way around. Therefore trends in capital accumulation are more relevant for examining the growth process than are trends in TFP growth.

Given that both the short run and the long run matter to policy makers, and that there is considerable debate over how to measure the capital stock, and over which is the 'right' model of economic growth, it seems reasonable to argue that both labour productivity and TFP are useful indicators of growth trends in the economy, but that neither should be relied upon exclusively.

Notes

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2 Statistics Canada refers to TFP as 'Multifactor Productivity', or MFP.

3 See for example May (2000).

4 Although the neoclassical model is at the heart of how economists usually interpret measures of TFP, it is possible to give an index number interpretation to TFP statistics that does not presuppose a particular economic model. See Hulten (2000) for more details.

5 Models of capital-embodied technical change are often called 'vintage' models, because capital goods of more recent vintages are more productive-of greater quality-than older capital goods.

6 When prices of capital goods are adjusted for quality change, the situation becomes more complicated. Statistical agencies such as Statistics Canada and the Bureau of Labor Statistics now adjust downwards the prices of computers and certain related capital goods to reflect quality change. This means that the real capital stock of these machines is now measured in efficiency units, to give a measure of the effective capital stock. In this case standard growth accounting procedures will only reveal the disembodied part of technological change. To calculate the part of technological change that is embodied in capital goods, one must use the difference between the non hedonically-adjusted price index and the hedonically-adjusted price, as in Greenwood et al. (1997). This will give an empirical estimate of the rate of capital-embodied technological change to calculate the long-run growth path of the economy. Note though that a complication arises if hedonic pricing methods used to calculate not only the effective capital stock, but also to the real value of output. Greenwood et al. (1997) argue that the appropriate way to measure real output is to use the price of consumption goods, not investment goods, to deflate the value of real investment. Failure to do so biases upward real output and therefore labour productivity and disembodied TFP, and in consequence reduces the relative importance of capital-embodied technical change.

7 Because there are still diminishing returns to physical capital, the (physical) capital-labour ratio cannot grow faster than adjusted TFP in the long run, and so TFP growth is still a good guide to long-term growth trends. The pattern of causation still runs from TFP to physical capital: the only change is that now TFP is determined by some other factor, such as investment in human capital or R&D spending.

8 See Coulombe (2000) for more on this topic in the context of U.S.-Canada comparisons. There is also the question of how to aggregate different components of the capital stock. While statistical agencies typically use historical cost to weight different kinds of capital goods, Jorgensen and Griliches (1967) argue that the more appropriate technique from a conceptual standpoint is to weight assets by an estimate of their marginal products. In this way measures of the capital stock can capture increases in the quality of capital resulting from substitution towards capital goods with higher marginal products. Failure to do so will bias downwards estimates of the capital stock and so bias upwards measures of TFP growth. The other reason why official estimates of capital may depart from the theoretically ideal measure is that not all capital goods are used at full capacity at all points during the business cycle. Just as the expression for labour input should only reflect the number of persons employed, so too should the measure of the capital stock include only capital employed. Although in the long run changes in capacity utilisation should even out, in the short term, failure to adjust for changes capacity utilisation will tend to impart a pro-cyclical bias to measured TFP.

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