Working Paper No. 251

Productivity and Economic Growth

by

T.N. Srinivasan*

September 2005

* Samuel C. Park, Jr. Professor of Economics, Yale University, New Haven, Connecticut, and Senior Visiting Fellow, Stanford Center for International Development, Stanford University, Stanford, California.
Productivity and Economic Growth

T. N. Srinivasan

JEL Classification Codes: F43, O47, O57
Keywords: productivity, economic growth, comparative studies of economies

1. Introduction

The interaction between gains in productivity of resources used and growth of economic output has been discussed extensively in the economic literature for a long time (see Jorgenson 1995a, 1995b; Jorgenson et al. 2005; Hulten et al. 2001). This literature, often called growth accounting, was in part driven in the fifties by the concern about what was then perceived as rapid growth of output in the Soviet Union. Whether such growth was sustainable depended partly on whether it was largely accounted by factor accumulation or by growth in total factor productivity (TFP). The same question came up much later in the context of the rapid growth of East Asian economies (Young 1995). Also, determinants of factor accumulation could be different from those of TFP, and further there could be variations across countries (particularly between developed and developing countries). It is not, therefore, surprising that accounting for observed growth within and across counties has received substantial attention from analytical and policy perspectives.

The scope of the discussion in the literature has also been wide ranging, from a narrow perspective of the productivity of a single resource (e.g., capital, land or labor) in the production of a particular commodity (e.g., foodgrains, apparel) at a point in time in a given country (or even within a region in a country) at one end of the spectrum to a much broader perspective of productivity of all resources (i.e., total factor productivity) in generating growth of aggregate output (i.e., gross domestic product) over a long period across a number of countries. The

* Samuel C. Park, Jr. Professor of Economics, Yale University, New Haven, Connecticut, and Senior Visiting Fellow, Stanford Center for International Development, Stanford University, Stanford, California.
analysis has also been wide ranging from the positive perspective of accounting for observed variations across commodities, regions or countries at a point in time or in growth again, across different time spans in a country or across countries and a normative perspective of policies to influence productivity and growth. Also, the methodology of analysis, including importantly, the econometric tools as well as the data used in the analysis, has received--and appropriately so--much attention in the literature. Needless to say, given the nature of the topic, controversies and disagreements, rather than consensus, characterize the literature, despite agreement that achieving sustained productivity gains is vital, especially for developing countries.

This is not the occasion to assess critically the findings of the vast literature. Instead, I will briefly discuss the well-known issues involved in defining and measuring total factor productivity and its contribution to growth (as well as the possible contribution of growth to productivity), the economic theory underpinning productivity, and policies that impact on and influence changes in productivity (Section 2). I then move on in Section 3 to a selective discussion of the studies on cross-country variation in productivity levels and growth. Section 4 is devoted to the experience of China, India, Mexico and South Africa. Section 5 concludes.

2. Defining and Measuring Total Factor Productivity (TFP)

Hulten (2000, p. 4) points out that “output per unit input, or total factor productivity, is not a deeply theoretical concept.” Clearly, given a measure of what constitutes aggregate output and input, it is a matter of pure arithmetic to define TFP as the ratio of the measure of aggregate output to the measure of input. In a market economy, prices of goods and services produced and consumed, as well as the prices of factor inputs used in producing them, are determined by the market. Since prices can be expected to vary over time, for productivity analysis, one needs a measure of real output and a corresponding measure of real input. A purely statistical approach
is to weight the basket of goods and services produced at different points of time at the same set of prices to measure aggregate real output and similarly weight the quantities of factor inputs used at different points of time by an unvarying set of factor prices to measure aggregate real input. Thus, using base year (year 0) prices as weights, real output \( O_t \) in year \( t \) is defined by:

\[
O_t = \sum_{j=1}^{J} P_{0j} O_{jt}
\]

where \( O_{jt} \) denotes output of good (or service) \( j \) in year \( t \), \( P_{0j} \) is the price of \( j \) in year 0, and \( J \) is the total number of goods and services produced. Similarly, aggregate input \( I_t \) in year \( t \) is defined by:

\[
I_t = \sum_{k=1}^{K} q_{0k} I_{kt}
\]

where \( I_{kt} \) denotes the quantity of input \( k \) used in year \( t \), \( q_{0k} \) the price of input \( k \) in year 0, and \( K \) is the total number of inputs. For simplicity, it is assumed that the same set of goods and services is produced and the same set of inputs is used in each year, and that base year prices are available for all of them. I will return below to the implications of relaxing this assumption.

With real output and input defined by (1) and (2), it is obvious that TFP, \( \pi_t \) at \( t \) is given by:

\[
\pi_t = \frac{O_t}{I_t}
\]

Even with this purely statistical definition, (i.e., no economic theory is being invoked), one can easily identify possible sources of changes in productivity over time.

First, suppose input \( I_t \) is the same as in year 0 so that \( I_t = I_0 \), but output \( O_t \) is greater than \( O_0 \). It follows that productivity \( \pi_t \) in year \( t \) will be greater than \( I_0 \). Clearly, \( O_t \) will
exceed $O_t$, with $I_t = I_0$ if inputs of the same total value in the base year are reallocated across goods and services in such a way that, on balance, the output of those goods which have higher prices in the base year increase and those with lower prices decrease. This is a pure resource or input allocation effect. Since $O_t > O_0$, there is growth in output as well as gains in productivity.

Second suppose input $I_{kt} = \lambda I_{k0}$ with $\lambda > 1$, so that in year $t$, $\lambda$ times as much of each input $k$ is being used in production. Then $I_t = \lambda I_0$. If $O_t > \lambda O_0$ so that output increases by a proportion larger than $\lambda$, then obviously $\pi_t$ will be higher than $\pi_0$ so that productivity increases. Since output $O_t$ has increased by a proportion larger than the increase in input, this is due to scale economies in aggregation production. Thus, the productivity gain in this case arises from economies of scale. Once again, growth in output is associated with gain in productivity.

Third, suppose the output $O_{jt}$ of each of the goods $j = 1, \ldots, J$ depend not only on the inputs used in the production of each, but also on the output $O_{jt}$ of good $1$. Concretely, suppose any increase $O_{jt}$, with inputs used in the production of each $j$ unchanged will increase the output $O_{jt}$, $j = 1, \ldots, J$, so that the output of good $1$ has a positive external effect on the output of other goods. Consider now the case of $I_t = I_0$ so that the value of inputs at base year prices is the same in year $t$ as in year $0$. If the inputs are reallocated to produce more of good $1$ while decreasing the inputs used in the production of other goods, as long as the external effect of the increase in output of good $1$ on the output of other goods dominates the effect of the decrease in the inputs used in their production, aggregate real output $O_t$ will increase so that productivity $\pi_t$ will increase as well. The productivity gain and the associated growth in output in this case are due to positive externalities.
Fourth, suppose once again \( I_t = I_0 \) so that, in the aggregate, inputs used in year \( t \) have the same value at base-year prices as in year 0. Assume further that the inputs used in year \( t \) in the production of each good \( j \) also remain the same, but the technology used in year \( t \) in the production of one or more goods is more productive than in year 0. Then aggregate output \( O_t \) will exceed its base year value \( O_0 \) and productivity \( \pi_t \) will exceed \( \pi_0 \). In this case, the source of the gain in productivity and associated output growth is technical progress or improvement.

The above illustrations were put together to derive gains in productivity and growth in output in a simple and transparent manner so as to isolate particular sources of both, such as resource reallocations, scale economies, positive externalities and technical progress. It is clear that in any economy, not only all these sources could be operating to varying degrees, but also not all need move in the same direction. For example, there could be diminishing returns to scale in the production of one or more goods, externalities could be negative as well as positive, and resources may be reallocated inefficiently and so on. Further, in a purely statistical exercise, the underlying technology of production, the economic processes that are behind allocation of resources at a point of and over time, as well as the institutional and policy underpinnings of the economic processes were left unspecified. Clearly, both for identifying the sources of growth and productivity gains empirically from economic data (an exercise in positive economics) and for drawing policy inferences, one has to specify these. Before doing so, let me briefly note the implication of the assumption that the set of goods and inputs remain the same over time.

There is no doubt that over time new goods are introduced (and some goods cease to be produced), the quality of preexisting goods changes, new inputs and new or different uses for the same inputs are found, and so on. To take a simple example, suppose the quality of some input doubles in the sense that one unit of the new higher quality input is twice as productive as that of
the old input of unchanged quality. Even if there is no change in the quantity used of that input, still outputs of one or more of the goods will increase and a gain in productivity will be seen in the data. If, on the other hand, the increase in quality of the input results in a reduction in the quantity used of that input while the quantities used of other inputs remain the same, the aggregate input used will go down while output remains the same or increases. This once again raises productivity. This way of describing productivity increase due to quality improvement in input is tautological, since quality itself is being implicitly defined by the increase in productivity!

In (1) and (2), aggregate real output and input were defined by base-year price-weighted sums of disaggregated quantities of outputs and inputs. However, aggregates such as real GDP, consumption, investment, outputs of sectors consisting of a number of goods, real inputs, etc., are often derived by deflating corresponding nominal values by a price index. The problems arising from quality changes and the appearance of new goods are seen more transparently in the latter procedure. For example, in the United States, the Boskin Commission Report (1996) concluded that the consumer price index (CPI) of the Bureau of Labor Statistics (BLS) overstated inflation by around 1% per year, of which unmeasured growth in the quality of goods contributed 0.6% (Bils 2004). Clearly, overstatement of inflation implies ipso facto an understatement of real consumption that is derived by deflating nominal value of consumption by the CPI. Moreover, the procedure by which quality changes are derived can have significant impact on estimates of growth and productivity. This is illustrated by Bils (2004).

He points out:

To calculate the CPI the BLS tracks a large set of prices, with each price specific to a particular product at a particular outlet. The products followed change for two principal reasons. At regular sample rotations, roughly every four years, the BLS draws a new sample of stores and products within a geographic area to better
reflect current consumer spending…In addition, a store may stop selling the particular product being priced. The BLS agent then substitutes another model of that brand or of a similar product. These (forced) substitutions occur on average about once every three years for all non-housing CPI items. They occur much more frequently, nearly once per year, for consumer durables. (Bils 2004, p. 1)

He then goes on to say:

Although the price increases accompanying scheduled and forced substitutions largely reflect the same economic phenomenon—newer versions of goods sell at higher prices than old, BLS methods treat them very differently. Current methods implicitly treat the increases in goods’ unit prices associated with sample rotations as reflecting quality growth. Therefore, the National Income and Product Accounts (NIPA) will interpret that part of the upward trend in unit prices as real growth. By contrast, the price increases from forced substitutions within sample rotations have been largely attributed to price inflation, not quality growth. (Bils 2004, pp. 1-2)

The implications of the BLS procedures are seen from Bils’ analysis. He notes that:

…most consumption deflators for the National Income and Product Accounts (NIPA) are based on BLS’s measures of CPI inflation. The NIPA derive real growth measures by subtracting measured inflation from nominal spending growth for each category of good. Thus any measurement error in CPI inflation will lead to an opposite error in rates of real growth. If we cannot accurately attribute the price changes from model substitutions between quality growth and price inflation then it is not possible to ascertain rates of growth in real consumption or productivity. To illustrate, TFP growth for motor vehicles and other transportation sector (SIC 37), reflecting BLS price measurement, averaged 1.1% per year for 1987 to 2001 (from Bosworth and Triplett, 2003). But suppose that forced substitutions for motor vehicles should be treated the way scheduled substitutions are treated, with price changes across models viewed as quality upgrades. I calculate then that both quality growth and productivity growth are understated by 4.4% per year. If, on the other hand, the treatment of price changes for forced substitutions should actually be applied to scheduled substitutions then both quality and productivity growth are overstated by 1.8% per year. The implied range for TFP growth for motor vehicles varies dramatically from -0.7% to 5.5% per year. (Bils 2004, pp. 2-3)

I have gone into Bils’ (2004) analysis in some detail only to show that quality changes in existing products as well as introduction of new products have to be allowed for and how this is done can have significant effects on the estimates of growth in TFP as well as real output.

Whether or not this phenomenon is important for the analysis of growth in developing countries
is an open question since, as far as I know, their statistical agencies do not routinely adjust their inflation rates to allow for new products and quality improvement. I am not aware of any empirical study comparable to that of Bils and others on this issue.¹

The postwar approach to measuring TFP based on economic theory was pioneered by Robert Solow in his seminal paper, “Technical Change and the Aggregate Production Function” (Solow 1957). Hulten (2000) cites a prewar study of Tinbergen (1942), which also is founded on economic theory. Solow (1957) postulated a constant returns to scale aggregate production function with capital and labor as inputs and a Hicks neutral shift parameter \( A_t \) as follows:

\[
O_t = A_t F(K_t, L_t) 
\]

where \( O_t \) denotes aggregate real output, \( K_t \) capital input and \( L_t \) labor input. By differentiating (4) logarithmically and assuming that each input is paid its marginal product, Solow arrived at his famous residual \( R_t \) as a measure of the rate of growth of \( A_t \):

\[
R_t = g_t - s_{kt} g_{kt} - s_{lt} g_{lt} 
\]

where \( g_t \) denotes the growth rate of aggregate output, \( g_{kt} \) the growth rate of capital, \( g_{lt} \) the growth rate of labor and \( s_{kt} (s_{lt}) \) the share of capital (labor) in output. It is easily seen from (4) that the residual \( R_t \) equals the rate of growth of \( A_t \). As Hulten (2000) remarks:

This is the theory. In practice, \( R_t \) is a ‘measure of our ignorance’…precisely because \( R_t \) is a residual. This ignorance covers many components, some wanted (like the effects of technical and organizational innovation), other unwanted (measurement error, omitted variables, aggregation bias, model misspecification) (p. 11).

Solow’s article spawned a vast literature that is briefly described in Hulten (2000). This is not the occasion to go into it and into the question of whether if inputs are properly measured

¹ Hedonic pricing methods are often used in developed countries to distinguish quality growth from true price increases for goods. Once again, such methods are rarely used in developing countries to the best of my knowledge.
(including allowing for human capital effects in the measurement of labor input) the residual will disappear as Jorgenson and Grilliches (1967) argued. Solow treated $A_t$ as exogenous “manna from heaven.” Significant theoretical developments in endogenizing it had to wait until the revival of growth theory in the late eighties. I have reproduced Solow’s approach only because much of the empirical literature relating to developing countries is based on it.

Before turning to the influence of policy choices on productivity growth, let me note that aggregate growth could influence productivity growth. For example, to the extent growth in aggregate output enables an increase in the scale of production it could raise TFP if scale economies are present. Also, growth in output may create markets for specialized inputs, including services, thereby unleashing Adam Smith’s specialization and gains in productivity. Thus, not only growth in TFP contributes to aggregate growth but also the latter could contribute to the former, thus making both growth rates endogenous. This two-way interaction between the two might be missed if the focus is exclusively on accounting for aggregate growth.

It is easy to see how policy choices could influence the sources of productivity growth. Let me cite a few important channels. First is policy towards international trade. Clearly, by enabling the economy to increase (decrease) the production of commodities in which it has a comparative advantage (disadvantage), trade liberalization enables a more efficient allocation of an economy’s resources and thus contributes to productivity gains. By the same token, an expansion of some activities following trade liberalization could enable the exploitation of scale economies. Moreover, if the producers “learn from doing,” output expansion could contribute to the productivity gains from the learning process. In the literature, the question of whether trade liberalization yields just once-and-for-all efficiency gains or it also contributes to an acceleration in growth has been debated. Both theory and empirical evidence point to growth effects of trade
liberalization in particular through opportunities to acquire more productive technologies and practices, both disembodied as well as embodied to equipment and promoting innovation.

Second, policies that address market failures and distortions could contribute to productivity gains. For example, public policy interventions that encourage internalization of positive externalities and discourage negative ones would generate productivity gains. Policies that improve the functioning of the financial sector also help by enabling those with productive ideas to get the credit they need to put their ideas into practice, and also by spreading and shifting the risks of innovation. Well functioning bankruptcy laws help smooth the transfer of resources from failed enterprises to more productive uses.

Third, in many developing countries, important markets such as product and labor markets are likely to be distorted. There are often barriers to movement of goods and factors within countries. Also, labor laws often are unduly protective of a small segment of the labor force employed in the public sector and large-scale industries. Such protection inhibits flexibility of labor markets and avoidably reduces productivity. Indeed, many analysts point to the relative rigidity of labor markets in France and Germany as an explanation of their relatively poor economic performance compared to the US (and also the UK) with its flexible labor markets.

Fourth, broadly speaking, appropriate fiscal, monetary, exchange rate and public debt policies could contribute to productivity gains. For example, the loss in output and productivity associated with recent financial crises has been very significant. It can be argued that a better functioning domestic financial system as well as public policies could have mitigated these losses and accelerated recovery.
It is evident that almost all public policies could potentially affect the level of TFP and its growth, as well as overall growth. This is recognized in the literature, particularly in the literature on the so-called “New” or “Endogenous” Growth Theory. As noted earlier, in the classic Solow (1957) model the rate of productivity growth is constant and exogenous. In “new” growth theory, on the other hand, this rate is not only endogenous but also, in general, variable over time. However, the process of productivity improvement has been modeled in different ways by various authors. For brevity, I will describe just two.

In Lucas (1988), human capital accumulation by each worker plays a dual role: it raises the worker’s productivity in the usual fashion, but by raising the average level of human capital in the economy, it creates an additional external effect. The reason for this effect is that a worker with a given endowment of human capital is more productive in an economy in which the average level of human capital is higher. Thus, there is an externality: social marginal product of human capital of a worker is higher than the private marginal product to the worker. In the standard fashion, in the absence of a public policy intervention to internalize this externality, workers will accumulate less human capital than would be socially optimal.

Helpman (1990), models innovation as an activity which produces “blueprints” for the manufacture of a variety of final product. In the innovation industry, there is “learning by doing,” so that the unit labor cost of producing a blueprint diminishes as the cumulative number of blueprints already produced increases. Thus, there is a “learning” externality in the innovation industry in which there is competition and free entry. The final product industry is modeled as a monopolistically competitive one. The rate of growth of blueprints is the rate of innovation in the economy and its steady state value is endogenously determined. Helpman (1990) also extends the model with two countries, an innovating North and an imitating South, which trade
with each other in varieties of final product. Interestingly, the steady state rate of innovation when North trades with the South is faster than the rate when it is autarkic. Thus, the model nicely illustrates the role of trade openness on innovation and growth.

3. Variation in Productivity and Growth Across Countries

The revival of theorizing about growth in the late eighties that had remained dormant after the sixties was also accompanied by a significant number of empirical studies of growth in a cross-country framework, in part stimulated by the availability of large data sets, notably from the International Comparison Project under the leadership of Robert Summers and Alan Heston of the University of Pennsylvania. The two authors published time series data on several countries, including income using purchasing power parity exchange rates in converting local currency values to a common “international” dollar. Variants of cross-country regressions of growth (over various time horizons) on determinants such as rates of investment, human capital, variables proxying political economy, trade policy, etc., have been published. For the purposes of this paper, a fairly robust conclusion of this literature is that although investment rates, savings rates, and R&D expenditures vary across countries in a persistent manner, correlation of growth rates across decades is low, suggesting that differences in growth rates across countries may be mostly transitory. This implies that the long-run growth rate is essentially the same—in other words, there is convergence over time across countries to a common growth rate. If in the long run, growth rates converge to a common value, then the focus of analysis of cross-country differences has to shift to explaining differences in levels of output per head or per worker.

Hall and Jones (1999, p. 84) hypothesize that:

…differences in capital accumulation, productivity and therefore output per worker are fundamentally related to differences in social infrastructure across countries. By social infrastructure we mean the institutions and government
policies that determine the economic environment within which individuals accumulate skills, and firms accumulate capital and produce output.

They recognize that feedback may occur from output per worker to social infrastructure and control for this feedback in their empirical analysis. They view that “the ideal measure of social infrastructure would quantify the wedge between the private return to productive activities and the social return to such activities” (p. 97). Since in practice the ideal measure does not exist, they proxy social infrastructure by combining two indexes. The first is an index of government anti-diversion policies created from data assembled by a firm that specializes in providing assessments of risks to international investors. The second index is a measure of trade openness. The details of their econometric specification, identification and robustness checks are not of importance for our purposes. However, their main conclusion that “the large variation in output per worker across countries is only partially explained by differences in physical capital and educational attainment…differences in social infrastructure across countries cause large differences in capital accumulation, educational attainment, and productivity, and therefore larger differences in income across countries” is very striking. It implies in particular that institutions of governance and policies, as well as openness to external trade, are the fundamental determinants of cross-country differences in productivity and income levels. This in turn implies that, if the institutions of governance are dysfunctional and tariff and non-tariff barriers restrict external trade, then increases in external aid are unlikely to be productive.

Senhadji (2000) takes the Hall-Jones analysis further by relaxing several of the latter’s econometric assumptions. In particular, he estimates production functions (Cobb-Douglas, constant returns to scale) for individual countries taking into account both the endogeneity of inputs and possible non-stationarity in the data. Further, unlike Hall and Jones, he does not assume that all countries (88 in his sample for 1960-94) have the same production function, but
only those within each of the six regions into which the countries are grouped. Further, he estimates production functions in two ways, one using the data on levels of outputs and inputs and the other using first differences. The latter, if the first differences are of logarithms of levels, is equivalent to estimation from growth rates. It turns out that it matters whether growth accounting is done with level-based or first-difference based estimates of the elasticity of output with respect to capital. Finally, he also analyzes the determinants of cross-country differences in TFP levels.

Without reproducing the details of Senhadji’s estimates, let me summarize his conclusions. First, in the debate over the accounting for East Asia’s growth, Senhadji’s accounting based on level-based estimates of capital elasticity support Alwyn Young’s (1995) conclusion that most of the growth came from physical capital accumulation. Interestingly, when first-differenced estimates are used, strong productivity growth as well as high levels of investment explain East Asia’s growth over 1960-94, thus contradicting Young. Second, Africa had negative growth of TFP of between -.066 and -0.56 percent depending which estimate of capital elasticity is used. Latin America had the next worse record of negative TFP growth of -0.52 and -0.39 percent. For some reason, he included China in the South Asian region. Because of its spectacular growth after 1980 (and also, less spectacular but still rapid growth of India after 1980), South Asian TFP growth, between 0.55 and 0.94 percent, was significant. Third, if the period 1960-94 is divided into three sub-periods (1960-73, 1974-86 and 1987-94), except for Asian countries, growth declined steadily from the first to the third period. Fourth, although TFP growth series at the country as well as regional levels vary significantly across different values of the elasticity of capital, still they are highly correlated. Fifth, real output in a developing country
is much more volatile than that in developed countries, and this volatility is passed to TFP series as well.

Turning to determinants of TFP, Senhadji estimates a set of regressions of level of TFP in a country relative to that of the United States on sets of explanatory variables, consisting of initial conditions, external shocks, macroeconomic variables, restrictions on current and capital account transactions and political stability. As in the literature on cross-country growth regressions, many of the explanatory variables are dummy variables and proxies for other variables. Besides, the mechanisms through which these variables affect growth or relative level of TFP are never satisfactorily explained in much of the literature. These caveats have to be kept in mind in assessing Senhadji’s findings. These are: there is evidence of conditional convergence of relative TFP levels in that the explanatory variable the initial (1960-64) relative level of TFP has a significant positive coefficient which is less than one. Relative (to the US) endowments of human and physical capital are important determinants of relative TFP. However, the former is far more important in that it has a coefficient ten times larger than that of the latter. As expected, a good macroeconomic environment and exchange rate flexibility contributes to a high relative TFP level, and political instability hurts TFP.

Let me conclude this section with a brief presentation of the analysis by Klenow and Rodriguez-Clare (2004) of externalities and growth. They focus on models with two features: first, in the steady state all countries grow at the same rate because of international knowledge spillovers (externalities) and, second, differences in policies and other country-specific features generate differences in TFP levels rather than in growth rates. They note that there has been a slow-down in TFP growth since the 1970s around the world (their data does not cover the recent upsurge in productivity, particularly in the US). They find investment rates in physical capital
across all countries were virtually unchanged while that in human capital rose strongly. These facts and others in their view point to international externalities as a possible explanation for the global productivity slowdown. In other words, there is something other than investment rates that link growth rates across countries. That something in their view is knowledge diffusion through trade, migration and foreign direct investment, although they do not explain in what way the process of diffusion resulted in the slowdown.

The precise algebraic model and calibration they use, are beyond the scope of the present discussion. More relevant are their findings, some of which are startling. For example, their estimates suggest that Senegal’s actual productivity was 187 times higher than what it would have been had Senegal been an isolated and autarkic country! Moreover, a world GDP would have been only 6% of its current level had countries not shared ideas! Even modest barriers to technology adoption as well as differences in knowledge investment could explain a large part of income and TFP differences across countries. Although they leave the identification of primary channels of international knowledge spillovers to future research, they suggest that trade, joint ventures, foreign direct investment, migration of key personnel and imitation may all play important roles.

4. **TFP Growth in China, India, Mexico and South Africa**

China and India have been fast growing economies since 1980, with China growing roughly at around 8-10 percent per year on the average and India around 6 percent. The story of China’s opening to the world economy and domestic economic liberalization after Deng Xiaoping’s accession to power in 1978 is well known. India followed an inward-oriented, import-substituting, state-directed and controlled development strategy for nearly four decades. Average growth during 1958-80 was a measly 3.75 percent. During the 1980s, hesitant and
limited economic reforms were initiated and state control over the economy was somewhat relaxed. Coupled with these limited reforms, there was an expansionary macroeconomic policy, with increasing fiscal deficits financed by domestic and external borrowing. This combination delivered a 5.8 percent growth per year on an average during 1980-90. However, this debt-led growth was unsustainable and culminated in a severe macroeconomic and balance-of-payments crisis in 1991. The crisis led to systemic reforms, including trade liberalization, floating of the exchange rate, and significant opening to foreign capital inflows, as well as a number of domestic reforms. Although the average rate of growth since 1991 has remained at around 6%, still it is far more solidly founded and sustainable than the growth of the eighties. It is no surprise that the issue of whether or not reforms contributed to an improvement in TFP growth in both these large economies have attracted scholarly attention.

Mexico grew rapidly at 6.5 percent per year during 1960-79. The growth rate sharply decelerated to 2.5 percent during 1980-2003, a period that included the debt crisis of the early 1980s and the peso crisis of 1994. Although growth averaged at more than 5 percent during 1996-2000 after recovery from the peso crisis, it dropped to less than 1 percent during 2000-03 and has since recovered to over 4 percent. Faal (2005), from whose paper these facts are drawn, attributes the swings in growth mostly to changes in the contribution to TFP as opposed to factor input.

Growth accounting exercises for South Africa that cover the pre- and post-apartheid era apparently do not exist. I will draw on the work of Arora and Bhundia (2003) for the post-apartheid period. They find that there was an increase in GDP growth after the end of apartheid in 1994, and much of it is attributable to TFP growth. Let me now turn to a brief description of the experiences of each of these countries.
China

A number of scholars have analyzed the TFP growth in China, including Hu and Khan (1997), Young (2000), Woo (1996), Wu (1999) and Ao and Fulginiti (2003). The last provides evidence from Chinese provinces as well as the nation as a whole. In addition to the conventional method of estimating TFP, they attempt to distinguish between shifts in the technology frontier (or best practice technology) and the gains in productivity by movement towards the frontier from below, thus decomposing TFP in the stochastic frontier model between technical change (movement of the frontier) and unfortunately, their analysis covers the period 1978-98 only.

During this period, they find (Ao and Fulginiti 2003, Table 1) that national GDP grew by 8.86 percent per year, with the Western Region growing at the slowest rate of 7.91 percent and the Eastern region growing at the fastest rate of 9.68 percent. Their estimates of TFP growth and its contribution to GDP growth drawn from their Table 5 are given below.

<table>
<thead>
<tr>
<th>TABLE 1: China’s TFP Growth and Contributions to GDP, 1978-98</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Estimation Method</strong></td>
</tr>
<tr>
<td>Region</td>
</tr>
<tr>
<td>East</td>
</tr>
<tr>
<td>Central</td>
</tr>
<tr>
<td>West</td>
</tr>
<tr>
<td>National</td>
</tr>
</tbody>
</table>

It is evident that although regional variations in TFP growth rates are not large, because of differences in GDP growth rates, the contribution of TFP growth to GDP growth shows regional variation. Also, TFP growth estimates are significantly higher than the estimates of Young (2000).
India

For India also, a number of estimates of TFP growth are available, some of which I cite in Table 3 below. One of the more recent and detailed is that of Virmani (2002), who refers to other estimates. Once again, I will leave out the methodology and the details of data used in the estimation except to say that they are largely conventional. What is of interest is that he estimates TFP growth separately for four periods, 1950-51 through 1964-65, 1965-66 through 1979-80, 1980-81 through 1991-92, and 1992-93 through 2003-04. The first period covers the first three five-year plans and the Prime Ministership of Jawaharlal Nehru. The second period includes two severe droughts in 1966 and 1967, two wars with Pakistan, the onset of the green revolution around 1967 and also intensification of state controls on the economy, including nationalization of commercial banks and insurance companies, all under the Prime Ministership of Indira Gandhi. The third period is of hesitant reforms and opening of the economy, the assassination of Mrs. Gandhi, the Prime Ministership of her son Rajiv Gandhi, and the macroeconomic crisis of 1991. The last period is the period of systemic reforms under several Prime Ministers who led coalitions. He also provides TFP growth estimates at the sectoral level as well. I reproduce below TFP growth and its contribution to growth of real net domestic product (NDP) per worker drawn from his Table 2.

<table>
<thead>
<tr>
<th>Period</th>
<th>TFP Growth (percent per year)</th>
<th>Contribution to Growth NDP Per Worker (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950-51 – 1964-65</td>
<td>1.9</td>
<td>41</td>
</tr>
<tr>
<td>1965-66 – 1979-80</td>
<td>0.1</td>
<td>4</td>
</tr>
<tr>
<td>1980-81 – 1991-92</td>
<td>2.5</td>
<td>46</td>
</tr>
<tr>
<td>1991-92 – 2003-04</td>
<td>3.6</td>
<td>59</td>
</tr>
</tbody>
</table>
The acceleration of TFP growth since the initiation of reforms hesitantly during 1980-90 and systemically in 1991 is evident. It is also striking that in the second period when the economy was largely insulated from the world economy and state controls on the economy were intrusive and extensive, TFP growth fell to almost zero.

The following table taken from Srinivasan (2004) compares TFP growth in China and India. Once again, the effect of reforms since 1978 on China’s TFP growth is evident.

**TABLE 3: Comparison of Historical TFP Growth in China and India**

<table>
<thead>
<tr>
<th></th>
<th>China (Hu and Khan)</th>
<th>India (IMF)</th>
<th>India (World Bank)</th>
<th>India (Ahluwalia)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1953-78</td>
<td>1.1</td>
<td>-1.0 to 1.1</td>
<td>1979-80 to 1997-98</td>
<td>160-80 -0.5&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>1979-94</td>
<td>3.9</td>
<td>-2.1 to 0.3</td>
<td>1.3 to 1.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1980s</td>
<td>0.7 to 2.9</td>
<td>1980s</td>
<td>2.8&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mid-1990s</td>
<td>1.5 to 3.4</td>
<td>1994-95 to 1996-97</td>
<td>2.4 to 2.8</td>
<td></td>
</tr>
<tr>
<td>Late 1990s</td>
<td>0.3 to 2.9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> – Figures for manufacturing sector only


The estimates of TFP growth for China and India also point to a general problem with such estimates. They are highly sensitive to the data used and above all the methodology of estimation. In particular, strong maintained (i.e., untested) assumptions are made in the empirical analysis about production functions and the statistical properties of the disturbance terms that are essential components of the model used for estimation. Not all of the maintained assumptions are explicitly stated and the robustness checks of the estimates with respect to the
use of alternative assumptions are sometimes omitted altogether. For all these reasons, in interpreting and using these estimates, extreme caution is called for.

Mexico

Faal (2005) adopts the Solow (1957) methodology of estimation of TFP growth during 1960-2003, assuming a constant returns to scale Cobb-Douglas production function with elasticity of output with respect to capital and labor of 0.33 and 0.67, respectively. Faal breaks the period into two sub-periods: 1965-79, 1980-2003 and also 1996-2003, a period which follows a long period of extensive structural reforms after the debt crisis of the early 1980s. The estimates are shown in Table 4.

| TABLE 4: Mexico’s TFP Growth and Contributions to GDP, 1965-2003 |
|---|---|---|---|
| Period | Real GDP Growth (percent per year) | Contribution to Real GDP Growth of: |
|    |                | Capital | Labor | TFP |
| 1965-79 | 6.5             | 2.0     | 2.4   | 2.1 |
| 1980-2003 | 2.6            | 1.1     | 2.0   | -0.5 |
| 1996-2003 | 3.5             | 1.2     | 1.6   | 0.7 |

The decline in growth of real GDP and of TFP after 1979 raises some important questions. Although the debt crisis of 1982 naturally led to a collapse of output and TFP growth, these have not recovered to their pre-1982 levels in spite of significant reforms of trade, financial and public sectors. As Faal notes, the decline in per capita growth after 1980 occurred not only in Mexico but also many other Latin American countries, with the exception of Chile, and indeed in some Asian countries (but to a lesser extent) as well (Faal 2005, Table 2). Faal cites the reasons that have been offered for Mexico’s poor performance in spite of reforms: first, the reforms were significant only with respect to foreign trade, but shallower and slower energy
sectors of electricity and petroleum. Second, although Mexico’s financial sector is no longer as repressive as it was prior to 1998, it is still not efficient in credit allocation, and much of loanable funds are invested in real estate and consumer loans. According to some authors cited by Faal, the Mexican labor market is one of the most distorted in Latin America and the Caribbean, primarily because the legal framework protects workers excessively, induces resistance to technical change, and restricts labor mobility. Apparently, this has induced a shift of activity to the informal sector characterized by lower wages and few restrictions. Faal suggests that the informal sector is less productive and, as such, the shift could have had adverse effects on TFP growth.

The reasons cited by Faal are plausible but not completely convincing. After all, labor market rigidities, poor credit allocation capabilities of the financial sector and slow progress in domestic regulatory reforms are not unique to Mexico but are also present in many developing countries, including India. Still, other economies have done better than Mexico in spite of these disabilities. It seems to me that Mexico’s poor performance requires further and deeper analysis.

South Africa

Arora and Bhundia (2003) estimate potential output growth in post-apartheid South Africa using three different econometric methodologies (two of which, the Hodrick-Prescott filter and structural vector autoregressions are purely statistical and a third based on a conventional production function). The so-called output gap between potential and actual output has been used in advanced countries as a measure of inflationary pressure. For the purpose of this paper, only their growth accounting exercise based on the Solow (1957) methodology using a Cobb-Douglas production function is of interest. Also, this exercise also covers the pre-apartheid period of 1980-93. The real GDP growth accelerated from 1 percent per year during 1980-93 to
2.8 percent during 1994-2001. There was no TFP growth at all in the pre-apartheid period, while it grew by 3.1 percent per year in the post-apartheid period. Interestingly, they attribute the growth in TFP in the post-apartheid period selectively to several factors. These include a substantial increase (to 47 percent from 34 percent of GDP) of trade as a proportion of GDP; a rise to 50 percent from 35 percent in the share of equipment and machinery (presumably embodying better technology) in total imports; and an increase (from 60 percent to 72 percent) in the participation of the private sector in total investment as well as investment in equipment and machinery. Since the analysis covers up to 2001, it cannot obviously examine the implications of HIV/AIDS, for example, for future growth and productivity gains.

5. Conclusions

I will be brief. First, there are several sources of improvements in total factor productivity: efficiency of resource allocation, exploitation of scale economies and positive externalities, and technological progress, to mention only the major factors.

Second, institutions matter for achieving gains in productivity. After all, institutions such as product and factor markets, social institutions that influence participation in the labor force as well as sharing of risks, financial institutions that intermediate savings and investment as well as allocate credit and, above all, governance have a major influence on the efficiency of resource allocation as well as factor accumulation. They affect individual incentives and those of production units such as firms for production, consumption, accumulation and trade.

Third, public policies matter a great deal. Whether or not foreign trade and investment is relatively free of barriers erected by the government, whether the government appropriates to itself a large share of investible resources thus crowding out private investment, and whether
publicly provided social (education and health) infrastructure are important from the perspective of each of the sources of productivity growth.

Fourth cross-country empirical evidence on TFP is supportive of the importance of institutions including social infrastructure and the contribution of knowledge externalities and spillover across countries. Obviously, any policy restriction on foreign trade, investment or migration policies could inhibit the growth of TFP by limiting such spillover.

Fifth, there is robust evidence from China and India (two of the world’s very large economies in terms of GDP at purchasing power parity exchange rates) that they experienced a substantial step up in TFP growth after they reformed their foreign trade as well as domestic policies. In contrast, the experience of Mexico is sobering: in spite of what prima facie appears to be extensive reforms, the economy is still mired in low productivity growth. The experience of post-apartheid South Africa is encouraging, although it has some way to go in raising its growth rate.

Sixth and last, the environment for external trade, investment and technology flows have to be free of barriers to enable developing countries to grow rapidly through productivity growth. Although it is outside the scope of this paper, I would add that a successful conclusion of the Doha Round of multilateral negotiations is extremely important from this perspective.
References

Productivity 33(2).

Provinces,” University of Nebraska, mimeo.


Bosworth, Barry and Jack Triplett. 2003. “Services Productivity in the United States:
Grilliches’ Services Volume Revisited.” Washington, DC: Brookings Institution,
Mimeo, forthcoming in Ernst R. Bendt and Charles Hulten (eds.) Hard-To Measure
Goods and Services: Essays in Honor of Zvi Grilliches (Draft manuscript, June 2005).


Helpman, Elhanan. 1990. “Monopolistic Competition in Trade Theory,” Sections 3, 5 and 7,
Department of Economics.


