

level of an industry or for the full sample. We are told that both entrances and exits were frequent, and that the number of entrants and exits was roughly equal, but we know nothing of their size.

Finally, what the authors call capital productivity is simply the output-capital ratio. I was surprised to observe in figure 5 that the growth of output exceeded that of the capital stock in this data set and that the output-capital ratio rose substantially after 1997, despite the incredible rates of investment that China has sustained over the past decade.

The remainder of the paper addresses some issues concerning the sustainability of China's growth. Much of that discussion seems to be drawn from an earlier paper by one of the authors that addresses R&D and patenting behavior in China. However, given the large remaining productivity gaps demonstrated between Chinese firms and their international competitors, China should be able to sustain its growth for many years through technological catch-up, without the need to focus on new innovations.

Gustav Ranis: This paper is laudable in its aims, ambitious in its scope, and prodigious in the energy expended on it, but somewhat disappointing in its execution. Its objective, to parse out the sources of China's astonishing past growth and its prospects for the future, is unexceptionable. China has made a dramatic recent entry onto the international scene, economically and politically as well as strategically. Consequently, there is a lot of discussion, in the professional economics literature as well as among policy experts, concerning the sources of that performance and, even more, concerning the system's prognosis, because China is now seen as a major player, whether as a brand new locomotive for the global economy or as a brand new threat to the established international economic order.

Gary Jefferson, Albert Hu, and Jian Su have chosen to analyze China's past and future by examining the extent of catch-up, both of China's interior toward its coastal, externally oriented, provinces, and of the latter toward the international technology frontier represented by either the United States or Japan, depending on the industry. At times, the authors refer to multiple gaps, between regional agriculture and coastal industry, between regional services and coastal industry, between interior industry and coastal industry, and between coastal industry and the international frontier. However, they frame their analysis, in what they call the "basic model," in terms of only two gaps, international and internal, and this is a source of some confusion.

Following Edward Denison, the authors first place heavy emphasis on the catch-up of China's coastal industries toward the international frontier. Since the coastal provinces are the most economically advanced, international convergence is not likely to be very pronounced, but, so the argument goes, they give rise to externalities such as technical diffusion that narrow the internal gaps and help to sustain over time the impact of the coast's gradual convergence with the frontier.

I have a basic problem with any definition of technological catch-up that is expressed in terms of labor productivity differentials. For example, the authors find that industrial labor productivity in 2002 in China's advanced coastal provinces was less than a quarter that in the United States or Japan. Defining technology gaps in this fashion is highly questionable, since one would expect rich countries to exhibit much higher industrial capital-labor ratios, and therefore higher labor productivity. The much preferred measure would seem to be differences in total factor productivity (TFP), independent of the extent of capital deepening. Simply substituting labor productivity for TFP requires some rather heroic assumptions concerning the constancy of relative income shares or factor price equalization.

Indeed, in all their treatment of productivity gaps, the authors appeal to factor reallocation, presumably with technology fixed, as a source of TFP growth. In their analysis they calculate the marginal productivity of labor as proportional to average labor productivity. If they were truly dealing with the marginal rather than the average productivity of labor, the authors' argument that aggregate TFP can be enhanced, even in the unlikely absence of any technical change, simply by reallocating labor in ways that eliminate existing gaps in marginal product, would make sense. But this is not what the authors have in mind. Estimates of TFP that exclude the contribution of innovation and rely entirely on reallocation are not realistic even in the case of the interaction between domestic agricultural and nonagricultural production (see below), and they are certainly inconsistent with the authors' emphasis on FDI, R&D, and patents when dealing with the catch-up of China's coastal industries to the international frontier. As their borrowed table 1 powerfully illustrates, factor reallocation represents only one, and by no means the dominant, component of the TFP residual in virtually all countries.

In their empirical analysis, the authors deal in turn with each of several of the gaps they have suggested as relevant. With respect to the international gap, they address two important issues: Has the existence initially of

a sizeable productivity gap caused an observable process of convergence? And does the resulting reduction of that gap over time imply a decline in China's future industrial productivity growth? The authors find that the larger the gap, the larger the catch-up in all of China's regions. But they also find that China's coastal industry enjoys higher rates of productivity growth than the more backward regions, which runs counter to the conventional convergence story. To explain this, the authors go outside their model, invoking higher concentrations of FDI and R&D as well as certain locational and industrial agglomeration advantages in the coastal region. But these are the very factors that directly determine endogenous TFP rather than labor productivity.

The authors find, using data for twenty-seven Chinese industries and thirty-one provinces, that China's industrial labor productivity has converged toward the international frontier in recent years. For example, labor productivity in the coastal region moved from one ninth of the international frontier in 1995 to one fourth in 2002, "demonstrating the degree of catch-up." However, as already pointed out, this result is likely due in large part to the more rapid pace of capital accumulation in China than in the United States or even Japan: investment in China has exceeded 40 percent of GDP in recent years. Even if we accept the authors' definition of catch-up and focus on the coastal region primarily (as in the top panel of their figure 1), it would have been helpful to examine why, as they note, the food, beverage, and tobacco industry stands out, in having labor productivity that is ten times that of industry as a whole. Is that because of an unusually high capital-labor ratio in that industry, or because of an unusually high rate of profits caused by government-imposed barriers to entry, as they claim?

The authors next discuss a variety of internal productivity gaps: between agriculture and domestic industry, between industry and services, and across regions within the services and industrial sectors, but, confusingly, they claim to empirically examine only two of these. Comparing domestic agriculture and industry, they find (table 3) that the ratio of industrial to agricultural labor productivity rose from 6.1 in 1980 to 7.1 in 2005, after initially declining with the shift from communes to the responsibility system in agriculture. However, with agricultural labor presumably largely unskilled, any comparison with "average industrial workers" rather than exclusively with reallocated unskilled industrial workers (for example, in construction or textiles) makes very little sense. In addition, I have a problem with the authors' reallocation effect, which is related mainly to

the size of the productivity gap g and the fraction β of labor in the low-productivity agricultural sector (see their equation 2 and figure 4). The authors neglect the possibility of technological change in agriculture, which historically almost inevitably accompanies the labor reallocation process. Moreover, I fail to see why the fraction of the population in agriculture should affect the annual rate of reallocation. After all, that rate depends less on how many workers are available for transfer in any one year than on their ability to move and be absorbed by higher-productivity nonagricultural activities. This is not to dispute the point that the bargains for GDP growth arising from labor reallocation in a dualistic economy are likely to diminish over time as the agricultural labor surplus itself diminishes.

The conceptual and empirical core of the paper, dealing with the internal productivity gaps across nonagricultural sectors, is presumably to be found in the implementation of their equations 3 to 6. However, the relevance for gap reduction of equations 3 and 4, which indicate how initial marginal factor productivities yield changes in the subsequent demand for labor and capital, is not at all clear to me. Equations 5 and 6, which do bring in TFP, bear a family resemblance to the Solow equation, even though the rates of growth of both labor and capital inputs are not included, and even though we know TFP in that context to be an exogenous residual. It is also here where the later discussion of FDI, R&D, and patenting could have been introduced to provide explicit endogenous behavioral elements.

The authors follow this discussion with a very interesting and novel analysis, based on rare primary data, of the contribution of the turnover (exit and entry) of firms to labor productivity change, by comparing these firms with those that survive over the same 1995–2004 period. Not surprisingly, exiting firms nearly always exhibit substantially lower, and entering firms substantially higher, productivity than survivor firms. Later on, the authors interestingly identify many of the exiting firms as state enterprises and many of the entrants as restructured or greenfield private enterprises. Two questions arise, however: First, is it reasonable to believe that out of a total annual population of 22,000 to 27,000 firms, more than 16,000 ($146,000 \div 9$) either entered or exited each year from 1996 to 2004? Moreover, as the authors admit, the number of firms gives no indication of the relative size of the three categories under discussion.

A potentially more serious issue arises with respect to the NBS panel used for the analysis that includes only large and medium-size enterprises. As Jian Gao and Jefferson acknowledge elsewhere, "the vast majority of

these [enterprises in China's industrial sector] are small household enterprises."¹ This must be especially true for the township and village enterprise sector and the rapidly growing private enterprise sector over the most recent decade. The exclusion of these firms from the analysis must cast considerable doubt on the findings.

Finally, in their discussion of the sustainability of China's productivity growth, the authors return to defining technical progress in terms of labor productivity. I agree that there continue to exist large opportunities to re-allocate labor from agriculture to other sectors, and undoubtedly these are best expressed in terms of technological and institutional changes. There follows a section on "China's Science and Technology Takeoff," which seems to ask what changes in R&D or in patenting have caused the changes in China's industrial TFP. The authors accept the empirical regularity of a "science and technology takeoff" when R&D reaches 1 percent of GDP, and they provide some interesting and generally plausible arguments as to why, with the help of R&D and FDI inflows, China has already reached this point.

Here again, however, the published R&D figures, which focus entirely on the official reports of large and medium-size firms, public and private, do not really convey a credible indication of a country's true R&D activity. For example, in the other East Asian economies cited in the paper, the kind of informal blue-collar R&D that takes place on the factory floor and in the repair shop has been shown to be extremely important in generating the adaptive technical changes that are often less than spectacular individually, but massive, and usually labor-absorbing, in the aggregate.² The ensuing discussion of patents indicates not only that FDI-related foreign patents played a major role in stimulating domestic invention patents, but indeed that these were dwarfed by the explosion of relatively low-inventiveness-threshold utility patents, presumably heavily concentrated in smaller firms. My educated guess would be that these utility models, in China as earlier in the case of Japan, amount to more than simple imitations (or reverse engineering); rather, they also represent individually modest but, in toto, massive adaptive changes in both the process and product quality dimensions. Unfortunately, the paper's interesting discussion of R&D, FDI, and patenting intensity is not at all integrated with the rest of the paper. It is, of course, no surprise that these variables are generally weighted more heav-

1. Gao and Jefferson (forthcoming).

2. Ranis (1990).

ily in the coastal provinces, but their precise impact on the closing of the various gaps and China's overall growth trajectory is not really demonstrated. And again, they could be modeled as contributing directly to TFP, not to the various factor productivities.

Finally, although I applaud the authors' effort, at the end of the paper, to include some important political economy and institutional dimensions, that discussion is necessarily *ex cathedra*. I find myself in full agreement with much of their argument—that to sustain its growth China needs to take into account such constraints as a worsening income distribution, environmental degradation, uncertain property rights (especially in agriculture), corruption, and lagging political reforms, and that even under optimistic assumptions about continued institutional reforms (and the authors are clearly optimistic), the shrinkage of China's various productivity gaps, especially the international one, is likely to mean smaller contributions to overall growth in the future. After all, what successful middle-income developing country has been able to maintain real growth rates in the 8 to 10 percent range as it approaches economic maturity?

General discussion: William Nordhaus complimented the authors on their analysis of Chinese firms' productivity, which provided valuable insights into the sources of China's remarkable growth. But he also expressed reservations about some of the more aggregate results. Because much of the underlying data are constructed using Laspeyres indexes, estimates of productivity growth in the Chinese economy and its various sectors are biased upward. Edward Denison showed long ago that the increase in productivity that results from moving labor from low-productivity to high-productivity sectors largely disappears when the more appropriate chain-weighted quantity indexes are used. This increase in measured productivity, or "Denison effect," can be quite large, accounting for over 1 percentage point of reported productivity growth in Italy from 1952 to 1960, for example. Nordhaus noted that the Chinese national accounts use Laspeyres indexes with 1990 planning prices; he expected that a substantial fraction of productivity growth, perhaps on the order of two-thirds of a percentage point, would disappear once the Chinese move to chain-weighted indexes.

Nordhaus also pointed out that the output indexes used by the authors need to take into account differences in price levels across regions and firms. It is not clear what methodology Chinese officials follow to deal with this issue, and no method is completely satisfactory. For example, the

methodology based on the consumer price index, where each model has to be matched by outlet, has difficulty dealing with such differences.

Nordhaus remarked that cross-country comparisons of the level of productivity, and by implication estimates of the rate of convergence, are even more problematic than within-country comparisons. The authors do not attempt to adjust for the difference between purchasing-power-parity (PPP) and market exchange rates. In the case of China, it seems likely that using the market exchange rate underestimates productivity and overestimates the gap between China and the industrial frontier, especially for industries that produce mostly nontradables. A further difficulty in the level comparisons is that domestically supplied inputs, such as structures, are likely to be undervalued. Nordhaus noted, however, that the available PPP data for China are far out of date: the Penn World Tables base their PPP estimates on Irving Kravis's data from 1975, with some updates, including from a bilateral city comparison from 1993 between Hong Kong and Guangdong; a scheduled ten-city study is still pending. Without more recent data, reliable PPP adjustments are not feasible.

David Backus thought it would be interesting to decompose productivity growth in Chinese industry into components that capture changes due to firm entry, and components that capture exit changes in surviving firms. He mentioned studies by Jan de Loecker and James Schmitz, Jr., that looked at productivity changes following transitions that made the environment more competitive. Both these authors found not only that some of the least productive firms exited, but also that relatively unproductive firms became more productive. Backus wondered whether changes in regulations in China had had similar effects and had resulted in less dispersion in productivity at the industry level. Also, given the large dispersion in firm productivity within industries, it would be interesting to know whether the low-productivity firms in the present authors' sample also have bank ties of the kind explored by Wendy Dobson and Anil Kashyap in their paper in this volume.

Wendy Dobson wondered whether the Chinese authorities are today actually devoting resources to the creation of new knowledge, or if they are still primarily preoccupied with catching up with the existing stock of knowledge. Gary Jefferson replied that his impression was that the Chinese authorities' intention is to put more emphasis on creation of new knowledge. Indeed, from the patent data it seemed that the firms themselves are focusing more on invention than they have in the past.

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