Comment on "Innovation, Competitiveness, and Growth: Korean Experiences," by Sungchul Chung

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Roughly half of cross-country differences in per capita income and growth are driven by differences in total factor productivity associated with technological progress. What roles does innovation play in development?[1] What makes it possible for countries like the Republic of Korea, in less than two generations, to move from a traditional agricultural society to a technologically advanced industrial society competing with advanced industrial economies? What are the factors that allow sustained technological change and productivity increases so that industrialization and development can take place over long periods? Fundamentals such as macroeconomic stability, a developed financial sector, protection of property rights, and adequate provision of public goods (such as education) are important both for investment and for innovation, but political factors such as strategies to avoid entry barriers erected by the West also play a major role (see Amsden 2001).

What are the main sources of innovation? Investment climate surveys for East Asia (Cambodia, Indonesia, Malaysia, Thailand, and the Philippines) show that more than 40 percent of enterprises cite technology embodied in new machinery or equipment (most of which probably is imported) as their most important source of technological innovation. The next two most cited sources of innovation—innovations developed in cooperation with client firms and the hiring of key personnel—were cited by 13 percent of firms, while innovations developed or adapted within the firm were cited by 12 percent of firms on average, which is only about one-quarter of the number citing new machinery and equipment (Gill and Kharas 2006). Ayyagari, Demirgüç-Kunt, and Maksimovic (2007) study the correlates of firm innovation and dynamism in a worldwide sample of firms and find that core innovation increases with firm size and with high-capacity utilization, taken to indicate high growth opportunities, while it declines with firm age (that is, younger firms are more inno-

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vative). These broader measures of innovation are not closely related to income per capita, suggesting that given favorable economic and institutional conditions, firms can be highly innovative and dynamic in even the poorest economies. Formal research and development (R&D) and sophisticated innovations that lead to patents are quite different in this respect, tending to rise sharply with income per capita. There is a strong negative association between state ownership and innovation, but there is no discernible difference between whether a firm is a domestic or a foreign privately owned firm. There is also a strong association between innovation and external financing (equity finance, local or foreign-owned commercial banks, lease finance, investment funds, trade credits, and funds from family and friends), corroborating the importance of financial sector development for innovation, which is mentioned in the paper by Philip Lane. Finally, there is a positive statistical association between innovation and the extent of competition faced by enterprises.[2]

The Korean Experience

Korea is one of the most successful cases of industrialization and growth. Over the past 50 years, Korea has achieved remarkable growth of gross domestic product (GDP) and has performed impressively on industrial upgrading, moving into industries such as automobiles and semiconductors.

The paper by Sungchul Chung offers an overview of the role of innovation in the process of Korea's development. In his masterful summary, Dr. Chung states that the key factors most critically linked to what he calls the Korean innovation system are (1) its relatively educated labor force, which provided a strong base for industrialization at the beginning of the process, (2) the export orientation of Korea and its outward-looking development strategy, (3) strong government intervention and control, and (4) the fact that industrial policy was heavily based on large firms (chaebol), thus allowing economies of scale and scope. Dr. Chung makes the point that Korea's industrialization proceeded from imitation to innovation using informal channels in the first stage of industrialization with virtually zero foreign direct investment (FDI) and using only long-term loans to finance the import of capital goods and technology (which it then later reverse-engineered). There was a remarkable increase in R&D spending during the 1980s, which can be explained by world market competition (which put pressure on Korean industries to be competitive) and the ability of the system to respond to this continuous demand for innovation (the famous "treadmill" of capitalism) because a disciplined and well-trained labor force was available and both government and private industry were willing to pay for it since it was in their collective interest to do so. The result, as we know, has been the international prominence of Korea in key sectors such as automobiles, semiconductors, and telecommunications equipment.

Dr. Chung mentions three vulnerabilities. First, Korea spends a large share of GDP on R&D, but it lags far behind advanced industrial countries in the cumulative R&D stock. Second, while applied sciences and industrial technology development have been given incentives, scientific research has been neglected. Korea is weaker in basic sciences and needs to strengthen university research. Third, the reliance on chaebols has made the innovation system vulnerable in two ways. There is no strong foundation for the long-term development of science and technology, and the R&D system reacts in a knee-jerk fashion to sudden changes in the international and national business environment. For instance, the system might have collapsed if the government had not intervened (by injecting R&D funds) to rescue it after the financial crisis of 1997.

Learning from the Korean Experience

There are two fundamental lessons that developing countries can draw from the remarkable Korean experience. First, at every point of its development, Korea more or less followed its comparative advantage. In the automotive sector, for example, early on, Korean manufacturers concentrated mostly on the assembly of imported parts, which was labor intensive and in line with their comparative advantage at the time. Similarly, in electronics, the focus was initially on household appliances, such as televisions, washing machines, and refrigerators, and then moved to memory chips, the least technologically complex segment of the information technology industry. Korea's technological ascent has been rapid, but then so has its accumulation of physical and human capital, largely due to the conformity of Korea's main industrial sectors to the existing comparative advantages and hence to changes in underlying comparative advantage.[3]

Second, growth was facilitated by an active industrial and trade policy. Korea protected certain sectors with high trade barriers and, in some cases, took an aggressive approach to upgrading into capital-intensive industries. Equally important, the Korean government had a record of managing protected sectors in ways that kept them subject to market discipline, which made it impossible to deviate far from the economy's comparative advantage. Industries benefiting from protection and subsidization were required to prove on export markets that their competitiveness was increasing over time. In addition, the government worked hard to make sure that Korean manufacturers could access intermediate inputs at world prices, for example, through duty-exemption schemes and export-processing zones. So the government clearly recognized that comparative advantage mattered and that successful technological upgrading depended on firms being influenced by world prices on both inputs and outputs. The evidence indicates that the Korean government served as a "facilitating state."

Importing technology from abroad and conducting domestic R&D are mutually supporting elements in national development strategy. It is a mistake to think that poor countries (such as Korea in the 1960s) can rely entirely on technology transfer from abroad, while more developed countries (such as Korea in the 1980s) can switch entirely to domestic R&D. Both are necessary at all levels of income, although the balance between the two may change. Even in poor economies, some indigenous innovation effort improves the country's capacity to absorb knowledge from abroad. As countries approach the global technology frontier, their expanded domestic R&D efforts draw even more intensively on the stock of advanced scientific knowledge in the world (see Stern, Dethier, and Rogers 2005).

Spending on R&D

Over the last decade, R&D spending grew much more in East Asia than in any other world region. But disparities in R&D spending between economies in the region became even wider. On the one hand, economies such as Korea, Singapore, and Taiwan, China, now devote more than 2 percent of GDP to R&D, among the most intensive R&D efforts in the world, with the business sector generally conducting more than two-thirds of R&D. China has also been rapidly boosting its R&D spending toward an official target of 1.5 percent of GDP. On the other hand, middle-income economies such as Indonesia, the Philippines, and Thailand spend a miniscule 0.2 percent of GDP on R&D, which is low relative to other economies at similar levels of income per capita.

Many studies document high social rates of return to R&D spending in developed Organisation for Economic Co-operation and Development (OECD) countries. Recent World Bank research suggests that social returns to R&D are even higher in developing than in developed countries. Why then are there such large disparities in R&D spending within East Asia and around the world? Part of the answer derives from the peculiar *nonexcludability* characteristic of knowledge, which makes it difficult for investors in business R&D to establish property rights over knowledge under the best of circumstances, but especially when the legal and institutional framework for protecting intellectual property rights is significantly weaker in some economies than in others. Being a type of investment, business R&D spending is also affected by cross-country differences in many standard factors affecting investment, for example, the extent of financial sector development, macroeconomic volatility, and the cost of capital, as well as by differences in the quality and availability of complementary factors of production, notably the level of education of the workforce (human capital) and related factors, such as the quality of academic R&D.

The main method of measuring the relationship between innovation and economic growth was suggested by Griliches and his collaborators. To measure the R&D elasticity of total factor productivity, they calculated the growth rate of total factor productivity (TFP) and related this to changes in the stock of R&D (see Griliches 1998).

The evidence (Bosch, Lederman, and Maloney 2005) shows that R&D rises exponentially with the level of development, measured by GDP per capita. Taiwan, China, and Korea in East Asia, Finland and Israel among the industrial countries, and even China and India (which experienced a takeoff that dramatically diverged from the median trajectory observed in the global data) are the "innovation overachievers."

The literature that estimates the social rates of return to R&D for developing countries is extremely thin. The main study, Bosch, Lederman, and Maloney (2005), suggests that R&D in developing countries is not necessarily insignificant relative to the size of their economies and, more importantly, that returns are substantial and generally above those for industrial countries. Exploring the determinants of R&D across countries and over time, Bosch, Lederman, and Maloney find that the depth of domestic credit markets, educational variables, the extent of protection offered to intellectual property rights, the ability to mobilize government resources, and the quality of complementary academic institutions influence cross-country differences in R&D; taken together, a subset of these variables completely eliminates the apparent effect of the level of development on R&D effort.

Patents

East Asia—and Korea in particular—has made huge progress in making innovations that advance the global frontier of knowledge, using patenting in the United States as an index. East Asian patenting per capita is closely related to patterns of R&D intensity, growing, on the one hand, in Korea and Taiwan, China, at a pace about four times that in the developed world and reaching levels that are not too distant from developed-country averages, while remaining, on the other hand, negligible in most of the middle-income economies in Southeast Asia and practically nonexistent in low-income economies. Patent citation analysis shows that not just the per capita quantity but also the quality of patents in the most advanced innovators like Korea and Taiwan, China, is now approaching developed economy levels.

Analyzing the technical and scientific citations made by East Asian patents in order to trace the international knowledge flows on which this high-level type of domestic knowledge creation is based, Gill and Kharas (2006) find that East Asian patented innovations continue to draw heavily on knowledge flows from the United States and Japan. But citations to other "compatriot" patents from the same East Asian economy or to other East Asian economies are rising quickly, indicating that East Asian national and regional knowledge stocks are now providing an indigenous or regional foundation for new innovations and for cross-border knowledge flows.

Policy Issues

Three main factors foster domestic innovation as well as knowledge absorbed from abroad, namely (1) the overall business environment for innovation, including macroeconomic stability, financial sector development, intellectual property rights, and the quality of the information and communications technology infrastructure; (2) human capital development; and (3) direct government support for innovation activities, including government funding for public sector and university R&D, fiscal subsidies and tax incentives for business R&D, fiscal incentives for FDI, and policies aimed at promoting FDI-related technology transfers.

I do not have enough space to discuss each one of these factors in detail, but I will say a few words about education and government support, which Dr. Chung identifies as vulnerable.

Higher education is increasingly becoming a critical factor for innovation, but the efforts to improve higher education are not uniform across countries. The proportion of adults with higher education tends to rise more than proportionately with income. Korea has managed to increase higher education more rapidly than the average newly industrialized economy. Korea is also ahead in terms of quality of education (measured, for instance, by math and science scores). For example, in the OECD's Program for International Student Assessment for mathematics proficiency, Korea has always been among the top five countries in a sample of 40.

The rationale for direct public interventions to foster domestic innovation or technology transfer from abroad (typically through targeted fiscal incentives or regulations) derives from the fact that they help to offset various types of *market failures* associated with knowledge, which makes it difficult for private firms to appropriate all the returns from their R&D investments and may result in the private sector undertaking inadequate innovation activities. Nonexcludability (or nonappropriability) is likely to be particularly significant for basic research that provides the early seeds for a variety of innovations by many firms or that helps countries to access the global pool of knowledge.

Support for Science and for University and Public Sector Research

A significant body of evidence indicates the positive effect of R&D funded or performed by universities and the public sector on both overall productivity and business R&D. The positive impact of university and public R&D stocks on productivity growth in OECD countries is larger than that of business R&D stocks. Nonbusiness R&D spending also has a large and significant impact on the growth of business R&D stocks in OECD countries. However, there are two caveats. First, the impact of public and university R&D is likely to depend on the quality of links between these sectors and the business R&D sector, which uses the results of more basic research to develop commercially valuable innovations and products. Second, a greater volume of public sector R&D can "crowd out" business R&D by pushing up wages for scientific and technical staff. The latter could be a particular concern in developing countries where such specialized skills are in scarce supply. At least for OECD countries, the overall impact of nonbusiness R&D on business R&D remains significantly positive, even after taking crowding-out effects into account (see Gill and Kharas 2006).

For developing countries, Lederman and Maloney (2003) have found that the perceived quality of research institutions such as universities and public research institutes has a significant, positive impact on overall R&D intensity in both developed and developing countries, as does the perceived quality of the interaction between these institutions and the private sector. They also have found that these two factors have a significant impact on the productivity of R&D in developed and developing countries. There are significant disparities in the quality of scientific-academic research institutions and the quality of university-industry research collaboration, with Korea and the other newly industrialized economies scoring significantly higher than other Southeast Asian economies and China. To ensure that public research efforts yield good results, policy makers need to be concerned not only about adequate funding and good public-private links, but also about whether public funding is allocated between various research areas using transparent, competitive, and merit-based procedures, according to criteria that strike an acceptable balance between short-term commercial interests and longer-term needs.

Fiscal Subsidies and Tax Incentives for Business R&D

There is a theoretical rationale for such fiscal measures as a means to counteract market failures related to knowledge. There are also serious informational and incentive problems in implementing such policies, and the limited amount of empirical work does not yield a consensus on their overall effectiveness.

Among the practical difficulties, two stand out. First, governments are unlikely to have any special information about which particular sectors might yield the largest knowledge spillovers from innovation and which therefore might merit fiscal incentives. In the face of these severe informational problems, government policies to “pick winners” could conceivably lead to outcomes that are worse than those of purely private decisions about R&D investment that, by definition, remain unconcerned about externalities and market failures (Pack and Saggi 2006). Reviewing research on the effectiveness of preferential industrial policies in Japan, Noland and Pack (2003) conclude that these policies tended to concentrate on declining sectors rather than on industries experiencing rapid technological change or increasing returns and had no noticeable impact on national or sectoral growth rates of total factor productivity. On reviewing research for Korea, they conclude, “The evidence does not support the notion that selective intervention had a decisive (or even necessarily a positive) impact on the Korean economy.” A “new” industrial policy should no longer aim to “pick winners” or sectors, but should instead be targeted at key activities that are likely to be underprovided or underperformed because of specific market failures, for example, through a generalized tax credit that does not discriminate across sectors or support for adaptation of foreign technologies to local conditions.

The second major difficulty is that a program of fiscal incentives for innovation can easily become a gateway for corruption and rent seeking. It is thus not clear if the social gains from a fiscal incentives program would offset all the compliance and administrative costs associated with it.

Cross-country experience with fiscal incentives for innovation has not been studied much until recently. In a review of the empirical literature, García-Quevado (2004) finds there is not yet a consensus on the effectiveness of public R&D subsidies. A number of studies find that such subsidies do have a significant positive impact on business R&D, but the impact declines after a certain point and even becomes negative, so that subsidies are substituting for private financing that would have been used in the absence of the subsidy. R&D subsidies have a slightly negative impact on growth in business R&D stocks, evaluated at the mean for the sample of OECD countries. The evidence seems clearer on the effectiveness of R&D tax credits. Changes in R&D tax credits have a large impact on the user cost of capital for R&D, and the long-run elasticity of business R&D with respect to tax incentives may be substantial, on the order of –1. While such analyses suggest that tax incentives are effective in stimulating business R&D, they do not, however, necessarily prove that they would be welfare enhancing overall. A full cost-benefit analysis would also need to account for the alternative uses to which the forgone tax revenues could have been put, the administrative costs of the R&D tax credit system, and the various distortions that the tax scheme could itself introduce.

Notes

1. The traditional definition of innovation processes includes not only new products and new technologies, but also activities that promote knowledge transfers and adapt production processes. Knowledge has distinctive economic features that create specialized preconditions for innovation activity. The partial nonexcludability of knowledge creates a need for specialized intellectual property rights regimes that allow inventors to recoup the rewards from risky innovation investments.
2. Ayyagarı, Demirgüç-Kunt, and Maksimovic (2007) investigate the determinants of firm innovation in more than 19,000 firms across 47 developing economies. The authors find that more innovative firms are large exporting firms characterized by private ownership, highly educated managers with mid-level managerial experience, and access to external finance. In contrast, firms that do not innovate much are typically state-owned firms without foreign competitors. The identity of the controlling shareholder seems to be particularly important for core innovation, with those private firms whose controlling shareholder is a financial institution being the least innovative. While the use of external finance is associated with greater innovation by all private firms, it does not make state-owned firms more innovative. Financing from foreign banks is associated with higher levels of innovation compared with financing from domestic banks.
3. Justin Lin makes this point in Lin and Chang (2009).

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