THE GROWTH DIALOGUE

April 2012
Number 8

POLICY BRIEF

The Changing Landscape of Innovation after the Economic Crisis: Notes from the Paris Symposium

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Note: This paper draws on presentations from the Paris Symposium, sponsored by the Growth Dialogue, OECD, and the World Bank Institute, January 19–20, 2012.

The past five years have witnessed a worldwide increase in science and technology (S&T) capacity. The gains are most evident in Asian countries relative to North America and Europe. Asia equaled North American outlay on research and development (R&D) in 2009, and most observers forecast that the advanced countries will continue losing ground.[1] The biggest gainer is likely to be China, which has raised its expenditure by about 10 percent annually over the past few years and is targeting a 2.2–2.5 percent share of GDP for R&D by 2020.[2] By then it expects to have surpassed the projected R&D conducted by the United States, as well as the U.S. output of scientific papers and patents. In this respect at least, the research capacity landscape is changing, and the crisis, by tightening government budgets and forcing Western countries to cut spending, is accelerating the process.

Middle-income Asian countries and a few in Latin America and Eastern Europe, which have experienced a slowing of growth in recent years paralleled by declining investment,[3] are seeking an alternative engine of growth. They are targeting aggregate growth rates of 5–6 percent per year over the medium term with the help of 'new' industrial and innovation policies that could yield sustainable gains in productivity. Countries such as Malaysia, Thailand, and Vietnam, which invest 1 percent or less of GDP in research, are all introducing policies that will bring them closer to the OECD average of 2 percent of GDP within a decade.

The Asian and other middle-income countries have set themselves ambitious targets of total factor productivity (TFP) growth of 2.5 percent and more per year. These targets will be difficult to reach, if their own track records of the recent past

1. See Mervis (2012). In most OECD countries, the crisis of 2007–08 resulted in a contraction of R&D and in the supply of venture financing in 2009. Although spending on research, particularly by large multinational corporations (MNCs), recovered in 2010, smaller firms that are unable to access public resources continue to skimp on R&D and the entry of firms in high-tech sectors has not returned to precrisis levels. See Paunov (2012).

2. In 2011, China's spending on R&D amounted to 1.76 percent of GDP.

3. Cheung, Dooley, and Sushko (2012) find that the impact of investment on growth could be weakening so a revival of investment may be less effective in raising growth.

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(except China) and European experience are any indication.[4]

Western countries are also keen to sustain or increase the share of research in GDP. However, they will be hampered by budgetary constraints, demographic trends, the continuing decline of R&D-intensive manufacturing activities, and the transfer by MNCs of R&D[5] to industrializing countries.

The changing S&T landscape is of considerable interest in its own right. However, much more important from the standpoint of sustainable growth and welfare is its implications for innovation and how innovation affects growth rates. R&D spending complemented by an increase in the quantum of S&T skills, correlates with the output of scientific papers and patents. But the impact of R&D spending and of tertiary-level skills on productivity growth depends upon a number of factors and it can be quite small. Countries that invest an additional 1 percent of GDP in research can expect to gain no more than a fraction of 1 percent in TFP growth per year—possibly as little as 0.1–0.2 percent depending on the sophistication and flexibility of national innovation systems. Even this could be squeezed if fixed capital accumulation and the share of the manufacturing sector shrink further, as they have in several middle-income countries.[6]

The symposium identified a number of issues relevant to R&D policy, among which the following four are uppermost:

- Is it meaningful for countries to target R&D spending in order to raise growth and do they have the policy instruments to achieve results?
- Does the composition of R&D spending count (for example, basic vs. applied; manufacturing vs. services; high tech subsectors vs. others) and can this be influenced by policy?
- How might policies enhance the potential of R&D to stimulate innovation[7] (by inducing the entry of new firms) and the productivity of spillovers from innovation?
- In a world where research activities are integrated and globe spanning, does it matter for innovation and productivity gains in any one country, where research is actually conducted?

In addressing these questions, symposium participants helped to flesh out some of the answers, identified the issues deserving further attention, and illuminated the known unknowns.

The Absence of Scientific Criteria for Targeting R&D

The symposium reaffirmed the importance of S&T policies and the central role of quality R&D activities but it also drew attention to the absence of scientific criteria for targeting R&D.[8] There is no evidence that Japan's 3.4 percent of GDP outlay on R&D is closer to the optimal for a middle-income country than the 2.7 percent invested by the United States. Much depends upon hard-to-measure R&D absorptive capacity, corporate strategies, market competition, the supply of risk capital and its uptake, the domestic macroeconomic environment and the state of the global economy. In many low- and middle-income countries the absorptive ca-

4. Peak TFP growth rates between 1995 and 2009 were less than 3 percent for almost all OECD countries—the Republic of Korea and Ireland being the exceptions. Even China's TFP growth has been declining since 2001 and is currently in the range of 2.7 percent per year. See Chen, Jefferson, and Zhang (2011).

5. In most instances, MNCs are transferring testing, product development for local markets, and downstream, applied research.

6. See Comin (2004) and CBO (2005).

7. Policy makers in developing countries are also attempting to make innovation more inclusive.

8. In this context, see Leydesdorff and Wagner (forthcoming) who attempt to gauge the relationship between research spending and output.

pacity is slow to materialize. Even when top-down directives to increase research backed by incentives to patent and publish—as in China and Singapore—produce many more scientific papers,[9] their consequences for growth can be negligible. Furthermore, in most countries, 60 percent or more of the applied research and development is by the private sector and companies will increase R&D only if it is in their interests to do so[10]—as the European countries have discovered.[11] China, with its large public sector and many government-controlled state-owned enterprises (SOEs) and research entities, can raise research activity according to plan, but few countries have the policy levers to bring about a 1 percent of GDP increase in R&D over a 10-year period. Even China took a good 10 years to achieve this outcome.

R&D spending does not automatically produce innovation. Creating a steady innovation pipeline takes time and the patient building of linked academic and corporate research that helps generate, seek,[12] and transform ideas with the government serving as a sort of midwife. Most middle-income countries are struggling to create such cultures. Thus far, few (or none) have transformed their universities into world-class institutions or built corporations that peg their international competitiveness to innovation. It is difficult to name a company from a middle- or low-income country that is an outstanding and consistent innovator in any sphere—although Huawei of China may soon join that league.[13] At best they are highly competitive, low-cost producers, some with the capacity for incremental process innovation. They have mastered the art of manufacturing and integrating with global value chains primarily serving developed-country markets.

Middle-income countries are finding that they need to increase both the number of graduates with S&T skills and the quality of training imparted because it is the latter that promotes good research.[14] But virtually all are failing to raise quality even as they expand enrollment. University reform and innovation in pedagogical practices are not keeping pace with expansion. Universities in aspiring innovators such as Malaysia, Vietnam, South Africa, and Brazil are seldom able to attract the best students into the teaching profession and into academic research. Hence the hunt is on for trained faculty from advanced countries and collaboration with the leading Western schools. In India, for example, a third of the faculty positions are vacant with more to follow as ageing instructors retire.[15] In South Africa,

9. Publication in catalogued journals by Asian researchers has been promoted by financial and other incentives and by the surge in scientific publications from Asian countries. See Wagner (2011).

10. The top spenders on R&D are not the ones with the best financial results. See Jaruzelski, Loehr, and Holman (2011).

11. Surprisingly, given the high private and social returns to R&D computed by economists, many companies prefer to maintain huge cash stockpiles that deliver negligible returns rather than invest a portion in their research activities. See Wieser (2005).

12. Kodama and Suzuki (2007) describe the "receiver active" approach of Japanese firms that actively look out for research that dovetails with and enhances the value of their own.

13. The Boston Consulting Group assembles a list of "New Challengers" that identifies rising firms from the MICs. The 2011 report (Boston Consulting Group 2011) identifies an imposing list of firms some of which are active incremental innovators but innovation is not as yet their strong suit.

14. This extrapolates from the link found by Hanushek and Woessmann (2007) between the quality of education as measured by test scores of secondary school graduates and GDP growth. It is also intuitively plausible.

15. A report by India's leading scientist C.N.R. Rao, a chemist by profession, observed that "India's laboratories are rife with mediocrity and its universities are in decay." Moreover, Rao remarked "In any given area of science or engineering, the number of experts is rather small in India…. I don't think that a professor in a university in any state in India has the freedom to think properly because he is completely cowed by the atmosphere" (Bagla 2012: 157).

well over a third of the faculty is approaching retirement and replacing them with equally talented teachers is proving to be a challenge.

To translate good ideas into innovation requires a deepening of entrepreneurship. Entrepreneurial talent appears to be relatively abundant in China and India. Elsewhere, including in the advanced European countries, there is a perceived dearth of entrepreneurial initiative and of young leading firms ("yollies") in dynamic industries.[16]

Determining the Composition of R&D for Innovation

With the benefit of hindsight we know that the composition of R&D has long-run implications for innovation, but determining the composition is difficult. Nevertheless, foresight analysis and Delphi (software) techniques have proven helpful in Japan and the United Kingdom in identifying priorities, evolving coordinated policies, and winning commitment.[17] Doing basic research in the 'right' and technologically most promising areas[18] is clearly advantageous. The problem, however, is to decide how much funding to allocate for basic research and of what sort (here foresight analysis is not helpful) and how to distribute the funds among universities, research institutes, and corporations. The United States devotes 18 percent of its spending to basic research. China devotes only about 6 percent of GDP, but with a per capita GDP of US$4,500, China may be spending wisely today. As it grows richer, it could rightly divert more resources into basic research but there is no fixed target to aim for.

16. See Veugelers and Cincera (2010).

17. See Martin and Irvine (1989). Forecasts have in some instances morphed into national research objectives and what started out as a forecast became a self fulfilling prophecy.

18. The most R&D intensive industries are identified by van Pottelsberghe (2008).

Formal R&D has traditionally been fostered by the manufacturing sector. Electronics, pharmaceuticals, chemicals, advanced materials, and automotive industries have proven to be among the most research-intensive and innovative sectors and have achieved the highest rates of productivity growth (Roche Holdings led the field in 2010, surpassing Toyota, which had been largest spender for a number of years). But in all advanced and most middle-income countries, the share of manufacturing in GDP is a fifth or less. This trend is likely to persist, with manufacturing's share of GDP possibly settling around 14 percent a decade from now (it was 17 percent in 2009, ranging from 12 percent in low-income to 21 percent in middle income countries). Although the multiplier effects of product and process innovations could remain sizable, its effects on TFP and on growth are likely to become progressively smaller. Some researchers worry[19] that substantive product innovation is becoming less prolific because the current general-purpose technologies (GPTs) are tapped out. Incremental innovations in electronics (opto and other), nanotechnology, and pharmaceuticals are yielding less bang for buck and much-touted green technologies still account for only a tiny share of total patents (a leading indicator of potential innovations).

Looking ahead, countries may have to rely more on innovations in services, design, marketing, finance, and organization that are increasingly important as services come to dominate GDP in all countries. Thus far, few companies from middle- and low-income countries have demonstrated much competence in this regard, even those that have shown a capacity to reverse engineer complex equipment and products and

19. See Huebner (2005); Cowen (2011). Arthur (2011) notes that a lot of innovation might now be happening somewhat unseen because it is prompted and mediated by digital technologies and artificial intelligence (AI).

subsequently incorporate some incremental innovation. There is a lot of learning to be acquired before the habit of innovation catches on, markets mature, and consumers demand such innovation.

Companies in the Republic of Korea; Taiwan, China; and Singapore provide some insight into the difficulty of maintaining innovation. These three economies broke away from the middle-income pack, joined the ranks of high-income countries, and nurtured world class companies. However, the business school literature offers few case studies extolling their soft innovations—or even breakthrough product innovations. Samsung and Taiwan Semiconductor Manufacturing Company (TSMC) come to mind immediately, but it is difficult to find other names to extend the list.[20]

Innovation in services is (formal) R&D intensive *lite* and until recently, the productivity of most services has benefitted less from innovation.[21] In particular, the productivity of the fastest-growing services segments such as government, health, education, construction, security, and hospitality has increased slowly if at all.[22] The question that arises is should countries continue to emphasize R&D for the purposes of product innovation and in the hope of uncovering new GPTs? Perhaps they should recognize that the big future gains lie in services, desist from pushing conventional R&D, and incentivize innovation in services. If so, we need to identify the policy levers (other than standard competition and trade polices) that will promote such innovation.

Fiscal Incentives and Institutional Reforms to Stimulate R&D and Encourage Patenting

Stimulating R&D and encouraging patenting are steps down the road to an innovative economy. These activities can be promoted through fiscal incentives and institutional reforms that seek to optimize intellectual property protection. More ambitiously, governments are pursuing innovation policies[23] that attempt to craft open and globalized innovation systems around a "triple helix" composed of the government, business, and academia. In this context, much emphasis is placed on the need to strengthen the individual elements and the connectedness among them. Many countries are attempting to build 'world class universities' and to create university industry linkages. However, progress in the Russian Federation, South Africa, Brazil, Mexico, and Malaysia—the only worthy contenders—has been imperceptible. Venture and angel financing, also a priority, has been slow to materialize. Only China stands out from the rest. In China, a systematic effort to stimulate R&D and patenting began in the 1980s. It was underpinned by steadily increasing funding, and complemented by overseas training and a tremendous growth of manufacturing. China's efforts appear to be producing an abundance of the precursors of innovation—patents and papers and a manufacturing sector, parts of which are approaching the technology frontier. But China is some distance from

20. Undeniably, numerous companies from these economies are operating at the technological frontier and many are responsible for incremental innovations in a number of manufacturing subsectors. A company such as Foxconn/Hon Hai dominates the contract manufacturing business worldwide, but is not associated with a new business model or with disruptive innovations. Nor are such firms as Acer, Asus, MSI, and HTC, all successful electronics producers, creating innovation.

21. The productivity gap between manufacturing and services was first highlighted by Baumol (1966). See also Nordhaus (2006) and Neilson (2008).

22. Jorgenson showed that the construction and health sectors generated negative productivity growth in the United States between 1960 and 2007.

23. These are the lineal descendants of the much-debated industrial policies of old, and are now making something of a comeback by way of functional, matrix-based industrial initiatives.

its goal. The innovation system as a whole is weakly interconnected. There remain quality issues with the scientific papers and with the patents, and corporate culture has still to embrace competition strategies hinging on innovation. How quickly the quality issues will be resolved and an innovation culture displaces a culture of imitation is a big unknown. Top-down S&T policies are not necessarily the most effective and the continuing dominance of SOEs does not help the cause of innovation. These behemoths do follow government signals and invest in R&D but they are frequently risk averse and not quick to innovate.[24]

It needs noting moreover, that China's is a qualified openness. The social sciences and the liberal arts are less open to ideas and thinking from elsewhere than the 'hard' sciences. This could slow innovation, because it is now about more than a product. To succeed, innovation is increasingly packaged with complementary advances in design and services. China could prove us all wrong, but the jury is still out. The country is rapidly acquiring research capacity but has yet to embrace an open, internationally collaborative[25] innovation system and to significantly affect the global landscape of innovation as distinct from R&D.

In fact, juxtaposing China's efforts and achievements to date with the experience of advanced countries highlights a number of characteristics of innovative societies.

- They are open societies, hospitable to diverse ideas and which encourage lateral thinking.
- They recognize that the future of scientific discovery and innovation lies in large-scale international collaboration with the help of advanced software and "thick" networking.
- Their economic activity is dominated by internationally competitive firms large and small that depend for survival on ceaseless innovation, and the churning of firms results in desirable entry, creative destruction, and exit.
- Their private sector recognizes that business failure is the rule, not the exception; risk taking is the norm; and failure is widely tolerated.
- They have a deeply embedded entrepreneurial culture, and, as industry has become more technology intensive, the university system is seen as both a source of ideas and a breeding ground of entrepreneurs who transfer ideas to the marketplace.
- They have created a plethora of institutions to reward, market, and finance innovation through risk capital, for start-ups and supporting services, which enable new companies to survive the difficult birthing process and infancy.
- Finally, they have succeeded in creating clusters of manufacturing firms or services providers in major cities—often adjacent to research universities—with the help of regional or municipal policies, assisted by a chain of serendipitous events.

The Speed of Research Diffusion and Possible Benefits of More Selective R&D

There is a body of research showing that the latest research findings diffuse slowly and that this privileges for several years the country or region where new ideas are being generated. But MNC-dominated research networks now straddle the world, and more academic research is being conducted by transnational teams. Thus, research findings are likely to diffuse with greater rapidity and

24. The innovation value chain is complex and China is not alone in its struggle to master its workings. See Roper, Du, and Love (2008).

25. This too is changing. Many Chinese labs are working closely with and under contract from foreign entities, for example, in the area of gene sequencing. See Normile (2012)

perhaps it matters less how much any one country spends on research. In fact, if we do believe that a globalized innovation system has emerged (and many do not[26]), then all countries would benefit if the activity of research is guided by the supply of research skills, enabling institutions, and state-of-the-art research infrastructure. Globalization calls for greater selectivity and specialization and a division of labor.[27] Instead of every country piling into stem cell research or nano-pharmacology, it might be better for some to concentrate on agro-biotechnology or health services and let a more advantaged country devote its resources to stem cell research. The ongoing R&D arms races seem uneconomic, especially in the light of current fiscal circumstances.

The Urban Correlates of Innovation

Last but not least, innovation has urban correlates and most if not all innovation occurs in specific urban locales. In other words, productive innovation systems are anchored to specific metropolitan areas or to regions, which over time (and rarely through long-range planning) have created a crucible in which innovation thrives.

Are such potentially innovative hotspots taking shape in middle- or low-income countries? China is trying, but other middle-income countries are making slow progress if any. Sao Paolo, Monterrey, Cape Town, and Kuala Lumpur are no closer to becoming innovation hotspots than they were a decade ago. The effort to build urban industrial clusters, frequently associated with innovation, has been ongoing for more than a decade. However, it really has not led anywhere except perhaps again in China. There is no creative cluster in a Malaysian or Brazilian city nor is one in the making. Sparse results after decades of trying might be traceable to weak policies, or it might be the case that clusters take time to materialize. Perhaps green sprouts are emerging and will begin to flower if policies supporting the demand for innovation, ameliorating risks, and rewarding entrepreneurship are sustained.

There is a shift occurring in the distribution of R&D spending and associated outputs, mostly because of the rise of China. By maintaining and refining S&T policies, a number of middle-income countries can build the desired productivity-enhancing innovation capabilities over the longer term. However, in spite of the increased speed at which technologies are currently being assimilated, this may take longer than many expect. Even if the pace of innovation, especially in services, picks up, the growth generated might well be less than what the optimists want. Perhaps expectations are pitched too high. Certainly, historical experience, global natural resource endowments, and the supply of global public goods do not suggest that the sort of growth rates being sought could be long sustained, even if achieved.

26. See Adams (2006) and Keller (2002).

27. Selectivity is vital for the smaller countries but also desirable for the larger ones such as the United States and (soon) China. See Wagner (2011).

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