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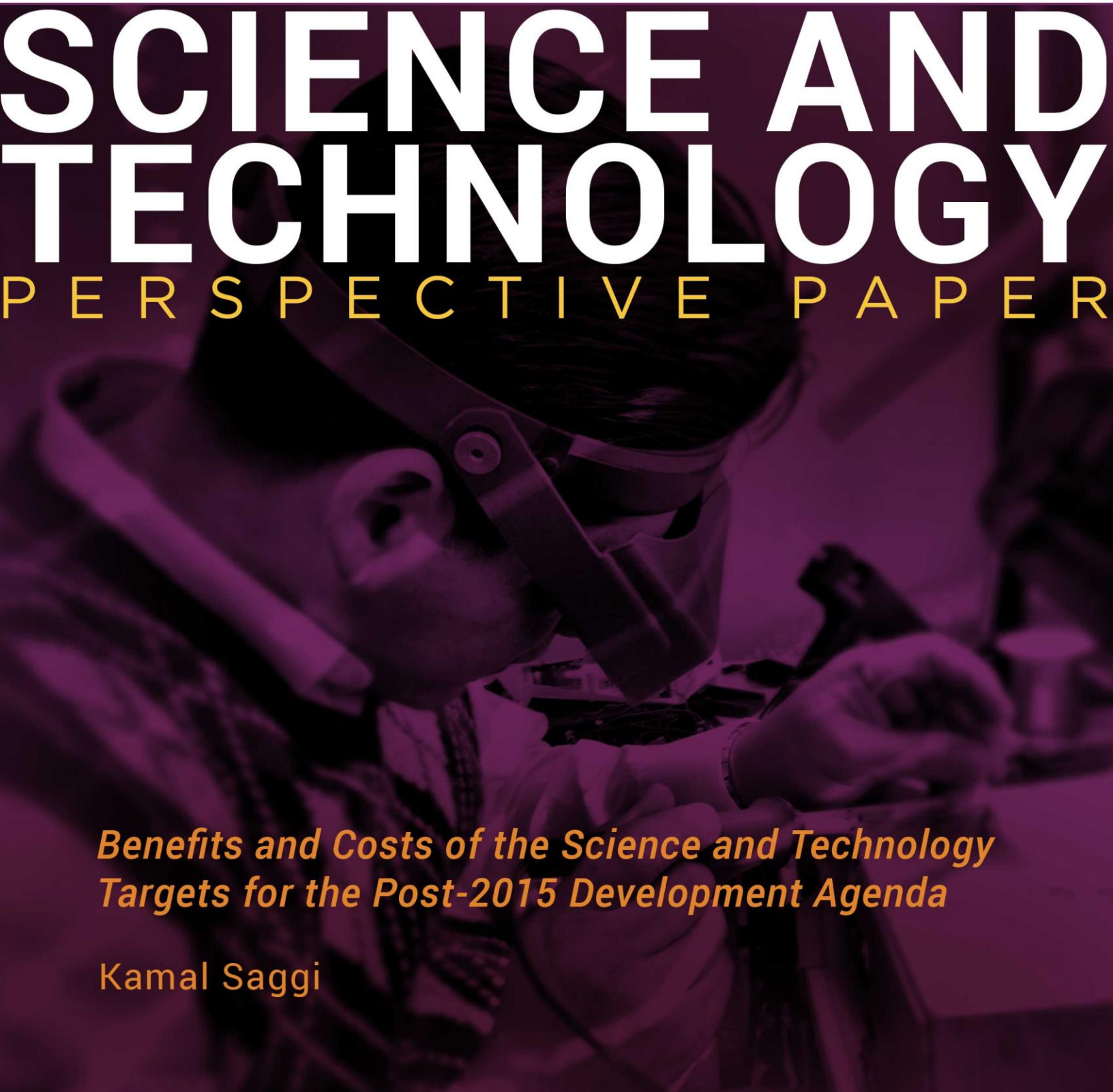

Benefits and Costs of the Science and Technology Targets for the Post-2015 Development Agenda

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Introduction

In a thought-provoking paper, Maskus (2014) considers two types of policy initiatives that could potentially help achieve the sustainable development goals (SDG) of the United Nations by facilitating international technology diffusion, access to knowledge, and growth of indigenous capacities in developing countries. In his analysis, Maskus correctly notes that these aforementioned processes are mostly market driven (although not entirely) and, therefore, the primary objective of any policy initiative ought to be "improve market and governance conditions to induce firms to disseminate technologies and undertake R&D programs that are more conducive to economic and social development (italics added)."

Maskus (2014) examines two specific types of policies. First, he considers the costs and benefits of raising R&D investment in developing and developed countries through direct governmental grants and tax credits that increase private incentives for R&D. Second, he proposes a much more fundamental policy change under which worker mobility within well defined "innovation zones" would be improved via changes in visa regulations pertaining to high skilled workers. Roughly speaking, Maskus argues that the net welfare gains of improving worker mobility are likely to be orders of magnitude higher than the net gains of raising R&D investment rates world-wide.

In this paper, I critically discuss each of these policy initiatives. My objective is to discuss the ideas contained in these initiatives at a broad level. Therefore, I have deliberately chosen to not comment on the various modeling assumptions underlying the numerical estimates derived by Maskus. Such a discussion runs the risk of becoming dry and technical and is therefore avoidable. In addition to analyzing the policy proposals made by Maskus, I argue that policy-makers in developing countries should also pay special attention to foreign direct investment (FDI) as a channel of international technology transfer. Here, I do not make specific policy proposals but rather point out the reasons why FDI can play an important role in achieving some of the objectives underlying the policy proposals made by Maskus.

Like his previous writings – such as Maskus (2000) and Maskus (2012) -- the present by Maskus paper provides a clear and convincing analysis of his chosen policy initiatives. There is little that I disagree with in this paper. My intention in writing this response paper is to push the limits of the arguments underlying the Maskus paper and to raise some further ideas for discussion and debate. Thus, my response paper should be viewed as being complementary to the Maskus paper. Furthermore, my discussion reflects my own expertise and interests which lie more on the side of R&D and technological change and less in the area of international labor mobility.[1]

[1] This is a bit ironic since I am a living example of the type of labor mobility that Maskus analyzes in his paper!

Policy Initiative I: Raising Investment in R&D

Perhaps the most important determinant of a country's living standard in the long run is its productivity (or what economists usually call total factor productivity). To raise productivity, a country needs to figure out how to make more efficient use of its existing resources. This can be done one of two ways. Either a country can continue to do what it does (i.e. produce the same basket of goods and services) but do it with fewer resources. Technological change which helps achieve this objective is often the result of investments in cost-reducing or process R&D. Alternatively, a country can boost productivity by investing in product R&D that delivers entirely new products or higher quality versions of existing products that command a better price on world markets. Of course, most countries can and usually do invest in both types of R&D and such investments are likely to be complementary in nature (although we do not have convincing evidence on this front).

While most of the global R&D is concentrated in developed countries, developing have started to increasingly invest in R&D. Is this necessary? Can't developing countries simply rely on the fruits of foreign R&D without making any such investments themselves? Following classical trade theory, shouldn't developing countries simply purchase technology from other countries that have comparative advantage in R&D?

There are at least two responses to this viewpoint. First, the prescription of efficient specialization based on comparative advantage applies only under a limited set of assumptions, many of which are not supported by empirical evidence. New technologies are rarely produced under conditions of perfect competition and the market for technology is plagued by transactions costs that stem (partly) from the presence of asymmetric information between buyers and sellers. Involvement in R&D by potential buyers can facilitate the market based exchange of new technologies by lowering transactions costs.

A second reason for conducting domestic R&D is that technological change is a dynamic phenomenon and technology acquisition is an on-going process as opposed to being a one shot decision. Not investing in local R&D may not only increase the transactions costs of technology acquisition but also force a country to bear such costs for a long time. The cumulative nature of knowledge (and technological change) creates a cross-temporal link between current and future investments in R&D and technology acquisition.

Private agents invest in R&D in order to profit from it. If first mover advantages created by R&D are small and others can easily imitate a new process or product, the incentive to invest will generally be too low. This is presumably why we have intellectual property rights: such rights grant inventors temporary monopoly power (typically 20 years for patents) by forbidding imitation and copying. To the extent that protection of IPRs has been strengthened in developing countries by the ratification of the Agreement on Intellectual Property Rights (TRIPS) in 1995, incentives for R&D should have been encouraged world-wide.[2]

[2] While the level of IPR protection in individual developing countries may not affect global incentives for R&D, the level such protection in all developing countries (as a bloc) is likely to have a significant effect on global R&D.

Maskus (2014) focuses on the input side of R&D by examining investment in R&D but does not say much about the output side. Of course, one reason for this is that it is generally much more difficult to measure the output side. After all, how does one measure an innovation? And furthermore, not all innovations are equally valuable. Nevertheless, it is useful to complement the discussion in Maskus (2014) by considering recent trends in patent applications.[3]

Global patent applications have grown rapidly during the post TRIPS era. Indeed, global patent applications in 2011 were roughly twice that in 1997. Asia has been the single biggest driver of global patent applications during the post-TRIPS era: its share of global patent applications has hovered around 50% during 1997-2011. Within Asia, the big story, of course, has been the emergence of China (something that also shows up in Maskus' analysis of R&D investment). So sharp and salient has been China's rise that patent filings in China during 2011 not only exceeded those in Japan but also the United States, making China the country with the largest number of patents filed (and granted) in 2011. Roughly 25% of all patent applications filed in the world during 2011 were filed in China. While these statistics pertaining to China's emergence are undoubtedly impressive, it is important to interpret them carefully since count data on patent applications (and grants) tell us virtually nothing about the economic values or the qualities of the underlying technologies.

Consider now the data on patents granted within Asia and the rest of the world. During 2011, nearly 1 million patents were granted world-wide with roughly 40% of them accruing to non-residents, a clear reflection of the globalization of contemporary innovation. Roughly 7.88 million patents were in force globally during 2011, over 25% of these being in the United States. From 1997 to 2011, the number of patents granted in Asia more than doubled. While more patents were granted in 2011 in all Asian countries, the sharpest increase was witnessed in China where the number in 2011 was almost fifty times that in 1997.

These sharp increases in global patenting activity nicely mirror the increases in R&D investments documented in Maskus (2014). His basic point that further increases in R&D investments by themselves are unlikely to yield large social gains seems essentially correct. But if the overall economic environment within which these investments are being made in developing countries could be improved then the R&D process could become more efficient and R&D investment more desirable. Alternatively, when viewed from the output side of R&D, the real challenge facing developing countries such as China that are heavily engaged in R&D is to raise the quality of their innovations. Raising the level of R&D investment in of itself may not raise the quality of innovation and a more appropriate policy goal for large developing countries should be to increase the productivity of local R&D as opposed to only its level. Unless the R&D process is subject to sharp increasing returns to scale, the productivity of R&D in developing countries is more likely to be determined by the availability of high quality inputs (such as skilled workers and infrastructure) as opposed

[3] The following discussion borrows from Geng and Saggi (2014).

to the level of R&D itself. Thus, in some senses, the two proposals by Maskus – increasing worker mobility and investing more in R&D – might have a complementary relationship to each other so that the social value of implementing the two together may be higher than implementing each in isolation.

Indeed, Maskus views the issue similarly since he argues in the paper that increasing R&D cannot be a goal in of itself. We care about R&D because of its impact on aggregate productivity and need to encourage it only if there exist market failures that lead to inefficient levels of R&D. For example, the market will yield too little investment in R&D if the R&D process is characterized by positive externalities. Simply put, externalities are said to characterize an economic activity if the costs and benefits of the activity are not fully internalized by those involved in it. For example, if the subsidiary of a multinational firm receives a new technology from which unrelated local agents (say in some other industries) derive some benefit, the parent firm's decision regarding the extent of technology transfer will be inefficient from a global welfare perspective since it will typically fail to account for the positive externalities enjoyed by those local agents.[4]

There are a variety of reasons why R&D investments might create positive externalities. At the most basic level, an inventor is generally unable to extract the full benefits enjoyed by consumers because third degree price discrimination (under which each consumer pays the maximum it is willing to pay for the new product) is rarely feasible. Thus, the market will yield an inefficient level of R&D simply because inventors can typically only extract a fraction of the benefits that consumers derive from their inventions.

As Maskus emphasizes, a second fundamental reason that the market may yield too R&D investment is because of positive externalities created by R&D. Due to the cumulative nature of technological change, it will generally be impossible for any inventor to fully extract the present discounted value of social surplus created by its investment. Consider, for example, the social value of the invention of electricity and the role it has played in generating future inventions. It is simply impossible for the market mechanism to fully anticipate the social value of such an invention at the time that it occurs. Sir Isaac Newton famously remarked that if he had seen further than others, it was because he had stood on the "shoulders of giants". This Newtonian insight succinctly captures the cumulative nature of knowledge and it applies to anyone and everyone engaged in R&D or the creation of knowledge.

It is clear then that markets are unlikely to yield the socially optimal level of investment in R&D.[5] If one further accepts the argument that the market errs, on average, on the side of

[4] Market failures create the *potential* for governments to play an important role in markets that create and disseminate of technology. However, to be effective government policy must take into account the incentives of private agents participating in these markets. Furthermore, the potential for welfare-improving government policy does not always transfer into the effective implementation of such policies. The domestic regulatory and political environment of a country needs to prevent policies from becoming hostage to rent-seeking and lobbying activities. Otherwise, well-intentioned policies can do more harm than good.

[5] I should note here that there also exist some good arguments as to why the market may lead to overinvestment in R&D. For example, consider a situation where a few firms engage in R&D competition where the first to make the invention reaps the rewards (guaranteed by some sort of a patent say). In such an environment, the market can yield

too little investment in R&D as opposed to too much then an argument for encouraging R&D beyond the level provided by the market naturally emerges. However, one still needs to be careful: what type of R&D should be encouraged? It is useful to remember that R&D comprises of "research" and "development" and that positive knowledge spillovers are more likely to arise in research than in development. For example, it is common for the pharmaceutical companies to point out how expensive it is for them develop a new pharmaceutical product and their critics, often rightly, point out that a significant share of the R&D cost of a typical new pharmaceutical are actually development and marketing costs that have little to do with research and also unlikely to yield significant positive externalities. Thus, any policy initiative aimed at increasing R&D stands to be more beneficial if it encourages investments in "research" as opposed to "development" where the case for knowledge spillovers and externalities seems to be weaker.

Policy Initiative II: Improving Mobility of High Skilled Workers

Maskus also correctly draws attention to the fact that the world economy has left large welfare gains on the table by not permitting relatively free mobility of skilled labor. As he notes, from a purely economic perspective, it is indeed a puzzle that "global negotiators are not focusing far more on mobility issues than on resurrecting the largely moribund Doha Round." Indeed, within mainstream economic theory the standard model of international trade starts with the assumption that labor is perfectly mobile within countries but completely immobile across countries. This standard assumption is so ingrained in the thinking of trade economists that few stop and wonder why this ought to be the case and what, if anything, should be done to change the reality it reflects.

Indeed, it is not stretch to say that the rules of the global trading system and the overall economic policy environment of the world has created a situation where capital is far more mobile across countries than labor. To an economist, this makes little sense: the basic economic case for the free mobility of labor is the same as that of the free mobility of capital – to ensure that factors of production are employed in the most productive fashion, they need to be able to move freely throughout the world. To see the strength of this argument, simply note that no serious person would suggest that the mobility of labor within countries should be restricted in any way. But the economic case for free mobility of workers across international borders is essentially the same as that within.

Maskus proposes the establishment of 10-year visas permitting free mobility of skilled (technical as well as managerial) labor among participating "innovation zones" with the idea of optimizing technology diffusion, efficiency, and learning among enterprises operating in such zones. It is no secret that even with today's efficient communication networks there is no real substitute for face-to-face interaction when it comes to the exchange of ideas among people. After all, this is one fundamental reason why we observe innovation clusters such as the one in Silicon Valley in the San Francisco bay area.

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overinvestment in R&D due to strategic competition between investors since each investor ignores the negative effect of its own investment on that of other investors.

Maskus estimates the gains from improved mobility of higher skilled workers by considering a standard competitive model wherein marginal product of labor declines in the quantity of labor in each country. When labor mobility is imperfect or restricted, the world economy can find itself in a situation where there exist large differences in the marginal product of labor in different locations. Loosening the constraint on international labor mobility allows the world economy to narrow the gap between the marginal products of labor in different locations and thereby increase world output. The model is based on the idea that the majority of observed labor productivity differences across countries are due to due to nation-specific factors as opposed to worker characteristics. For example, a worker in a country with poor infrastructure and excessive red-tape is likely to be much more productive in another country that has high quality infrastructure and a business friendly environment.

Any proposal suggesting the movement of high skilled workers from developing to developed countries has to contend with the idea that this essentially amounts to "brain drain" a phenomenon that may further impoverish developing countries. First, Maskus correctly argues that the workers that move are likely to capture a large share of the gains of improved worker mobility and if they choose to remit a share of their income to their home countries, then the adverse impact on the source countries could be minimized. Second, he points out that the idea that the loss of the best and the brightest lowers the productivity of those that do not move has not found much empirical support since "extensive empirical analysis has failed to find evidence of significant human-capital externalities, whether in production, infrastructure, or public health." Be that as it may, it is difficult to square the lack of such evidence with the value that high skilled workers (particularly in research) seem to place on proximity to other high skilled workers. I would agree that human capital externalities are difficult to quantify but I am not sure this means that they are unimportant or do not exist at all.

While the limited mobility of labor across international borders that is observed in the world today cannot be explained in purely economic terms, it can perhaps be explained in political economy terms. Indeed, international labor mobility is one part of the complex web of international relations that stretches beyond economics and is perhaps best understood as part and parcel of a grand bargain between countries.

All in all, I concur with Maskus that constraints on worker mobility are a major drag on global economic efficiency and that the world economy is leaving large welfare gains on the table by not tackling this thorny issue. The political economy considerations at play seem formidable but this need not imply that no effort should be made to take them on.

In the remaining portion of the paper, I suggest another policy domain within which government interventions in developing countries are likely to be fruitful.

How FDI Contributes to Technology Creation and its Global Diffusion

While governments across the world are involved in basic research and development (R&D) in a variety of ways, commercialization and the globalization of technology is largely in the hands of private agents, the most important of which are multinational firms. It is generally recognized that in today's global economy, trade between subsidiaries and headquarters of multinational firms, may account for one-third of total world trade. It is also well known that sales of subsidiaries of multinational firms exceed worldwide exports of goods and services so that foreign direct investment (FDI) is now the dominant channel through which firms serve customers in foreign markets.

The global stock of FDI increased from roughly $2 trillion in 1990 to over $22 trillion in 2012 (UNCTAD 2013). Over the same time period, sales of local affiliates of multinational firms increased from $5 trillion to $25 trillion. On the technology side, over the same time period, the royalties and licensing fee receipts of multinational firms increased from $27 billion to $235 billion. Given the importance multinational firms play in R&D and international technology transfer, any policy initiatives pertaining to encouraging the international flow of technology need to take the incentives of such firms fully into account.

The scale of R&D and technology activities of some multinational firms can be difficult to grasp: for example, in 2009 the R&D expenditures of Toyota exceeded that of India, a country of roughly 1.2 billion people (UNCTAD, 2010). Similarly, in a typical year, over twenty multinational firms more in R&D than Turkey, a country of roughly 75 million people. These are a sharp reminder of the uneven nature of the technology terrain of today's world. But this need not be a ground for pessimism: the uneven environment also creates the potential for large gains to be had from encouraging international technology transfer to developing countries. The challenge for policy-makers is to ensure that their chosen policies assist rather than hinder the process of international technology transfer.

While most FDI flows occur primarily between industrial countries (much like most intra-industry trade), developing countries are becoming increasingly important host countries for FDI, especially due to the large-scale liberalization undertaken by large countries such as China and India. From 1990-2012, the share of global stock of FDI residing in developing countries increased from 25% to just over 33% (UNCTAD 2013). While FDI between industrialized countries primarily occurs via international mergers and acquisitions, FDI into developing countries is more likely to involve the construction of new production facilities (i.e. is more likely to be greenfield in nature). However, both types of FDI carry the potential for international knowledge transfer: while mergers and acquisitions are more likely to yield productivity improvements via changes in management and organization structure of acquired firms, greenfield FDI leads to direct transfer of production know-how either in the form of entirely now products or via improvements in existing production processes).

When measured by the receipts and payments of royalties and licensing fees, much of the global action in technology transfer is within developed countries and occurs within the

boundaries of multinational firms: estimates vary but in a typical year over 80 percent of global royalty payments for international transfers of technology are made between subsidiaries and their parent firms. Of course, royalty payments only record the explicit sale of technology and do not capture the full magnitude of technology transfer through FDI relative to technology transfer via imitation, trade in goods, and other channels. Technology transfer to developing countries via multinationals has increased in magnitude during the last decade or so: from 1990 to 2009 the share of developing countries in global technology payments doubled to 26% (UNCTAD 2010).

In recent years there has been substantial growth in investments of international firms in research facilities in different countries (OECD, 2008). Most occur among the developed economies but China and India recently have entered top ten recipients of such facilities within enterprises and among research collaborations. These research affiliates and contract R&D facilities have several purposes: modifying products for local markets, situating R&D close to growing markets, using lower-cost research personnel, and establishing centers of original innovation. For example, Japanese multinationals allocated 38% of their R&D activities abroad to developing countries, a significant increase from 6% in 1993. Thus, market forces are already at work that will help achieve some of SDGS of the United Nations. The question for policy is what, if anything, should be done to complement the market forces that are already at work.

Developing countries hope not only to import more efficient foreign technologies via FDI, but also to improve the productivity of local firms via technological spillovers to them. Government policies in developing countries need to be compatible with the incentives of multinational firms. For example, considerable empirical evidence shows that while spillovers from FDI to competing local firms are elusive, such is not the case for spillovers to local suppliers and other agents involved in vertical relationships with multinationals.

In section 2 it was noted that while the volume of patenting activity in large developing countries (especially China) has increased substantially in the last two decades, the same cannot be said about the quality of patents that have been created. It is possible that FDI could also help address this concern. In a recent paper, Branstetter et al. (2013) examine data on patents issued by the US to foreign residents and find that a majority of patents in China (as well as India) have been granted to researchers working for subsidiaries of multinational corporations. They argue that the general rise of international co-invention reflects an expanded international division of labor within global R&D networks, much like the slicing of the global production chain across the world.

Branstetter et al. (2013) also compare the quality of patents (as measured by citations) granted to Chinese or Indian indigenous inventions with those granted to (a) co-inventions with inputs from advanced economies and to (b) co-inventions with inputs from advanced economies under the sponsorship of multinational firms. They find that co-invented patents tend to be of higher quality, as do patents developed under the sponsorship of multinationals.

Given the overwhelming importance of FDI to R&D and technology transfer and the scarcity of resources in developing countries, it might be easier for such countries to secure productivity gains by encouraging FDI to their local economies and having multinationals invest in R&D as opposed to doing it entirely on their own. Rather than trying to reproduce complex industrial goods (such as cars or computers) entirely on their own, developing countries need to ensure that their firms fit into the global production and innovation chains of such products to the mutual advantage of all parties. This is not to say that the role a developing country plays in a given production or innovation chain is immutable. Far from it: evolving market conditions would naturally call for adjustments over time. But policy intervention should look to ease such adjustments as opposed to working against them.

Multinational firms are one part, perhaps one of the most important one, of global innovation networks that incorporate many other agents such as startup companies, universities and public research laboratories, and even foundations, NGOs, and government agencies. Within these networks there are potential gains from specialization (e.g., basic research versus commercialization) and collaboration (e.g., in licensing, pooling information and intellectual property, and cross-border research alliances). Both private firms and government authorities increasingly see participation in such innovation networks in order to boost competitiveness, growth, and technology transfer.

Global innovation networks offer considerable scope for enhancing technology transfer and increasing access of developing countries to both basic knowledge and applied outcomes. Although empirical studies are not yet available, global innovation networks seem likely to facilitate collaborative research and information sharing among small and medium-sized enterprises. Thus, they could act as a potentially powerful and leveraged international tool for innovation. Unfortunately, however, there is very little systematic data available on the emergence of inter-enterprise and cross-border research collaborations (public or private). Nor is there much information on research arrangements among universities, private firms, and foundations. In this regard, it would be useful for international organizations and scientific agencies to invest in better statistical flows about the nature and activities of innovation networks.

Concluding Remarks

The basic message of the paper by Maskus – i.e. improved worker mobility within "innovation zones" is likely to yield much larger welfare gains relative to encouraging greater investment in R&D – seems essentially correct. But the implementation hurdle facing the two policies also appear to be rather different.

First, there is likely to be much more political resistance to policies aimed at improving worker mobility. As the paper correctly notes, most of benefits of improved worker mobility are likely to accrue to the workers that end up moving to high wage locations. Indeed, such mobility will also create losers in countries that import workers who will have an incentive to oppose reforms aimed at improving worker mobility. Second, such policies would probably require much greater coordination between countries relative to

encouraging investments in R&D, which can be done more or less unilaterally. Indeed, Maskus notes that his proposal for improved worker mobility within innovation zones would likely require the adoption of a plurilateral approach at the WTO, something he views as a "difficult prospect".

To the extent that R&D creates positive international spillovers, the scope for disagreement over R&D policies is perhaps smaller than that over labor mobility policies. This is because the movement of people raises some contentious issues related to culture and financing of public goods (such as schooling) that are often difficult to resolve.

I have proposed that policy makers in developing countries should also consider how to integrate their economies into the global production and innovation chains controlled largely my multinational firms. Since the range of policies that affect FDI decisions is rather large, I have deliberately chosen to not make specific policy recommendations. Indeed, most developing countries could (and should) attempt to achieve this objective my improving local infrastructure, the quality of local labor and human capital, overall business climate, rules and regulations concerning labor, and the overall protection of property rights (pertaining to both physical and intellectual property). The benefit to cost ratio of increasing FDI through these fundamental changes in the local economic and policy environment is likely to be quite high since they will yield benefits to developing countries that are likely to extend beyond greater integration with the world economy via FDI and participation in global production networks.

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This paper was written by Kamal Saggi, Professor of Economics at Vanderbilt University. The project brings together more than 50 top economists, NGOs, international agencies and businesses to identify the goals with the greatest benefit-to-cost ratio for the next set of UN development goals.

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