Components of a Proposed Technology Transfer Index: Background Note

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1. Background

This note is offered as an extension and supplement to the earlier work done by Alicia Bannon and David Roodman of CGD entitled "Technology and the Commitment to Development Index," (April 2004). They introduced a technology component to the CGD/*Foreign Policy* Commitment to Development Index (CDI) in an attempt to assess how the policies of 21 developed countries might contribute to the technology stock available for use by developing countries. They considered both a measure of technology creation through government support of R&D and restraints on technology diffusion through protection of intellectual property rights (IPR).

Regarding technology creation the authors employed a simple weighted average of tax incentives for R&D (applied to business enterprise R&D) and government R&D funding as a percentage of GDP. The index sub-component suggested below retains this general approach but extends the latter variable to account for the nature of financing objectives.

The authors considered IPR protection and decided to exclude it from the technology component because of significant ambiguities in measurement and concepts. Somewhat surprisingly, they rejected use of IPR in part because practices adopted in developing countries (see below) may be inimical to some forms of development, though they may also be beneficial. This is surprising because the nature of the CDE exercise is to rank the policies of developed countries in restraining or expanding technology diffusion. In that context, they found it difficult to distinguish among rich countries because of problems in interpreting such things as negotiating positions at the WTO (as regards the Agreement on Trade-Related Aspects of Intellectual Property Rights, or TRIPS) and so-called "TRIPS-Plus" measures in bilateral trading agreements.

In my view this approach fails to consider the important fact that the scope of IPR policies of rich countries retains significant variations from each other in ways that could affect access of poor countries to new knowledge. This is explained further below, but one example would be the patentability of new plant varieties or computer software. The

TRIPS Agreement does not require either treatment but countries are free to adopt them. Similarly, there are subtle differences in patent scope and copyright laws that make new information more or less accessible. An example is restrictions on what constitutes fair use in electronic copyrighted materials. Thus, one extension offered here is a ranking of countries in terms of their approach to establishing the scope of IPR protection. Further, some consideration of "TRIPS-Plus" policies in bilateral trade negotiations is retained.

Bannon and Roodman noted in their paper that one approach to assessing the willingness of countries to encourage technology transfer is to read the submissions of those countries to the TRIPS Council under Article 66.2 of TRIPS. This Article commits rich countries to find means to encourage the transfer of private technologies to the least-developed countries (Maskus, 2004). However, those authors note correctly that these submissions are not particularly informative about policies, nor are they very comparable across countries. Indeed, most such submissions simply list programs that may affect the ability of developing economies to acquire technology, such as training and capacity building. While there may be some mention of tax incentives or subsidies to transferring technology, these are rarely aimed at the least-developed countries, nor is it possible to assess the relative strength of such policies across rich nations. Indeed, within the TRIPS Council of the WTO, delegates from developing countries express frustration with the inability of such submissions actually to signal a commitment to raising private flows of technology. Thus, I agree that it is not particularly sensible to base a sub-component of the technology index on these submissions.

However, it is possible to provide a quantitative assessment of how much countries offer the developing world in terms of disbursements of assistance funds for training, technical capacity building, and similar programs. This may be done through use of OECD data as explained below. Thus, I add a "public technology transfer" component through considering these data.

2. Support for Research and Development

It is evident that there are two central processes in technology transfer and government policies are involved in both. First is the act of creating new technologies and governments are directly involved by both financing R&D directly and providing indirect incentives. Second is the diffusion of new information across entities (e.g., universities, government laboratories, and firms) and across borders, with the latter being of greater significance here. In this section I discuss government fiscal supports for R&D.

The OECD (2004b) provides data on the government as both a financer and a performer of research. Its role in financing R&D is more central to this analysis, as pointed out by Bannon and Roodman (2004) and I retain their basic approach. In terms of direct finance, I compute the ratios of government funding to GDP (in constant US dollars, 2002 prices) for all countries.

However, it is important to pay attention to the socioeconomic objectives of these financing programs, as broken down in OECD (2004c). We can identify three general categories of such objectives that may require separate treatment. First, some programs focus on such public goods research as health, science and technology, and atmospheric research. The notion I adopt is that such public goods would more readily spill over into internationally available knowledge than would private technologies. Second, some programs are aimed at improving knowledge of direct use in commercial applications. This knowledge surely can be useful for improving production technologies in developing countries but is more likely to be mediated through private channels that may be protected by intellectual property or other forms of secrecy. I therefore discount those contributions to finance by 25 percent, meaning that 75 percent of the sums are included. Third, in the area of national defense a substantial amount of research goes into the production of ideas, technologies, and goods that cannot be transmitted across borders or into commerce, though some of it surely does. This requires financing for defense to be subject also to a discount. I follow the Bannon-Roodman approach of reducing the amount of expenditures in total public research for defense by 50 percent.

To summarize, the following socioeconomic objectives were included in the computation of government-financed research, with the associated discounts.

1. Public Goods Category (no discount)

Advancement of research;
Civil space;
Earth and atmosphere;
Health;
Social development;
Science and technology advancement;
Science and technology environment;
Science and technology infrastructure.

2. Commercial Category (25 percent discount)

Agriculture, forestry, and fishing;
Energy;
Industrial development;
Transport and telecommunications;
Urban-rural planning.

3. National Defense (50 percent discount)

National defense.

Standardizing the selection of such categories across countries was problematic because for all countries the sum of government-financed R&D in all categories exceeds the reported amount for total R&D, often by large amounts. This suggests that certain research funds are counted in more than one objective group, making comparisons across countries at the category level difficult. However, it was possible with close examination to determine the categories that are included in each country's total research funding, either precisely or within an error of one percent. Thus, for example, the total figures for most countries exclude "advancement of research" because funds in that category are actually disbursed across other components.[1] Some countries exclude "transport and telecommunications" and "urban and rural planning" from their totals because these funds are allocated into other components as well. It is possible, therefore, that in some countries the weight of 1.0 (no discount) is applied to funds that might ordinarily receive a weight of 0.75 (25 percent discount). However, funds in these excluded categories are rarely more than a very small percentage of the total funds and errors made in this way are surely small.

Next, as Bannon and Roodman noted, governments provide indirect subsidies to business-sector R&D through their tax treatment of research expenditures. The OECD (2002) calculates a standard measure of the net subsidy or tax to small and large manufacturing enterprises per dollar of R&D spending. The so-called "B-index" attempts to calculate the present value of before-tax income needed to cover the initial cost of R&D investment and to pay corporate income tax, thereby making it profitable to undertake research. The OECD reports a figure that is one minus this B-index, with a positive score indicating a net tax subsidy to research and a negative score indicating a net tax (less than complete write-off of R&D expenses). I follow Bannon and Roodman in taking the average OECD score for small and large firms and multiplying these scores by the share of Business Enterprise R&D (BERD) as a percentage of GDP. Adding this figure to the discounted R&D financing share described above provides the full value of research support.

These figures are listed in Table 1. The first data column indicates the tax/subsidy rate computed from OECD. The second column lists business enterprise R&D as a percentage of GDP. In the third column I list the results of multiplying the tax/subsidy rate times the BERD percentage. These computations are, therefore, a measure of each government's net tax or subsidy to business enterprise R&D as a percentage of GDP. They form a basic sub-component of the R&D support component for the overall index.

The fourth column depicts government financed R&D for the socioeconomic objectives listed above as a percentage of GDP. These figures are not discounted for commercial and defense activities but are provided simply to show the relative presence of governments in research financing across countries. The fifth column shows the discounts in research financing for commercial activities and defense, computed as a share of GDP. Thus, for example, Australia's government research in the above objectives amounts to 0.59 percent of GDP, while 50 percent of defense and 25 percent of commercial activity research add up to 0.06 percent of GDP. It is interesting to note from these columns the relative commitment of each government to various types of research. For example, Austria has a relatively high overall research figure (0.62 percent), but devotes only a small amount to defense and commercial activities. Finland

[1] Another category, called "general university funds" is similarly allocated across components in all countries and is therefore not included here to avoid double-counting.

and France are high on both counts, while the United States has the highest relative presence of defense research.[2]

Thus, in the sixth column I list the "weighted government objectives" research as a percentage of GDP. This is simply the difference between columns four and five. Stated precisely, it is the amount of government financing for public-goods research, plus 75 percent of financing for commercial-activity research, plus 50 percent of financing for defense, as a percentage of GDP, taken as an average over the period 1997-2001.[3] It is an attempt to recognize the differential objectives of governments in financing research and the potential for these programs to generate technologies of potential applicability in developing countries.

These computations are similar to those in Bannon and Roodman, with two significant differences. The first is the data source, with the financing figures here coming from the OECD's reporting on socioeconomic objectives, while those in Bannon and Roodman came from the OECD's *Main Science and Technology Indicators,* a less detailed source. Second is the breakdown here of financing into socioeconomic objectives, with weights attached to different categories.

The eighth column provides the computed figures for total government support for research. They range from 0.26 for Ireland to 0.92 for Finland. The rankings are similar to those in Bannon and Roodman, but some exceptions are worth noting. Use of the more detailed objectives-based data source tends to change the relative share of overall government research financing in GDP for some countries, reducing the figures for Australia, Austria, and Switzerland, while raising them for Finland and Spain. Applying the discounts here to commercial-activity research reduces the support figures for a few countries, such as Australia and New Zealand, that engage in relatively high shares of such activity.

The final column of Table 1 converts the figures for total government support to a standardized score, centered on an average of 5.0.[4]

3. Perspectives on IPR Protection

Certainly it is difficult to establish meaningful quantitative comparisons of IPR across countries in terms of their ability to promote invention or discourage diffusion. Unlike taxes, IPRs cannot be given dollar values or be computed as price wedges. Researchers can read the particulars of IPR laws, however, and attempt to develop an index based on variations in those laws.

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[2] For additional perspective and clarity, the figures in column seven list the percentage of government research that is devoted to the defense and commercial activities. These range from a low of 8.2 percent in Switzerland to a high of 59.7 percent in the United States.

[3] For some countries the figures are available for only a subset of these years and the averages are taken over the years in which data exist.

[4] This is the procedure adopted for other components of the Commitment to Development Index (Roodman, 2004).

Background Observations

It is not straightforward to determine how the strength of a developed nation's IPRs regime may affect the availability of technology and information that may be used by firms, students, and researchers in developing economies.[5] There are cross-cutting effects that make it difficult to assign a unitary direction tot this question. First, one essential reason for strong IPRs, in principle, is that they provide incentives for undertaking investments in R&D and creative activities. The exclusive rights provided by patents and copyrights to developers of new technologies, products, and creative goods help solve the problem that knowledge and information are non-rival and may not be excludable from second users. Without such protection, inventors, authors, and artists may be unwilling to invest in invention and organize the high costs of developing software, music, films, and other knowledge goods. Next, more certainty about ownership of information can provide important support for the development of technology markets and licensing contracts, helping support the dissemination of knowledge and information goods through market channels. For example, it is often argued that the introduction of the Bayh-Dole Act (1980) in the United States, which permits university researchers to license the results of their endeavors to private firms, has materially increased the amount of both basic invention and product innovation, particularly in biotechnology and medicine. And, for their part, trademarks and protected brand names provide certainty to consumers about the ultimate producers of the goods they buy. These devices play an important role in efficiently improving information flows in markets about the true origin of products and, in consequence, encourage enterprises to differentiate their goods in terms of quality and price. These signaling functions are among the most important benefits of intellectual property protection.

At the same time, these exclusive rights, by definition, raise barriers to others from having access to new inventions, technologies, and products. Governments place certain limitations on the scope of a patent grant or copyright exclusivity because of public interests in ensuring beneficial access. Thus, for example, patent grants may be challenged as having been invalidly issued because the subject matter should not have been patented, the examiners failed to recognize prior art, and the like. Patents may also be revoked for a failure to exploit the protected information ("work the patent") in a particular market. Researchers and potential business rivals may be able to use the information in a patent for research (the so-called "research exemption") without authorization in some countries. Perhaps most significantly, patents may be subject to compulsory licensing for purposes of meeting public health needs, public (government) use, or anti-trust remedies. There are other such limitations on scope as well. Generally speaking, the broader are these exceptions, the greater emphasis governments place on access for competitive and social-protection reasons. Countries with strong patent scope sharply circumscribe these exceptions, favoring the rights of patent holders.

In the copyright area there are similar restrictions on scope. A copyright gives its owner exclusive rights to make copies, including in digital and electronic formats, for a lengthy period of time (such as life of the author plus 70 years in the United States and European Union). However, governments invoke rules of "fair use", under which others may make

[5] Maskus (2004) discusses these issues in detail.

copies without authorization. It is common to permit single copies for individual use, for example. Some countries permit widespread use of copyrighted materials for educational, scientific, and research purposes, while others greatly restrain those uses. Copyrights may also be subject to compulsory licenses in order to provide, say, broadcast services to underprovided areas within a country.

Available empirical evidence does not offer great confidence about the gains in innovation and creation versus the costs of limited access from various IPR regimes. Much depends on the nature of technologies, competition, and development levels of individual countries. For example, it is common to point out that the United States, Japan, and Korea all developed sophisticated technological capabilities through the benefit of weak intellectual property protection, which permitted firms to free ride on technologies available both in the global economy and within their own economies (Commission on Intellectual Property Rights, 2002). Once they achieved a strong degree of technological comparative advantage these countries were willing to adopt tight regimes for protecting industrial property. Similar statements may be made about copyrights.

Unfortunately, available empirical evidence does not provide clear guidance on the importance of IPRs for encouraging and disseminating technological information. Recent surveys of U.S. enterprises indicate that, except in pharmaceuticals and biotechnology, the promise of even domestic (never mind global) patent protection is not of much significance to firms in determining their research programs and willingness to market new technologies (Levin, et al 1997, Cohen, et al 2000). Thus, except for medicines and agro-biotechnologies, where patents seem quite important, it is debatable whether the patent regime has much ability to encourage invention.

However, this conclusion fails to account for the ability of IPRs to support markets for transacting in information through selling goods and licensing technologies. There are few direct studies of this possibility, though one extensive examination suggests it is important (Arora, et al 2001), while econometric evidence seems to support the importance of intellectual property for encouraging formal international technology transfer (Maskus, 2000). At the same time, a number of commentators worry that easily attainable patents with broad scope raise considerable potential for firms in medical research, biotechnology, and information technologies to refuse to license their inventions, thereby raising significant roadblocks to future innovation (Rai, 2005). Thus, even in these "patent-sensitive" sectors, extensive patent portfolios can serve as defense mechanisms to reduce competition and diffusion.

There are no systematic empirical studies of the importance of copyrights in encouraging creative activity, and this question remains intensely controversial. The fact that the "copyright industries" in the United States and Europe lobby intensively for long copyrights with extensive scope indicates that there may be some importance. This seems particularly likely in light of the difficult contracting mechanisms necessary to organize production of an extensive piece of software, a movie or a video game (Caves, 2000). Others suggest that the development of open-source software suggests intellectual property protection may be both unnecessary and counter-productive.

Relevance for the Technology Index

It is evident that basic questions about the incentive effects of intellectual property protection remain partially unanswered and dependent on circumstances. The issue for this report is how to conceptualize the role of IPRs in promoting or hindering access of developing countries to technologies.

To answer this question I take the following approach. I do not deny the potential importance of patents and copyrights in encouraging the development of new technologies and products. To the extent they have this effect the available supply of technologies from developed countries would be enhanced. However, we should remain aware of how these technologies may be transferred to developing countries. By far the greater share appears to be through formal mechanisms of market-mediated transfers, including international trade and foreign direct investment (Maskus, 2004). These channels are already accounted for in the trade and investment sub-components of the Commitment to Development Index. In my view, therefore, it would be excessive to try to account for the innovation-enhancement aspects of IPRs in the technology sub-component, which is aimed at government policies that may enhance transfers.

In this regard, it should be stressed that the ability and willingness of private firms to transfer proprietary information, which may have been generated because of strong IPRs in the developed countries, is a function of, among other things, intellectual property protection in the recipient developing countries (Maskus, 2000). It is not contingent on the patent or copyright regime of the rich countries.

However, the second general form of technology transfers does depend on those regimes. This is transfers through non-market mediated forms, including reverse engineering, imitation, and downloading or copying of materials in the public domain. To the extent that limitations on the scope of IPRs in the developed economies tend to push products and technologies more rapidly into the public domain, the limitations may be considered more amenable to low-cost technology transfers and learning. Put in a different light, the greater the availability of information in the public domain, the larger the ability of firms and researchers in developing countries to take advantage of them in improving their own technological base, rather like the histories of Japan and Korea.

To be sure, the prospects for undertaking such imitation depend in part on the strength of IPRs in the developing economies themselves. For purposes of the index, however, it is sensible to characterize the IPR regimes of developed countries in terms of how likely they are to increase or decrease the availability of information for public use. This is the essential principle I use to define IPR systems in the following sub-section.

Limitations on Scope

With respect to technology, perhaps most important is the scope of protection for patents (especially), copyrights, and other forms of IPR. The greater the scope the more costly it is to invent around the patent or otherwise use it, and therefore the less likely the information it protects will support follow-on innovation within a reasonable time period. Thus, strong protection limits diffusion of new technologies, which should be considered a negative factor for the technology index.

Beginning with patents, two forms of scope issues are amenable to some form of quantification. First is the degree of exclusions from patent eligibility across technologies. The TRIPS Agreement enjoins WTO Members to make eligible for patents all technologies without discrimination but permits a number of exclusions. Among the more important are algorithms, mathematical models, genetic codes, and other forms of discovery (as opposed to utilitarian invention). Also excludable are surgical methods, plant and animal varieties, and computer software. However, while such exclusions offer the “minimum” TRIPS standards in this area, countries are free to exceed them by making such elements patentable.

Among the 21 countries in the dataset there remains significant variation in two important technologies as regards patentability. These are patents for plant and animal varieties and patents for software, including business methods patents. Both of these are areas of intense interest for development purposes. Thus, for example, a new plant variety (which may arise, for example, from biogenetic engineering) that achieves widespread patent coverage in rich countries may not be available for use (due to licensing restrictions) in developing economies for some time. For their part, software patents prevent reverse engineering of computer programs and may restrict the number of programs available for developing countries to access.

Thus, I examined eligibility standards for these two categories of patents in the 21 developed countries as of 2004. For each area a figure of 1.0 is added to gain a total patent coverage measure. In fact, seven countries make patents available for new plant varieties (the United States, the United Kingdom, Ireland, Italy, Japan, New Zealand, and Australia). The European countries explicitly exclude plant and animal varieties from patent protection. Software patents are subject to some uncertainty legally in these countries. They are clearly patentable in the laws of the United States, Japan, and Australia, to which I assign a value of 1.0 for this category. The members of the European Union and most members of the European Free Trade Area are making patents available based on basic criteria only (earning a count of 0.5), which is true also of Canada. Norway and New Zealand are only just beginning to award patents for industrially useful software, earning scores of 0.25.

Thus, there are two categories of patent eligibility considered, with a maximum coverage count of 2.0. These figures are reported in the first data column of Table 2. The notion again is that the higher is this figure the more the number of technologies that are protected, tending to reduce the potential for global diffusion.

A second sub-component here comes from the possibility that, once granted, patent rights may be revoked for various reasons. Among these are revocation procedures in the event a patent holder chooses to discontinue its use "working" on the domestic market[6] and procedures for compulsory licensing for purposes of social policy (eg, in pharmaceuticals and educational materials) or competition policy. If such procedures exist and are effective, they constitute an effective limitation on patent scope and push technologies into the public domain.[7] Thus, in cases where they do not exist or are heavily restricted, I assign a value of unity to these categories, with a maximum score of 2.0. For example, Germany does not issue compulsory licenses in pharmaceuticals for purposes of expanding access or competition. The United States places virtually no restrictions on patentees in terms of working requirements. The resulting scores are given in the second data column of Table 2, with a higher score indicating a stronger scope of patent protection.

There are three additional forms of IPR protection that I incorporate here. First, some countries have enacted into law strict limitations on the development or use of anti-circumvention technologies or software that may defeat encryption of copyrighted digital materials. For example, the United States has adopted the Digital Millenium Copyright Act (DMCA), which establishes criminal penalties for such activity. Thus, the United States is given a score of 1.0 for this feature of its copyright law. The European Union issued Copyright Directive 2001/29/EC but to date only Austria, Denmark, Germany and Greece have implemented it. These countries are accordingly given a score of 1.0 for anti-circumvention. Australia adopted rules similar to those of the DMCA as a condition of its bilateral free trade agreement with the United States and also gains a 1.0 score, as does Japan for its own rules in this regard.

A second element is the protection of commercial databases, including digital databases. The European Union members have adopted a highly restrictive Database Directive, which offers patent-like proprietary rights to developers of data compilations. Under that directive, even publicly-funded data in the public domain can be assembled into value-added databases rendering the included data as private property. This protection may be extended indefinitely with minimal additional creative effort, making the law highly restrictive and a severe restriction on information diffusion possibilities for developing countries. The Directive has also been adopted by members of the European Free Trade Area (EFTA). Thus, EU and EFTA member states are given a score of 1.0 for database restrictions.

Finally, both the United States and the European Union negotiate bilateral free trade agreements with developing countries, in part with the intention of encouraging local adoption of IPR standards that exceed those required in the TRIPS Agreement. Thus, I add a figure of unity to the U.S. data to reflect that country's push to incorporate "TRIPS-Plus" provisions in its bilateral trade agreements. For example, the U.S.-Vietnam agreement requires Vietnam to enforce a 10-year period of confidentiality for test data

[6] While some rich countries retain requirements that patents be worked in the first place through production or imports, they are virtually never invoked.
[7] Another significant limitation is permission of parallel imports of patented (or copyrighted) goods, but while this policy might reduce prices of protected goods in developed-country markets it does not expand public access to use rights.

submitted to the government for approval of new drugs and agricultural chemicals. The analogous period is only five years in the United States while TRIPS requires no such period. U.S. trade negotiators have also pushed for bans on compulsory licensing and patenting of genetic sequences in developing countries, among other strong provisions. These provisions are likely to slow down diffusion and competition in the developing countries rather than to encourage effective technology development. For its part, the European Union typically takes a softer approach, requiring essentially accelerated adoption of TRIPS standards. However, the EU pushes also for adoption of geographical indications, which are private rights to use names and logos derived from locational attributes of products. For these reasons, I assign a value of 0.5 to EU member countries as regards "TRIPS-Plus". Finally, EFTA members (Switzerland and Norway in this group) tend to push for strong test-data protection and limits on compulsory licensing, earning a score of 0.5.

Thus, in the third column of Table 2 I give the score for the sum of anti-circumvention laws, database protection, and "TRIPS-Plus" policies. Here the highest scores exist for Austria, Denmark, Germany, and Greece, which have database protection, anti-circumvention, and a soft "TRIPS-Plus" approach.

To develop a standardized score for the IPRs component of the technology matrix, each of the three categories in Table 2 is first standardized around a mean of 5.0 and inverted so that higher scores mean less restrictive intellectual property policies. This is done in a manner consistent with that in Roodman (2004).

Next, to achieve a final score, it is necessary to assign weights to these categories, which requires judgment based on an understanding of the potential scope of the underlying restrictions. In my view, the restrictions in column 3 are potentially most significant for preventing access to information in developing countries. That is, "TRIPS-Plus" measures are liable to be excessively strong for development purposes and could reduce access to key technologies, including medicines. Similarly, database protection could retard the ability of researchers to employ EU-protected data for scientific and educational purposes. Strong anti-circumvention rules in digital copyrights also may limit the development of competing technologies in developed economies, which might otherwise be available for transfer. Thus, I assign a weight of 0.5 to this column.

Next, limitations on patent scope that can result in revocation or compulsory licensing of patents have the potential to move technologies more quickly into the public domain. Thus, I assign a weight of 0.3 to this column. Finally, locking up key technologies, through awarding patents in plant varieties and software, could represent a significant restriction on access to new information. However, as discussed above, the potential impact on innovation should mitigate this problem overall. Accordingly, I assign a weight of 0.2 to that category.

Weighted in this way, the overall standardized scores for intellectual property protection are given in the final column of Table 2. In this column the higher the score, the weaker is the scope of protection and the greater the chances for effective technological diffusion and spillovers. Here, Canada gains the highest score because of its remaining limitations on patent eligibility and absence of laws governing anti-circumvention and database protection. The United States garners the lowest score, reflecting both its highly protective IPRs system and its enthusiasm for negotiating "TRIPS-Plus" standards with developing countries. It should be noted that these policy stances reflect largely the interests of these individual nations as net creators of technology (and therefore stronger protection) or net users of technology (and therefore weaker protection), rather than explicit concerns for the development prospects of poor countries. However, by raising the potential for knowledge to enter the public domain they have this latter spillover effect, at least in principle.

4. ODA Financing for Research and Training

While another component of the CDI considers foreign aid, which comes largely as overseas development assistance (ODA) loans and grants, it is possible to look at specific expenditure figures to see how those monies are targeted. It is evident that a direct form of technology transfer is for governments in rich countries to finance research activities in developing countries. Another form is to finance education and training of personnel in developing countries, an activity that is important for building skills and entrepreneurship.

Looking at the 5-digit program codes within the ODA accounts by year, it is possible to compute the value, in constant US dollars, of programs aimed at local research, education, and training.[8] These accounts list both "commitments" and "disbursements" by year. It is difficult to figure out which data are most appropriate in this context. Commitments are sums promised to a particular program at one point in time but that will be spent over time. Thus, it makes little sense to look at a single year and compare commitments across programs or countries. Disbursements are monies actually released into programs within a calendar year and are closer to actual development spending. However, disbursements tend to be somewhat volatile, especially for small programs, and selection of a particular year can suggest that some countries are more active than others, when that is really an artifact of the year chosen.

Thus, to smooth out the annual fluctuations I computed disbursements over the period 1998-2002 for which consistent data exist in 31 categories. These categories are listed in the Annex Table. In Table 3 I present the sum of these disbursements as a share of GDP over the same period for each country. The notion here is that a higher share of research and education programs in overall ODA funds signals a higher commitment to financing technology transfer and learning.

There is considerable variation in these ratios, ranging from 0.0001 percent of GDP in Italy to 0.0179 percent of GDP in Austria. (NOTE TO DAVID ROODMAN: I STRONGLY SUSPECT THAT THE FIGURES FOR ITALY AND SWITZERLAND ARE TOO LOW BECAUSE OF REPORTING PROBLEMS. LET ME KNOW IF YOU

[8] Readers should note that these are just a component of total ODA disbursements.

FIND SOMETHING OUT.) It is evident that several of the smaller countries relatively larger shares of GDP to ODA programs in research and education, even though the dollar figures are far smaller than those for the United States or Germany. The average of these ratios was 0.0067. Standardized scores are in the final column, scaled to average 5.0.

5. Combining the Sub-components

The final task is to combine the three sub-component standardized scores into an overall standardized score. Again, this effort requires judgment from experience; there is no model that would ascribe particular weights to the sub-components. In my view, the most important part is the government support to research, for this activity directly generates knowledge that can both be transferred directly and supports development of other technologies that developing countries may access. Thus, I assign a weight of 0.65 to this sub-component, as shown in Table 4.

Less important, but still significant, would be the limitations on the scope of IPR protection. One reason for assigning a lower weight is the ambiguity noted earlier. Strong IPRs can act as roadblocks to technology access and diffusion. At the same time, they can be instrumental in generating new innovation and can reduce the costs of international transactions in technology. The construction of the sub-component here attempts to emphasize the former effect by looking at patent eligibility, patent scope, and limits on circumvention and database use. But the ambiguity merits caution. Another reason is that international technology flows seem to be relatively fluid, even in the presence of IPR protection. Accordingly, I assign a weight of 0.20 to this sub-component.

Finally, ODA grants and loans for research and training surely help build capacity for absorbing international knowledge and technology. The sums seem relatively small, however, in relation to the knowledge generation and protection aspects of the first two sub-components. I assign a weight of 0.15 to this category.

Applying these weights generates the overall technology score for the CDI, shown in the final column of Table 4. It ranges from a low of 2.74 for Greece, the government of which neither supports much research nor offers much ODA for training, to a high of 6.65 for Finland, which does have extensive governmental research support and ODA financing. The score for the United States is 4.51, the sixth-lowest in the table. This reflects mainly the strongly protective IPR system in that country.

Table 1. Sub-component Based on Government Support for R&D

Country	*Tax/Subsidy Rate*	*BERD (%GDP)*	*Tax/Subsidy *BERD*	*Govt. Objectives R&D Finance (%GDP)*	*Discounts R&D to Defense & Commercial (%GDP)*	*Weighted Govt. Objectives R&D (%GDP)*	*Note: Defense & Commercial Share of Govt. R&D(%)*	*Total Gov support (% GDP)*	*Standardized Score*
Australia	0.199	0.78	0.16	0.59	0.06	0.53	32.4	0.69	5.28
Austria	0.117	1.14	0.13	0.62	0.02	0.60	12.8	0.76	5.66
Belgium	-0.008	1.64	-0.01	0.54	0.04	0.50	30.3	0.49	3.75
Canada	0.248	1.01	0.25	0.53	0.05	0.48	36.1	0.73	5.63
Denmark	-0.009	1.75	-0.02	0.72	0.04	0.68	22.7	0.66	5.12
Finland	-0.01	2.41	-0.02	1.05	0.11	0.94	42.9	0.92	7.06
France	0.061	1.37	0.08	0.93	0.14	0.79	38.5	0.87	6.74
Germany	-0.025	1.73	-0.04	0.82	0.07	0.75	28.8	0.71	5.45
Greece	-0.015	0.21	0.00	0.31	0.02	0.29	19.2	0.29	2.21
Ireland	0	0.8	0.00	0.29	0.03	0.26	50.4	0.26	2.01
Italy	0.209	0.55	0.11	0.61	0.03	0.58	19.2	0.69	5.36
Japan	0.065	2.32	0.15	0.60	0.06	0.54	37.6	0.69	5.33
Netherlands	0.05	1.03	0.05	0.81	0.06	0.75	25.9	0.80	6.18
N. Zealand	-0.023	0.43	-0.01	0.54	0.05	0.49	45.5	0.48	3.70
Norway	0.107	0.96	0.10	0.70	0.06	0.64	31.4	0.74	5.73
Portugal	0.335	0.32	0.11	0.56	0.04	0.52	29.5	0.63	4.84
Spain	0.441	0.56	0.25	0.54	0.10	0.44	50.5	0.69	5.30
Sweden	-0.015	3.32	-0.05	0.77	0.06	0.71	21.2	0.66	5.09
Switzerland	-0.01	1.9	-0.02	0.44	0.01	0.43	8.2	0.41	3.17
UK	0.101	1.26	0.13	0.69	0.13	0.56	45.4	0.69	5.30
USA	0.066	1.81	0.12	0.84	0.17	0.67	59.7	0.79	6.09

Source: Calculated from OECD (2002) and OECD (2004a).

Table 2. Sub-component Based on Limits on Domestic IPR Protection

Country	*Patent Coverage*	*Protection from Rights Loss*	*Anticircum-Vention, Database Protection, & TRIPS +*	*Standardized Score*
Australia	2.0	1	1	5.04
Austria	0.5	2	2.5	3.23
Belgium	0.5	1	1.5	5.92
Canada	0.5	1	0	8.38
Denmark	0.5	2	2.5	3.23
Finland	0.5	1	1.5	5.92
France	0.5	1	1.5	5.92
Germany	0.5	2	2.5	3.23
Greece	0.5	0	2.5	5.33
Ireland	1.5	2	1.5	3.74
Italy	1.5	1	1.5	4.79
Japan	2.0	1	1	5.04
Netherlands	0.5	2	1.5	4.87
N. Zealand	1.25	1	0	7.53
Norway	0.25	2	1.5	5.16
Portugal	0.5	1	1.5	5.92
Spain	0.5	1	1.5	5.92
Sweden	0.5	2	1.5	4.87
Switzerland	0.5	2	1.5	4.87
UK	1.5	2	1.5	3.74
USA	2.0	2	2	2.35

Source: Constructed from data provided by Walter Park and from author's reading of available patent protection and database protection.

Table 3. Sub-component Based on Cumulative ODA Disbursements (1998-2002) for Financing Research or Training in Developing Countries, as Percentage of Cumulative GDP

Country	*ODA Research and Education/Training as % Donor GDP*	*Standardized Score*
Australia	0.0105	7.86
Austria	0.0179	13.43
Belgium	0.0143	10.73
Canada	0.0031	2.32
Denmark	0.0056	4.22
Finland	0.0077	5.80
France	0.0006	0.42
Germany	0.0091	6.85
Greece	0.0021	1.59
Ireland	0.0122	9.14
Italy	0.0001	0.11
Japan	0.0020	1.49
Netherlands	0.0080	6.04
New Zealand	0.0037	2.81
Norway	0.0094	7.04
Portugal	0.0061	4.58
Spain	0.0114	8.59
Sweden	0.0113	8.49
Switzerland	0.0005	0.39
UK	0.0034	2.57
USA	0.0007	0.52

Source: Computed from OECD (2004d).

Table 4. Weighted Overall Technology Component Score

Country	*R&D Support (weight = 0.65)*	*Limits on IPR Protection (weight = 0.20)*	*ODA Research and Training (weight = 0.15)*	*Overall Technology Score*
Australia	5.28	5.74	7.86	5.62
Austria	5.66	3.64	13.43	6.34
Belgium	3.75	5.77	10.73	5.23
Canada	5.63	6.37	2.32	5.69
Denmark	5.12	3.87	4.22	4.61
Finland	7.06	5.20	5.80	6.65
France	6.74	5.60	0.42	5.63
Germany	5.45	3.87	6.85	5.22
Greece	2.21	5.15	1.59	2.74
Ireland	2.01	4.33	9.14	3.42
Italy	5.36	4.80	0.11	4.46
Japan	5.33	5.20	1.49	4.69
Netherlands	6.18	4.97	6.04	5.90
New Zealand	3.70	6.20	2.81	4.33
Norway	5.73	5.80	7.04	5.81
Portugal	4.84	5.37	4.58	5.02
Spain	5.30	5.60	8.59	5.92
Sweden	5.09	4.97	8.49	5.56
Switzerland	3.17	5.17	0.39	3.09
UK	5.30	4.56	2.57	4.58
USA	6.09	2.81	0.52	4.51

Annex Table: ODA Research and Training Categories

Purpose_Research
11181 Educational Research
12182 Medical Research
13010 Population Policy and Administrative Management
16381 Research/Scientific Institutions
23082 Energy Research
31183 Agricultural Research
31184 Livestock Research
31282 Forestry Research
31382 Fishery Research
32181 Technological Research and Development
41082 Environmental Research
Purpose_Training
11120 Education Facilities and Training
11130 Teacher Training
11330 Vocational Training
11430 Advanced Technical and Managerial Training
12181 Medical Education/Training
12281 Health Education
12282 Health Personnel Development
13081 Personnel Development for Population and Reproductive Health
14081 Education and Training in Water Supply and Sanitation
15030 Legal and Judicial Development
21081 Education and Training in Transport and Storage
23081 Energy Education/Training
24081 Education/Training in Banking and Financial Services
31181 Agricultural Education/Training
31182 Agricultural Extension
31281 Forestry Education/Training
31381 Fishery Education/Training
33181 Trade Education/Training
41081 Environmental Education/Training
43081 Multisector Education/Training

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