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View From Afar:

'Visible' Productivity of Scientists in the Developing World

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Wesley Shrum

Abstract

Much of what we know about science and technology in less developed countries comes from international databases such as bibliographies and citation indices. However, it is not clear if researchers whose work appears in international databases are representative of scientists in the developing world as a whole, or whether they differ in terms of important social characteristics. A search of international databases on agriculture and natural resource management in Ghana, Kenya, and Kerala was used to compile a bibliography that could be compared with results from a face-to-face survey of researchers. Results indicate that many of the characteristics of those who are internationally visible differ from the wider population of scientists. The implication is that the "view from afar" based exclusively on information drawn from international databases does not accurately reflect the population of researchers or domestic productivity in less developed countries.

The developing world often seems remote from the concerns of science and technology studies in Europe and the U.S.[1] Part of the reason is that STS has not yet flourished in these regions, so research reports typically originate from scholars in industrialized countries. Often even the information on which they are based comes from the developed world, particularly in the form of studies using international bibliographic databases.[2,3,4] Such studies can depict the position of a country or region within the world scientific community because that community is, in one important sense, defined by the research front that is incorporated in these databases.[5] But however useful such information may be for depicting research activity *in relation to other locations*, it remains questionable whether it accurately represents research activities *within developing countries themselves*.

An increasing number of scholars have called the use of such databases into question, owing to their underrepresentation of research published within the developing world.[6] International databases typically focus on English language publications and some make no systematic attempt to catalog research published in Africa, Asia, and Latin America.[i] Many countries studied in this way appear to be doing little research at all.[7] Databases such as the Science Citation Index include only a fraction of the extant journal literature, using various indicators for journal inclusion, and have reduced their coverage of journals originating in LDCs.[8] Most research literature not published in journal format fails the criteria for inclusion. Further, even advocates of bibliometric indicators have expressed reservations about their use in fields such as agriculture--which may be precisely the kind of research that is most important for developing countries.[7] Such problems lead many to conclude that bibliometric indicators, and particularly the SCI, are fraught with serious problems when used to evaluate scientific production in peripheral regions.[10,11]

These concerns lead to the two problems addressed in what follows--the measurement of research productivity and the characteristics of 'visible scientists.' The measurement of productivity in scientific and technological research is important not only for science and technology studies but also for policy development. It is not that indicators of research activity in the developing world are unavailable--as we have seen, one can use the selfsame measurement techniques typically employed for developed countries. But there are serious doubts about the validity of indicators based on standard bibliographic databases when used in the developing country context.[10] I address this issue by attempting to answer the following question: **to what degree do productivity indicators derived from international bibliometric sources correspond to self-reported productivity by scientists in LDCs?**

This central issue suggests two corollary questions. The developing world is not a unity, nor is all research conducted under the same organizational circumstances. In addition to the general question of correspondence, to what degree does the level of development of a country make a difference to this relationship? Rather than consider the meaning of aggregate indicators for developing countries generally, it would be well to know if the level of development affects this relationship between bibliometric and self-reported indicators. Further, does this relationship obtain equally for the primary sectors in which research is conducted: universities, state research institutes, international organizations, and nongovernmental organizations.

The second problem concerns representativeness and arises in the attempt to describe science in developing countries based on those individuals identified by their appearance in international databases. That is, if a set of researchers is visible, as indicated by authorship of items indexed in internationally available sources, to what degree are they similar to or different from other scientists in the same locations that are 'invisible' from afar? This issue is addressed through a survey of scientists in Africa (Ghana and Kenya) and Asia (the State of Kerala in southwest India) by asking the question: **how, if at all, are visible scientists different from their colleagues who are invisible?** In other words, do social characteristics, organizational contexts, or attitudes distinguish those whose work appears in the international arena from others whose work does not?

Methodology

Two kinds of information are required to answer these research questions. The first is information on the international visibility of scientists, as indicated by appearance in international databases. The second is information on the characteristics of these scientists, as well as a comparison group of similarly situated others. The substantive focus of this study is agricultural, environmental, and natural resource research in Ghana, Kenya, and Kerala.[ii]

Scholars and policy analysts in developed countries typically rely on measures provided by a limited number of internationally available data sources. From these sources, individual and aggregate measures of productivity and performance may be developed from publication counts and citations. The Science Citation Index produced by the Institute for Scientific Information is widely known, but in recent years most such databases are available through commercial vendors which provide online access and search capabilities. In principle, these are searchable worldwide for anyone with access to the requisite electronic and financial resources.[iii]

To maximize the scope of the search and increase the comprehensiveness of the pool of publications, a preliminary search of databases was carried out using the DIALOG system.[iv] Of 79 databases that provided information on the source of items, from 54 to 58 produced at least one "hit" from Ghana, Kenya, and Kerala without specification of a time frame. Differences in coverage are large, but each database covers hundreds (sometimes thousands) of journals, providing titles, authors, and complete references to articles, books, reports, and other published and unpublished items. In addition, most provide abstracts and subject keywords in addition.

After discarding sources in irrelevant fields and those with few hits, seventeen international databases were searched for the 1992-1993 period.[v] The Corporate Source field, containing the organizational affiliation and address of authors of entries in these data bases, indicates that the entry (publication, report, conference paper) originates in a particular location. In the present case, the subject matter of interest--agricultural and environmental research--encompasses a large proportion of the total research profile of most developing countries.

Duplicate records were eliminated, the remaining records were downloaded, and the results from seventeen databases were incorporated into a single relational data file that was used in the field study as well as for the productivity analysis that follows.

This diverse set of references was combined according to common fields to produce a relatively comprehensive set of references for Ghana, Kerala, and Kenya. While there is an admixture of reports, collections, and books, journal articles constitute the most common item in the database by far. These publication counts include all items, but given the coverage of European and U.S. databases, domestic journal sources are not represented (that is, apart from minor exceptions, those published within Kenya, Ghana, and Kerala). Thus, the publication count derived in this fashion is a good indicator of the work done in these locations that is *visible* from an international perspective. Indeed, the use of seventeen databases for this search is relatively exhaustive of the possibilities for interested parties in the developed world. It is difficult to see how else a researcher in an OECD country could become cognizant of articles originating in these locations without an informal, personal connection to the country.[vi]

The field survey of researchers was conducted in 1994 in three locations, selected to represent low (Ghana), medium (Kenya), and high (India) levels of development in Africa and Asia. A team of three interviewers (always including nationals) spent 4-5 weeks in each location, conducting a total of 293 structured interviews. The sample was stratified by sector, including university departments, national research institutes, nongovernmental organizations, and international research organizations. We used the bibliometric count of articles by organization as a selection criterion when needed, but this was rarely the case. The number of interviews per organization ranged from one to five and was proportional to the size of each organization. In all, interviews were conducted in 53 national research institutes, 48 academic departments, 31 NGOs, and 5 international organizations.[vii] With the cooperation of the director of each organization, we targeted mid-career researchers. We sought to divide our interviews between those whose names appeared in the international databases and those whose did not. A special effort was made to interview women researchers, who constitute about one quarter of the sample.[viii]

Specific interviewees were identified after discussions with the director, assistant director, or head of department at each institution that explained the purposes of the study and discussed the bibliometric data base. We sought to interview at least one researcher who appeared on the bibliometric list and one researcher who was not on the list, preferring mid-career individuals where there was more than one possibility. In fact, owing to the small size of many organizations and scheduling difficulties, there was little need for another criterion. The survey instrument included both structured and unstructured sections on the major dimensions of professional research activities, international and national organizational contacts, frequency of discussions with various groups, supervisory roles and local contacts, professional memberships and activities, self-reported productivity, attitudes on agricultural and environmental issues, and the needs of the research system.

The survey contained a series of ten "written output" questions asking respondents to report their own productivity since 1990, but the most salient items for what follows pertain to articles in foreign journals and articles in national journals. Respondents rarely needed to consult documents prior to responding, but answered straightaway, or after a little thought. Publications are no less relevant to researchers in developing countries and they have no apparent difficulty in remembering them--perhaps even more with publications appearing in international journals. I refer to these indicators as International and National publications. However, there is no further check on the accuracy of these self-reported publications.[ix]

Results of Productivity Analysis

(a) Bibliometric and Self-Reported Productivity

In the first part of this analysis, the correspondence of self-reported productivity and international productivity is assessed. First, average productivity values are presented by sector and country, followed by the associations between these different measures. In the second part of the analysis, the question of differences among visible and invisible scientists is addressed.

Table 1 provides basic information on three methods of measuring productivity for the entire sample. Two self-reported measures are followed by the count of publications from the compilation of seventeen databases. Average values for the two self-reported methods are slightly over two items for the five year period. Since the bibliometric count was for a shorter period, the final row of the table presents an adjusted count of 1.6, less than either of the self-reported measures. Such a finding is not unexpected, since either inflated self-reports or, more likely, a bibliometric undercount would produce such a relationship. Since the "true" value of individual productivity is the *sum* of national and international indicators, self-reported productivity is approximately 2.7 times the adjusted count based on the international data.

[Table 1 about here.]

Like all measures of publication productivity the distributions are highly skewed in a positive direction (with skewness statistics from 5.5 to 7.7) and relatively peaked (positive kurtosis values from 40 to 85). This simply indicates that many scientists publish little or nothing, while a few publish a great deal--exactly the pattern of researchers in developed countries. About half of the sample as a whole reports no publications in the past five years in either national or international journals. Almost 70% of the sample does *not* appear in the count compiled from seventeen international databases.

[Table 2 about here.]

Table 2 presents average productivity counts by sector. The rows of the table are ordered roughly in terms of decreasing productivity, but a simple ranking by sector is impossible. What stands out are the extreme values of the table--international researchers (all of whom are located in Kenya) report publishing virtually nothing in national journals, while the NGO staff we interviewed do not appear *at all* in the bibliometric sources. The highest values for international journal publication overall are for researchers in international organizations (whether self-report or bibliometric indicators are used). NGO researchers report an average of about two publications in domestic journals.[x]

The traditional research sectors are national institutes and university departments. The latter report more articles in domestic journals, producing more than twice as many, on average, as researchers in other national sectors. Academics also publish more articles in international outlets than government scientists, but not by such a large margin. Whether we consider self-reports or bibliometric publication counts, university scientists have greater published output.

Table 3 presents average productivity counts by location. The rows of the table are ordered in terms of general level of social and technical development as indicated earlier. The finding here is clear and consistent with prior studies: publication productivity is positively associated with development. While the overall rate is not high, Kerala displays the highest publication rates, followed by Kenya and then Ghana. In terms of the bibliometric count, Keralan respondents average 1.35 times the rate of Kenyans and 2.8 times the rate of Ghanaians.

Although differences exist on each measure the largest difference is apparent for domestic articles. The highest reported rate of publication applies for domestic articles for the most developed of the three locations. In Kerala more than one article per year per researcher is published in local journals, more than six times that of Kenya and more than eight times that of Ghana. When we consider that international publication attention is much more focused on Kenya, this fact seems especially relevant.[xi]

[Table 3 about here.]

The relationships between average values of indicators is one dimension of the measurement problem. However, the degree to which publication counts produced by international databases correspond to self-reported publications is best addressed by looking directly at the *association* between indicators.

Table 4 reports two correlation coefficients for the entire sample and for each sector separately.[xii] The first pair of columns expresses the relationship between foreign and domestic publications (self-reported). These correlations are important for both theoretical and methodological reasons. First, what is the meaning of "productivity" in a developing country context? On the one hand, many argue that research productivity is single dimension, i.e., that "productivity is productivity," and it does not matter whether we are speaking of international or domestic contexts. This suggests the empirical consequence that the two measures should be positively correlated: an orientation towards research results in publications both nationally and internationally.

The alternative argument is made by those who believe that an orientation toward the global scientific community is counterproductive to the national interest: there is no single, underlying "productivity" dimension. National and international publication represent different phenomena, different "orientations" towards the research enterprise, reflecting the priorities of careers in international science versus local development interests, or at least the advantages of training abroad at centers of Western research. If this is true, the association between foreign and domestic productivity should be weak or absent.

A second reason for an interest in the association is primarily methodological. A relationship between publications in national and foreign journals could be used to indicate the extent to which national journal publication activity may be *assumed* when productivity in international journals is high, and, of course, that information is easier to acquire. However, this would only be warranted if there is a reasonably strong relationship between the two indicators of international publication productivity, as indicated by the second pair of columns in Table 4. Indeed, this the crucial comparison:[xiii] the degree to which the measure of productivity derived from bibliometric databases (online and widely available) can be used as a proxy for a self-reported measure of publications. Finally, the third pair of columns in Table 4 shows the correlation between the bibliometric indicator of productivity and the self-reported indicator of national journal publications. This is significant only to the extent that an underlying dimension of productivity exists.

[Table 4 about here.]

For the entire sample, there are statistically significant but not high correlations between self-reported measures of productivity as well as between self-reported articles in foreign journals and the bibliometric count. However, this overall figure glosses important differences between sectors. The only high correlations in the table occur for international researchers, for whom self-reported international articles are strongly associated with the bibliometric count. That is, for researchers whose career patterns and type of science most closely approximate academic science in the developed world, bibliometric measures are a reasonably good measure of publication productivity. For university and government researchers, all four indicators of the relationship are statistically significant but weak. For example, the Pearson coefficient of .21 for the latter group means that less than 5% of the variance in international productivity may be explained by the bibliometric count.

The next highest correlation involves the self-reported publications of academic researchers. It is, indeed, the only moderately strong relationship between foreign and domestic productivity. We might be tempted to conclude that, at least for university scientists, there is an underlying dimension of productivity, that those who are most productive nationally are also most productive internationally. However, the rank order correlation is only .05, suggesting that the correlation is not robust. For government scientists, international researchers, and even for the group of university scientists taken as a whole, it seems prudent to conclude that domestic productivity is relatively independent of international work.

Table 5 shows associations for each location separately by decreasing level of development. Again, there are weak but significant associations between the self-reported measure of international productivity and the bibliometric count, but not consistent associations for the other measures. The relationship between national productivity and the bibliometric count is weak or nonexistent, while the relationship between national and international productivity is significant only for Kerala.

[Table 5 about here.]

Table 5 reveals an unexpected relationship between location and the strength of the association for measures of international productivity. Reading down the second pair of columns we see that Ghana displays the strongest association, while Kerala displays the weakest. That is, where the level of development is lowest, international databases seem to be more accurate indicators of international productivity than where levels are higher.

One clue may be in the first pair of columns. For Kerala, there is a weak relationship between foreign and domestic productivity, while for Ghana there is no hint of an association. The few internationally oriented publishers in Ghana exhibit no significant tendency to publish more in domestic journals, while in Kerala those who are oriented to the international scientific community seem more likely to publish research in domestic journals as well. The reason may be that journals in locations with higher levels of development as well as the research practices of scientists are less likely to be distinctive than at lower levels. Put simply, the lower the level of development, the clearer is the distinction between national and international orientations.

The difference can be seen clearly by drawing a simple distinction between those who do and those who do not appear in the international bibliography. In Kerala, about half of those who appear in the bibliography, reported publication in an international journal, while in Ghana *all* of those who appeared reported such publications. Though far fewer Ghanaian scientists appeared in the bibliography at all, self-reported productivity is a better measure of international publication productivity.[xiv]

A sectoral analysis of correlations for the three locations in Table 6 provides partial confirmation. Although the number of cases is reduced (and hence the power of the statistical test), when the relationship between international productivity and the bibliometric count is examined (second pair of columns), the only consistent coefficients for both national sectors are for Ghanaian scientists, and to a lesser extent, for Kenyans.[xv] The same result is given by a cross-tabular analysis, which shows that for African locations, but not south India, self-reported publications in foreign journals is related to appearances in the bibliography.

[Table 6 about here.]

(b) Visible and Invisible Scientists

We have seen that the association between bibliometric and self-reported measures varies across locations and across research sectors. In this section attention is restricted to the two primary national research settings (national research institutes and universities) for an examination of visibility. If a set of researchers is visible, as indicated by authorship of items indexed in internationally available sources, to what degree are they similar to or different from other scientists in the same locations that are 'invisible' from afar? In this section, social, organizational, and attitudinal differences between these scientists are examined.

Table 7 presents basic social and organizational comparisons between two groups in the sample, differentiated by appearance or non-appearance in the international bibliometric data. Statistically significant differences are apparent in all but five of the measures presented in the table, a finding inconsistent with the notion that scientists who are internationally visible are representative of the population of scientists in the developing world as a whole. Although there are no differences by gender in visibility status, visible scientists tend to be older, have greater tenure with their organizations, and have worked longer with their particular program.[xvi]

University scientists are represented more strongly than those from state research institutes. One of the largest differences is educational level. While 80% of visible scientists report holding the Ph.D., fewer than half of the invisible scientists do so, and are equally likely to hold a Master's as their highest credential. As we would expect, visible scientists are more active professionally, as indicated by officeholding in professional associations, membership on the editorial boards of journals, and professional meetings attended.

In terms of organizational context, visible scientists seem to have somewhat higher status, supervising twice as many professionals. This difference does not necessarily entail a difference in actual work structure, since both groups report *working closely* with approximately equal numbers of professionals and report involvement in similar numbers of projects. When one examines professional resources, small differences appear only in access to relatively common items like telephones, typewriters, and private offices--which one might expect of university professors. Visible scientists are slightly (but not significantly) *less* likely to have ready access to personal computers.[xvii]

[Table 7 about here.]

Thus, those scientists that appear in international databases tend to be more established, university scientists with Ph.D.'s who are professionally active and have higher supervisory status. In short, these characteristics are consistent with the model of developing country scientists who have an external orientation towards the global scientific community. However, to confirm this view requires more direct measures of orientation.

Table 8 exhibits differences in selected communication and attitudinal variables, including self-reported influences on problem selection. Differences between categories of scientists here support the notion that visible scientists have a stronger external orientation. First, with respect to self-reported discussions with individuals in various sectors, those with international publications report more frequent discussions with universities and outside the country and fewer discussions with nongovernmental organizations, which are typically more focused on local problems. Second, with respect to influences on the selection of research problems, these individuals report less influence by their immediate supervisor and *significantly greater influence of scientists abroad*.

It is important to note that this difference in the frequency of reported discussions does not necessarily indicate that visible scientists are more connected to any *particular* circle of associates. In addition to the measures reported in Table 8, we created a network measure of linkages to a set of specific, named organizations that included both international and national components. On this network measure, invisible scientists reported an average of 23 organizational contacts, while visible scientists reported an average of 21. Further, network measures are methodologically preferable to generic questions where respondents are asked about their general frequency of discussions without information on the specific identities of their contacts.[12] So while visible scientists may have discussions with colleagues abroad, without further information it is not justifiable to infer that they are more "integrated" in any specific community--particularly since they are no more likely to have spent time abroad.

Finally, a number of Likert-type opinion items were presented to respondents, who were asked their agreement with a series of statements, several of which pertained to agricultural and environmental questions. In the third panel of Table 8, lower scale values indicate stronger agreement with the specified item. The first pair of statements shows that visible scientists are more likely to view themselves as "autonomous scientists" with freedom to select their own research problems without external influence and publish the results without organizational review.

[Table 8 about here.]

The remaining statements were selected to represent views that are generally considered characteristic of international organizations (including bilateral and multilateral donors) and developed countries. Of course, it is not claimed that particular individuals in the developing world do not share many of these views. Many of those in international organizations and highly industrialized nations disagree with them as well. However, there is a broad set of formulations, many of which include "sustainability" and "environmental" issues that did not originate in LDCs and are often viewed as external impositions.

The two items on sustainable agriculture are more favorably viewed by those with international publications. Visible scientists are significantly more likely to feel that "pollution" and "water quality" are very important for sustainable agriculture. Moreover, they are more likely to agree with the view that the research program should concentrate more on increasing productivity in favorable than marginal regions, a view that is generally characteristic of international research organizations. Even the international research centers themselves are seen in a more favorable like by those who appeared on the international bibliography than by those who did not appear. Visible scientists are *more* likely to view the research of centers as useful for the national agricultural research systems of developing countries--even though they are *less* likely to work within the system themselves!

Discussion

Based on the indicators in the tables above, some preliminary conclusions may be drawn about the ways in which visible scientists differ from invisible scientists and the usefulness of productivity measures derived from online databases. The main findings are summarized, followed by a discussion of the usefulness of bibliometric indicators.

(1) Self-reported productivity is 2-3 times higher than productivity estimated using international sources.

(2) Researchers in international centers publish more than those in other sectors, but do not publish in

national journals in the country where they are located.

(3) University scientists have higher publication productivity than scientists at national institutes.

(4) For researchers whose career pattern and type of science most closely approximates academic science in the developed world--that is, for scientists in developing countries working in *international* institutes--bibliometric measures are a reasonably good measure of publication productivity. These measures are less reliable as indicators of publication productivity for university and government researchers, since they bear only a weak relationship with self-reported measures.

(5) Publication productivity is positively associated with national level of development.

(6) The *highest* rate of domestic publication occurs in the *most* developed of the three locations studied.

(7) For Africa, but not India, the count of self-reported publications in foreign journals is related to appearances in the bibliography.

(8) "Visible scientists"--those that appear in international literature sources--tend to be more established, university scientists with Ph.D.'s who participate actively in professional associations and journals.

(9) Resource differentials between visible and invisible scientists are not large, and are limited to "low tech" items such as telephone and typewriters rather than computers.

(10) Visible scientists have a stronger orientation towards international science, reporting more influence on problem selection and greater frequency of discussions with colleagues abroad as well as stronger agreement with views that are conventionally associated with international organizations and developed countries.

The difficulty of developing indicators of productivity in LDCs has been frequently noted,[13] causing some investigators to throw up their hands in despair.[xviii] The situation would be ideal--or at least easier--if we could resolve the doubts that have been expressed about the use of readily available indicators that can be generated from computerized, bibliometric databases. These results, however, have served only to exacerbate them. For some groups--Ghanaian university researchers, for example--bibliometric indicators correlate with self-reported international productivity. For others, such as university researchers in Kerala, the use of such indicators seems of little value. Should we then repudiate these indicators altogether? I hesitate to draw such a strong conclusion for four reasons.

First, the measure used to assess correspondence with bibliometric indicators was self-reported productivity. In this study, such reports were the best indicator possible given the absence, accuracy, and reproduction problems with written documents. Yet it may be feasible for alternative study locations or designs to collect other kinds of information to compare with *both* international sources and self-reports.

Second, online bibliographies are sometimes all that is available and are quite useful for some purposes. For all three locations, nearly all of the primary research *organizations* were accurately identified before going into the field.[xix] This is not an insignificant advantage when lead time is scarce and is consistent with results by Yuthavong.[14] Yet the particular individuals identified by the search would not have constituted a representative sample of the population of researchers in these locations. Unless there is some reason for an exclusive focus on scientists with international publication records, it would seem to be a poor means of sampling.

Third, these sources are useful for the measurement of international publication productivity for the relatively small number of researchers working in international organizations in developing countries. Of course, such a use is limited at best. Only Kenya, of the three locations studied, is home to such international centers, owing to the historical popularity of Nairobi within the international development community.

The most important reason to use international bibliometric databases in the construction of productivity indicators is simple but paradoxical. Bibliometric data *are* useful as indicators of international publication productivity for countries at lower levels of development. Again, the empirical finding is that where development is least, international databases seem to be more accurate indicators of international productivity than where levels are higher. One might conclude that this is precisely why they should be viewed as important. This argument holds that just in those resource-poor locations where compilation of indicators is impossible, where surveys are difficult, and so forth, reliable information on scientific output is readily available. The use of bibliometric measures should therefore be promoted as indicators of productivity in LDCs.

While this argument seems reasonable, the conclusion is mistaken, and therein lies the paradox: in the least developed countries international productivity is also less likely to be associated with domestic productivity. In other words, the conclusion in the above argument evades the issue of the meaning of productivity in the international arena and assumes that productivity represents a unitary dimension. But this is not the case in the less developed countries. The findings here indicate a unitary productivity dimension is more likely to characterize countries such as India with relatively higher levels of development.[xx]

In the African locations the relationship between national productivity and either self-reported or bibliometric counts is weak or absent. This suggests that domestic and international productivity are dissimilar. For example, Ghanaian academics were used as an example of a sector where the association between bibliometric counts and self-reported international productivity is high. But this group also exhibits a *negative* association between international and national productivity. The mechanism for the relationship between level of development and bibliometric indicators warrants extreme caution in their use, since at lower levels of development the distinction between national and international orientations to the research enterprise is more significant. At its worst an international orientation may reflect the priorities of careers in international science as opposed to research contributing to local or national problems.[15][xxi]

This possibility was illuminated by a direct comparison of scientists who appeared in international bibliographies--scientists who are internationally visible--with a group who did not. Visible scientists have a stronger orientation towards international science, reporting more frequent discussions and more influence on problem selection by colleagues abroad.[xxii] They have greater organizational tenure and higher supervisory status. They are more likely to be university scientists with Ph.D.'s who participate actively in professional associations and journals. The implication is that the "view from afar" based exclusively on information drawn from international databases does not accurately represent the population of researchers or domestic productivity in less developed countries.

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List of Tables

Table 1. Average values for three indicators of productivity*		
	Mean (N)	Std Dev
1) Articles-national*	2.29 (272)	6.09
2) Articles-international	2.04 (275)	4.49
3) Bibliometric count	.64 (293)	1.71
4) Adjusted count***	1.6	

*Full sample.
**Rows 1 and 2 are self-reported; rows 3 and 4 are based on publication counts from 17 databases (see text).
***Row 3 multiplied by 2.5 (time period adjustment).

Table 2. Average values for three indicators of productivity by sector*

SECTOR	Articles - National**	Articles - International	Bibliometric Count	Adjusted Count
International	.18 (11)	5.23 (13)	3 (15)	7.5
University	3.81 (79)	2.86 (79)	.84 (82)	2.1
National Institutes	1.71 (148)	1.63 (148)	.47 (154)	1.19
NGO	1.97 (34)	.71 (35)	0 (42)	0

*Cell entries are mean values followed by the number of non-missing cases.

**See Table 1.

Table 3. Average values for three indicators of productivity by location*				
LOCATION	Articles - National	Articles - International	Bibliometric Count	Adjusted Count
Kerala	5.24 (96)	2.27 (96)	.73 (101)	1.83
Kenya	.84 (73)	1.92 (74)	.54 (79)	1.36
Ghana	.62 (92)	1.43 (92)	.26 (98)	0.64

*Cell entries are mean values followed by the number of non-missing cases.

Table 4. Associations among productivity indicators by sector[1]

	Relationship between:					
	National and international productivity[2]		International productivity and bibliometric count		National productivity and bibliometric count	
SECTOR	Pearson (n)	Rank order	Pearson (n)	Rank order	Pearson (n)	Rank order
Full sample	.32* (271)	.12*	.40* (275)	.41*	.12 (272)	.15*
International	-.07 (11)	0.15	.88* (13)	.66*	.03 (11)	0.39
University	.55* (79)	0.05	.29* (79)	.30*	.27* (79)	0.06
National Institutes	.08 (147)	.18*	.21* (148)	.41*	.23* (148)	.22*
NGO	.18 (34)	0.18	--	--	--	--

[1] Pearson and Spearman rank-order correlation coefficients for the entire sample and by sector. Items by NGO respondents did not appear in the bibliometric count.
[2] Both self-reported indicators.
* Significant at .05 level.

Table 5. Associations among productivity indicators by location[1]

	Relationship between					
	National and international productivity[2]		International productivity and bibliometric count		National productivity and bibliometric count	
LOCATION	Pearson	Rank order	Pearson	Rank order	Pearson	Rank order
Kerala (n=96)	.38*	0.27*	.22*	0.27*	.27*	0.15
Kenya (n=73)	0.18	0.34*	.36*	0.43*	0.15	0.18
Ghana (n=92)	0	0.1	.52*	0.58*	-0.08	-0.05

[1] Pearson and Spearman correlation coefficients by location. National institutes, universities, and NGOs are included here, but the exclusion of NGOs does not change the results.
[2] Self-reported indicators.
* Significant at .05 level.

Table 6. Associations among productivity indicators by location and research sector [1]

	Relationship between:					
	National and international productivity[2]		International productivity and bibliometric count		National productivity and bibliometric count	
	Pearson	Rank order	Pearson	Rank order	Pearson	Rank order
Kerala-Government (n=55)	-0.01	0.16	0.18	0.36*	0.29*	0.26
Kerala-Academic (n=30)	0.7*	0.34	0.24	0.15	0.26	0.06
Kenya-Government (n=46)	0.3*	0.38*	0.42*	0.43*	0.11	0.11
Kenya-Academic (n=19)	0.09	0.26	0.36	0.47*	0.28	0.28
Ghana-Government (n=47)	0.18	0.07	0.44*	0.52*	0.02	-0.08
Ghana-Academic (n=30)	-0.12	0.01	0.56*	0.65*	-0.28	-0.23

[1] Pearson and Spearman correlation coefficients by location and sector.
[2] Self-reported indicators.
* Significant at .05 level.

Table 7. Social and Organizational Characteristics of Scientists[1]		
	Invisible Scientists[2] n=153	Visible Scientists n=83
Female	26%[3]	26%
Age	41**	44
Years with organization	10.9**	14.5
Yrs. worked with commodity or program	9.3**	12.2
Highest degree Ph.D.	47%**	80*
Yrs. education abroad	2.6	2.4
University affiliation	29%**	45%
# of professionals supervised	2.1**	4.2
# of professionals worked with closely	7.2	8.1
# of research projects	3.3	3.8
Held office in professional association	36%**	51%
Membership of journal editorial board	17%**	38%
# professional meetings attended	7.2**	9.9
Private office	64%**	76%
Ready access to telephone	66%*	77%
Ready access to typewriter	62%*	75%
Ready access to PC	61%	59%

[1] University and national research institutes only.
[2] Visibility is indicated by at least one appearance in international bibliometric databases. Number of cases vary slightly for each dimension owing to missing data.
[3] Tests of significance employed are mean differences for variables measured at least ordinal levels (using a t test, for equal or unequal variances, as appropriate), or chi square test for nominal variables.
*p<.10 **p<.05

Table 8. Characteristics of Scientists: Communication and Attitudes[1]

	Invisible Scientists[2]	Visible Scientists
Communication (1=frequent, 4=never)		
# of contacts (organizational roster)	23	21
Frequency of discussions with universities (1=frequent)	1.6**	1.3
Frequency of discussions with NGOs	2.7*	3.2
Frequency of discussions outside country	2.3**	2.0
Problem Selection (1=most influence, 3=very little or no influence)		
Influence of supervisor (1=most influence)	1.9**	2.1
Influence of scientists abroad	2.6**	2.3
Research & the environment (1=agree strongly, 4=disagree strongly)		
I have a lot of freedom to select my own research problems.	2.0**	1.7
I am free to publish the results or reports of my research without asking permission.	2.3**	2.0
The international research centers usually undertake research that is useful for the national agricultural research systems of developing countries.	2.2*	2.0
Agricultural research should concentrate more on increasing productivity in favorable than in marginal regions.	2.2*	1.9
Importance of water quality to sustainable agriculture. (1=very important)	1.6**	1.4
Importance of pollution to sustainable agriculture.	1.5**	1.3

[1] University and national research institutes only.
[2] Visibility is indicated by at least one appearance in international bibliometric databases. Number of cases vary slightly for each dimension owing to missing data. Tests of significance employed are mean differences for variables measured at least ordinal levels (using a t test, for equal or unequal variances, as appropriate), or chi square test for nominal variables.
*p<.05 **p<.10

[i] Whitney [16] shows that the inclusion of non-U.S. publications and those in non-English languages has declined in major scientific and technical databases over the period from 1970-1990. But for Kenya and India, the most frequently referenced countries of publication for their respective regions, the number of documents in MEDLINE is slightly higher in the 1980s than in the 1970s.

[ii] Meneghini [17] showed for the Brazilian case that the ratio between international and total publications varied between fields from .143 in the agricultural sciences to .73 in chemistry, but the definition of "international" was simply "written in a foreign language," usually English.

[iii] This effort sought to provide the widest possible coverage of LDC research and eventually searched more databases than is typical for such a study. Often, the SCI has been used exclusively. However, the cost of such a search is substantial (approximately U.S.$3,000 in this case). While it would have been desirable to perform the search for a longer period, cost considerations made this impossible.

[iv] Sancho [11] shows that databases like AGRIS have superior coverage to SCI. Whitney [16] recommends the use of DIALOG as the system with the broadest range of disciplines among bibliographic databases. A preliminary search was conducted using the ALLSCIENCE facility in DIALOG, which provides an overview of over 160 databases concerned with all fields of science and engineering. However, many of these databases do not provide full information on the corporate source of the items.

[v] It is useful to divide databases into (1) a general type that seeks relatively comprehensive coverage like SCISEARCH (the Science Citation Index) and (2) field-specific data bases (such as CAB Abstracts, AGRIS International, and AGRICOLA for agricultural topics). When general databases are selected, classification codes are available in almost all cases to subset the records and allow some selection by topic. In this case, we selected all records that pertained to agriculture, to the environment, and to natural resource management that originated in the three study locations. The use of three specialized databases in agriculture overcomes the underrepresentation problem presented by the use of generalized indices.

[vi] The recent development of internet resources may change this, but web sites in these locations ares still quite rudimentary.

[vii] International organizations were all located in Kenya.

[viii] A standard response rate is difficult to calculate owing to the method used to obtain the interviews. In each location we tried to conduct interviews at every significant organization in the state and NGO sectors, and at all university departments with significant agricultural or environmental research. When the organization is considered as the sampled unit, then we failed in only one case (a Kenyan NGO that had just incurred the loss of all their computer equipment owing to theft). In Ghana, one university professor terminated the interview without explanation after twenty minutes.

[ix] One objection to using self-reports is based on memory, but the alternative is using vitae. These are often unavailable and outdated, and there is frequently no means of reproducing

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them.

[x] Some publications reported by NGO staff as national journal articles may not have been based on research, but this is also true of respondents in other sectors.

[xi] The bibliometric search technique described earlier allows us to measure the international interest in each locations by enumerating the number of articles *on* each location that originate *outside* each location.

[xii] Pearson correlations indicate the strength of the linear relationships among variables, while Spearman correlations indicate the association between variables where the values are ranked from low to high. Given the skewed distribution of productivity variables, the consistency between two indicators of association should yield more robust conclusions than relying on one or the other exclusively.

[xiii] There is no need for an adjustment to the bibliometric indicator here because it is a simple linear transformation of the measure, which has no effect on a correlation.

[xiv] In Kenya, 80% of those with at least a single entry in the international bibliography reported a publication in a foreign journal, as we would expect, since the level of development is intermediate.

[xv] For university scientists in Kerala, the relationship between self-reported national and foreign productivity seems strong, but crosstabular analysis shows why the nonsignificant rank-order correlation should be taken seriously. While there are clusters of low and high producers

on both factors--which leads to the high Pearson correlation--there is also a large cluster of scientists who produce articles for national journals but not foreign journals. It would be an oversimplification, therefore, to suggest that in more developed countries there is an underlying dimension of productivity. Even for university scientists in Kerala, the tendency to high publication productivity in both domestic and foreign journals is not strong.

[xvi] The question wording was "Years worked with commodity, resource, or program." This item was intended as one measure of the duration of the respondent's effort in a consistent research direction. The consistency of these duration items is surprising but convincing, since we tried to match the two groups in terms of professional age.

[xvii] We were unable to include items on technical equipment owing to the diversity of disciplines involved.

[xviii] As Frame noted years ago in Scientometrics, publication counts may be the most *reliable* indicator of scientific activity in developing countries, but their "principal problem" is lack of validity.[18] Konrad and Wahl [19] compared 30 developing countries using a large group of demographic, economic, and R&D indicators, concluding that publication output should not be used as a central indicator for decision-making in science and technology in LDCs.

[xix] The exception was nongovernmental organizations, which did not appear at all in our searches.

[xx] See in this regard Spagnolo's findings on Brazil [20] and Davis and Eisemon on four Asian communities.[21]

[xxi] Recent work on national priority setting by the International Service for National Agricultural Research (ISNAR) has addressed this issue in a number of reports.

[xxii] A further difference between visible and invisible scientists appeared in a group of questions on the needs of the research system. Invisible scientists were significantly more likely to say that the *users of research* should be included in the process of setting of research priorities.