Performance, Specialization and International Integration of Science in Brazil: Changes and Comparisons with Other Latin America and Israel.

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Contents.

Summary.

How have Brazilian research performance, specialization and ties with local, regional and distant colleagues been shaped by the institutionalization of science? Changes in Brazilian research are here ascertained and compared to research in the rest of Latin America and Israel which have similar and different, respectively, institutional arrangements for science.

Science is now institutionalized in Brazil insofar as it is appreciated and granted autonomy and support. Scientific activities such as research and training of researchers, however, have been concentrated in a fraction of the universities in Brazil, like elsewhere in Latin America but unlike in Israel where scientific research and training has been the primary purpose at all the institutions of higher education.

This difference between Brazil, or Latin America more generally, and Israel in their institutional arrangements for science has enhanced scientific performance in Israel so that research performance has been higher than in Brazil and in the rest of Latin America. Israeli performance has been higher despite the smallness of the country; actually, relative to its population and economy, Israeli performance has been higher than any other nation. But scientific research has expanded in Brazil, and the Brazilian rate of increase from the 1960s up to 1993 was higher than in the rest of Latin America, in Israel, and in the world as a whole. The current Brazilian crisis and doubts about the worthiness of science may entail a decline in the creation of scientific knowledge in the near future.

Brazilian research is specialized insofar as certain disciplines and specialties are foci of scientific attention in Brazil more than elsewhere. Brazilian specialization emphasizes the disciplines of physics, biology and mathematics, it is rather typical in biomedicine and earth and space science, and it deemphasizes clinical medicine, chemistry and technological science. Within medicine, though, tropical medicine and parasitology are fields of strong specialization in Brazil, like in the rest of Latin America, but unlike in Israel where specialization is more concentrated on mathematics and fertility. Brazilian growth has been highest in technological science, especially in computing. These directions of Brazilian specialization seem shaped by national needs and research policies.

Brazilian scientists are tied to colleagues who have influenced their research, and also are variously collaborators and competitors in research, and often also are significant recognizers of their work. These ties are not confined within Brazil but are also rather extensive with foreign colleagues. Brazilian research is somewhat integrated with science in the rest of Latin America insofar as regional influence and collaboration are higher than expected. This integration in collegial ties is promoted by the embeddedness of scientific ties in the links between Brazil and the rest of Latin America in other spheres of life. Although this regional integration is noticable, it is

rather weak and is overshadowed by the attachment to the world centers of science, located in North America and Western Europe. Scientists in Brazil, like elsewhere, defer to science in these centers, travel there, receive influence from science in the centers, seek collaboration there and value recognition from colleagues in the centers. The involvement of Brazilian scientists with the centers, though, has been slightly less than the participation of other Latin American scientists and much less than the integration of Israeli scientists in the centers. The Israeli ties with the centers, especially the North American center, is enhanced by their embeddedness in the strong political-economic links between Israel and the United States and also by institutional arrangements for science such as comprehensive scientific cooperation agreements with the centers and travel funds which are results of Israeli research policies for enhancing research performance through integration with the world centers of science.

National scientific development and participation in world science.

Throughout history people have interpreted sensed phenomena, and their interpretations have fueled intellectual traditions within many civilizations. Typically, a tradition has been parochial insofar as its cultivators have not been interested in extending participation, and even if they occasionally have sought to extend participation, is has remained a local endeavor because people in other civilizations aware of the exogenous tradition have refrained from participating in it (Shils 1981).

Science, however, is an atypical tradition in its extensive communality. Present-day participation in the scientific tradition is world-wide. Not only is science practiced in every society but its practitioners are receptive to ideas from any place on earth, pursue long-distance collegial ties, and disseminate their creations globally. This globality has evolved only recently. Until the 19th century, the tradition was concentrated within one area, Europe, where it had become established just a few centuries earlier. Global participation emerged in the 20th century. The formation of a global communal endeavor was a process of institution-building: both institutionalization, that is, granting legitimacy, appreciation and autonomy, and establishing institutional arrangements for global communal participation.

In early-seventeenth-century Europe the pursuit of knowledge about natural phenomena had some legitimacy and some appreciation but little autonomy. It was controlled by political and ecclestial authorities who respected religious dogma over natural knowledge. But a social movement had formed in Europe which was inspired by an utopian faith in progress by advancing empirical knowledge applicable to controling and exploiting nature. This scientistic movement advocated legitimation for the search for truth through empirical inquiry as an activity worthy of cultivation. The movement was successful first in England in the middle of the seventeenth century. The movement won legitimation for science as an intellectual tradition cognitively distinguishable from intellectual traditions such as contemplative philosophy, practical arts, crafts and religious thought. The shift to a considerable appreciation for empirical inquiry into God's creations, especially nature, was triggered by Puritan thought (see the content analysis of Puritan statements by Merton [1938] 1970, chapters 4-5). But the enhanced appreciation was broad as evidenced by the participation in science of not only Puritans but also many people from diverse other faiths (Merton [1938] 1970, chapter 6, shows the high participation of Puritans and the high participation from diverse other faiths is shown in many studies; whether Puritans were overrepresented is debated but not crucial here where the documented great diversity of participation is the relevant evidence showing the breadth of the appreciation of natural inquiry). Political and religious authorities granted natural inquiry considerable autonomy and authority as a source of truth along with the Bible. This institutionalization in England was imitated in the continental societies that in the culturally well-connected but politically decentralized Europe were competing for national esteem through appreciated cultural forms (Ben-David [1971] 1984, 75-87; Greenfeld 1987; Wuthnow

1987, 265-298). Empirical inquiry became appreciated as worthy of pursuit and support, it was granted autonomy from control by other spheres, and it was differentiated from other activities by establishing organizational arrangements specifically for this endeavor. These arrangements included the separation of a dignified social role or vocation devoted to empirical inquiry and organizational arrangements for formulating and implementing policies shaping the endeavor, for recruiting and training incumbents of the new social role, for validating claims to knowledge and disseminating knowledge, for evaluating and rewarding role-performance, for promoting and regulating communication and other role-relations, and, more generally, arrangements for integrating the practitioners into a community with a self-organization spanning across long distances, across nations, religions and other social divisions. This differentiated tradition became coined *'science'* and the social role became coined *'scientist'*. Science became supported by the provision of social resources such as laboratories, apparatus, libraries, and livelihood of the incumbents of the new role. Many of the scientists were employed as teachers in universities and in the nineteenth century scientific research became adopted as another purpose of many universities, along with teaching, especially in Germany. Although the scientific role became anchored on universities, hospitals, museums and other organizations, science continued to be practiced as a communal enterprise. The establishment of distinctiveness, legitimation and autonomy for the pursuit of science is commonly refered to as the institutionalization of science (Ben-David, [1971] 1984).

This first institutionalization occurred mainly in Northwestern and Central Europe but less extensively on the Iberian Peninsula and elsewhere. Institutionalization was then extended to the European settler-societies around the world, notably in North America, Australia and in what became Israel, but it did not extend much beyond the boundaries of Western civilization. There was little institutionalization of science on the Iberian Peninsula and therefore institutionalization did not extend to the colonies in Latin America (Schwartzman 1991, chapters 2-3). Despite the boundedness of the scientistic movement within Europe, the institutionalization of science had a potential for expansion.

The institutionalization of science in Europe codified a conception of nature as invariant in time and place. Knowledge was conceived to have a truth value independent of the researcher and therefore have the same truthfulness in all civilizations. The participants were recognized and considered themselves as discoverers of truth. Knowledge was considered to be cumulative and to be a component in the broader vision of human progress as an ongoing advancement of humanity. The doctrine of progress of humanity as an imagined global civilization promoted a cosmopolitan orientation among the participants (Anderson 1983; Robertson 1992; Schott 1993b, forthcoming). Natural inquiry was to be open to participation from any part of mankind (extended later to include women), and the resulting knowledge was to be widely disseminated as a collective good of humanity. This cosmopolitan orientation sustained knowledge diffusion and collegial ties across social divisions and long distances (Daston 1991). The faith in invariance of nature and in truthfulness of knowledge across places, together with the cosmopolitan orientation of the participants, created a potential for adoption of the European tradition in the non-Western civilizations.

The non-Western civilizations encountered European civilization mainly through its military, political, economic, and religious expansion. European intruders were not interested in imposing the European scientific tradition on indigenous peoples, but brought local people into contact with European goods and equipment; systems of communication, transportation, extraction, and production; and means for curing diseases and conducting warfare. Some local people considered European techniques better than their own and therefore judged European knowledge worth obtaining. Their efforts to import that knowledge promoted interest in participating in the creation of such knowledge, especially when some went to study at universities in Europe where they acquired a taste for research and upon their return home advocated establishing scientific organizations. This local legitimation and appreciation for science led to some autonomy for efforts to assimilate the tradition from the West (Adas 1989, 1991; Altbach and Selvaratnam 1989; Eisemon and Davis 1991; Petitjean, Jami and Moulin 1992; Shils 1976, 1991). The adoption of the scientific tradition seems to have preceded the adoption of other Western traditions such as the ideology of human progress and rationalization. The institutionalization proceeded, albeit with fragility and frequent moves toward deinstitutionalization, mainly around the 19th century in the non-colonial societies and also in the colonial societies, despite many colonizers' opposition. Institutionalization was one step of institution-building; the other step was to establish social arrangements for practicing science.

The institutionalization was accompanied by establishing institutional arrangements comprizing a specific social role or vocation for science, organizations for housing the scientific role, and arrangements for mobilizing needed social resources. Such arrangements, established in every society, are strikingly similar around the world. The similarity of institutional arrangements can be explained by their common source in world standards, both model arrangements diffusing through the web of scientists from center to periphery and doctrines promulgated by a global science policy regime.

Over the centuries scientific ideas and institutional arrangements have diffused from a center, located where scientists have recognized the greatest accomplishment (Ben-David [1971] 1984; Shils [1961] 1972a, [1961] 1972b). Scientists have attributed the achievements of the center partly to its institutional arrangements and therefore considered the center arrangements to be especially effective. In addition, their deference toward the achievements created in these institutions have infused a sense of appropriateness in the center arrangements so they have become standards to which adherence is expected. The foreign observers' beliefs in the effectiveness and in the appropriateness of the center arrangements have made them standards for imitation in their home countries (Schott 1980, 1987b). Notably, non-Western participants regarded

Western practitioners of science as role-models and the Western role-definition of a 'scientist' became imitated as a new role in the non-Western societies. This role of assimilator-creator-disseminator of knowledge also included a cosmopolitan orientation and an identity as a participant in a communal endeavor transcending traditional civilizational boundaries. Modified by the local social ecology, organizations for the practice of science were likewise established in the non-Western societies as copies of Western organizational forms such as the university and the scientific academy. Mobilization of social resources has been regularized, as in the West, by taxes, by grants and contracts for research, and by combining science with higher education.

Institutional arrangements are established not only by the process of diffusion of center models through the global scientific community, but also by adherence to doctrines promulgated by the global science policy regime, that is, the complex of arrangements shaping science policy around the world (King 1974; on international regimes in general, see Young 1989). Science policy, including doctrines of science and policies for and through science, is increasingly formulated and advocated by a regime sustained by and operating through a network of organizations such as the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Organization for Economic Co-operation and Development (OECD), the Rockefeller Foundation, and the World Bank. These scientistic doctrines become standards that are adhered to around the world partly because organizations such as UNESCO and OECD work through experts in rational organization and acceleration of progress with authority to design and recommend policies and strategies, because organizations such as the Rockefeller Foundation sponsor scientific endeavors selectively around the world, and because organizations such as the World Bank make loans to a state contingent on its policy for science. The scientistic doctrines of the global science policy regime are also influential because by adhering to the standards, nation-states and their leaders can enhance their esteem as participants in the emerging global civilization of modernity in which the scientistic doctrines are part of the prevailing broad ideology of human progress that is also promulgated by these organizations. Indeed, the global science policy regime is an element of the world-polity (Meyer 1987; Ramirez 1987). Science continues to be considered a component of the progress of individuals, nations, and humankind, and there is a widespread belief that such progress can be accelerated by rational organization and mobilization of resources for the pursuit of science. The meaning of human progress, though, is no longer mainly religious, but focuses on social and economic growth, power, and wealth. In mighty and wealthy societies, progress is considered in terms of national security and competitiveness (Hill 1989), and in poor societies it is concretized in terms of catching-up, development and modernization (Apter 1974; Sagasti 1979; Shahidullah 1991). Thus the rapid growth of scientific activity in virtually all societies since mid-century can be explained as a result of the scientism and the doctrines promulgated by the global science policy regime (Ben-David 1991, 521-559).

The science policy regime also shapes communal participation. The rational organization of science for national progress is thought to require integration of the national research endeavor with world science. The doctrine against intellectual protectionism, combined with the scientists' cosmopolitanism, counteracts parochialism and enhances participation in communal formations spanning the globe.

Although each scientist knows very few of the other practitioners, they consider themselves cultivators of a collective tradition, forming not only local communities but even a global community (Anderson 1983). Their sense of intellectual and moral communion is reinforced by their ties across social divisions and long distances and by institutional arrangements such as the Nobel Prize ritual and international scientific meetings and organizations, e.g. the International Council of Scientific Unions, and the agreement on free dissemination of scientific literature, an international agreement that is vital. The global scientific community of all scientists is informally organized into a global web of collegial ties. Between the macro-level of the global scientific community and the micro-level of the individual scientist are numerous intermediate groupings. The kinds of groupings commonly examined are a Kuhnian community of specialists, a research team, the scientists in an organization, and those in a country (reviewed by Shrum and Mullins 1988). Specialization, membership in a research team, organizational affiliation and societal location are groupings that all shape the web of ties among scientists (e.g. Schott 1987a; Shrum 1985). For understanding national participation in science, an especially significant grouping is the national scientific community. The national scientific community of the scientists in a country is informally organized by the web of their ties with one another and with foreign colleagues. Their foreign ties shape national participation in world science. Individual participation in world science can be described by the concept of a social circle consisting of a scientist's web of collegial ties with the local and distant peers who are significant for the scientist's work. These individual, national, and global webs are nested: a scientist's collegial circle is nested in the web of the scientist's national scientific community, which in turn is nested in the global scientific community. These web enable network modeling (Schott 1991a).

Brazil in regional and peripheral locations.

The scientific tradition is being adopted in virtually every society around the world. Science is becoming legimated and appreciated and practiced with support and backing from the local population or at least from a powerful stratum of the society. Science is being valued variously as an endeavor worthy in itself and variously for its multiple uses in nation-building and national development, and perhaps also as a symbol of modernization signalling participation in the world system of significant societies. Institutional arrangements for scientific activity are typically not local innovations but are usually modeled on arrangements prevailing in the place of highest performance, the center of world science. Scientists from much of the world congregate in the center. They consider the institutional arrangements in the center as most appropriate and also as most efficient insofar as the high performance of the center plausibly can be attributed to its institutional arrangements.

Despite the widespread modeling of the central institutional arrangements, however, there are considerable differences among societies in their institutionalization of science. Institutionalization differs among societies in degree and manner. Societies differ in their appreciation of science, in their granting of autonomy, in their provision of social resources, and in their institutional arrangements for science, and this shapes their scientific activities, including their research performance (Schott 1987b). Scientific activity in a small national scientific community cannot be self-reliant - not even Soviet research was self-reliant (Schott 1992a, 1992b). Local scientific work is more or less integrated with scientific traditions elsewhere, especially in the places of greatest creativity. World science has had its shifting center, the center was in England at time of institutionalization, then moved to France, then to Germany, and since the Second World War the major center has been in the United States (Ben-David, [1971] 1984), with Western Europe emerging as a secondary center (Schott 1991b). Scientifically small countries have tended to be peripheries that are attached to and variously integrated with the center (Shils [1961] 1972a, [1961] 1972b). Integration of the periphery with the center shapes the specialization in the periphery and enhances performance (Schott 1987b, 1992a).

This study focuses on a scientifically rather small country, Brazil. I shall ascertain Brazilian research performance and specialization and examine the manners and degrees of integration of Brazilian research into world science. I shall also attempt to ascertain how these developments have been shaped by the institutionalization of science in Brazil.

Brazilian society is part of the Latin American region. Brazil has rather intense links with other Latin American societies in most cultural domains, especially in religion and life style. In the economic and political spheres, Brazil participates in the regional life of Latin America and is dependent on trade and political links with other continents, mainly North America and Europe. Scientific ties are partly embedded in political-economic and other links (Schott 1988). But insofar as scientists are attracted to loci of creative work, their scientific ties may also transcend political and economic constraints, so also for this reason we would expect Brazilian scientists to pursue ties with colleagues in the North American and Western European centers of world science. In short, we would expect Brazilian research to be attached to and variously integrated with science done in elsewhere in Latin America, in North America, and in Western Europe.

Historical and comparative perspectives: changes and contrasts.

My purpose is to ascertain contemporary science in Brazil. But contemporary science can be understood better when contrasted to its own past and to science elsewhere. Therefore I adopt a historical perspective and shall ascertain changes in recent decades (as many years as time series data are available, which is back only a few decades). Furthermore, I adopt a comparative perspective and shall contrast Brazil to a place that is similar in its institutionalization of science and therefore expectedly also similar in its research, namely the rest of Latin America, and I shall compare Brazil to a place that is different in its institutionalization of science and therefore expectedly also different in its research, namely Israel. These two comparisons are suitable insofar as one is highly similar to and the other is highly different from Brazil in institutionalization of science.

I shall attempt to provide an interpretation that is up to date. However, although data go up to 1992, they tap outcomes of processes that have occured over some years. For example, I shall use indicators derived from publications up to 1992. But, typically, publications appear a year or so after submission of a manuscript and a manuscript is the result of a project conducted in the preceding year or so which has been designed earlier on the based of influence received even earlier. I shall use responses from interview surveys of scientists which I directed around 1991 but the questions focused on the scientists' activity in the period from 1985 to time of interview. Futhermore, changes in policy and in funding do not have instant effects but affect scientific activity, especially results of research, with a lag of some years (for example, funding reductions in the United Kingdom entailed decline in publications only about three years later; Irvine et al. 1985). I am emphasizing that the effects are lagged because the recent acknowledged crisis in Brazilian science (see, e.g. Schwartzman 1991, ch. 10) may not yet have had its impact on the currently available outcome measures up to 1992.

My study of individual, national, and global communal formations in science takes an institutional and interactional approach (the institutional approach is reviewed in Zuckerman 1988, and the interactional approach is reviewed in Shrum and Mullins 1988). My conceptualization of nested communal formations was developed over the years mainly from the general center and periphery theory (e.g. Greenfeld and Martin (eds.) 1988, see especially the essay by Shils). Accordingly, my perspective shares much with world-polity theory (e.g. Meyer 1987; Ramirez 1987) and globalization theory (Robertson 1992) and complements or supplements the more specific political-economic world-systems theory (e.g. Chase-Dunn 1989) and organizational field perspective (e.g. Powell and DiMaggio 1991; Shrum 1985). The general usefulness of my nested-level approach for disentangling complex local and global dynamics has been emphasized by Knoke (1990, pp. 201-202), and it is compared and contrasted to the organizational approach to research endeavors by Shrum and Bankston (forthcoming).

Institutionalization of science in Brazil, other Latin America, and Israel.

Science has become institutionalized in Brazil, in other Latin American societies and in Israel insofar as science is legitimated, appreciated and practiced with public backing and support. Science is appreciated in these societies partly as a cultural endeavor in its own right and partly for its multiple uses, notably for nation-building and national development in higher education, industry, agriculture, health services, the military, and as a channel for social mobility. The societies differ, however, in the firmness and pervasiveness of institutionalization and in their institutional arrangements for practicing science.

In Brazil, like in other Latin American countries, an emerging local scientific community has in the course of this century created a space for natural, medical and technological science around research institutes, some of the hospitals and some of the universities (on Brazil, see Schwartzman 1978, 1991, esp. Part 2; Velho 1990; Velho and Krige 1984; Verhine 1991; and also Ben-David 1976, 1987; on other parts of Latin America, see Albornoz 1991; Frame 1977; Glick forthcoming; Inter-American Development Bank 1988; Levy 1986; Schwartzman 1985, 1986; Vessuri 1986, 1990). But most of the up toward one hundred universities and university-like institutions in Brazil, like the many professional schools and other tertiary schools, have primarily emphasized teaching. In by far most of the nearly one thousand tertiary institutions in Brazil, research has not been a significant organizational purpose, and the faculty has had little training and experience in research and has not engaged in training researchers. The small space for the education of researchers implied that when the educational system expanded rapidly since the late 1960s in Brazil, like in other Latin American societies, the supply of researchers was far below the number of available academic positions, which in turn entailed a perpetuation of the two-tier academic system of a small fraction of research-oriented universities and a mass of teaching-oriented universities and professional schools. The financial support for scientific research, furthermore, has been rather turbulent and the public backing of science as a value in itself and as a means for national development is not widely rooted. The institutionalization of science is therefore rather precarious in Brazil and elsewhere in Latin America.

Earlier studies comparing scientific research in Brazil to that in other Latin American countries have found Brazil to be rather typical of Latin America with respect to social and human resources expended on scientific activity relative to population, such as stock of scientists and engineers, employment of scientists and engineers in research and experimental development, and expenditures on research and experimental development. Brazil has also been rather typical in terms of outcomes of scientific activity such as scientific publications relative to the national economic product and the influence of these publications on world science (Inter-American Development Bank, 1988). This similarity between Brazil and the rest of Latin America in both institutional conditions and some outcomes of course entails the hypothesis that the more detailed analyses undertaken here will show more similarities. Indeed, insofar as similarities are shown by all indications in the analyses, this will show the reliability of the indicators.

Israel provides a contrasting case. Israel is already known to be exceptional among the societies in the world by its high extent of scientific activity. Already in the 1960s were Israeli scientific authors exceptionally numerous relative the the national economic product (Price 1986). This high scientific activity has continued until today when Israel is the nation with the higest number of scientific articles relative to population and also relative to gross national product (Schott 1993a). This exceptional activity is the results of several conditions.

In Israel science has been highly appreciated, both in the dominant stratum and increasingly throughout the population (Ben-David 1962, 1964, 1986, 1991, chapter 3 with Aran and chapter 13 with Katz; Katz 1979; Tal and Ezrahi 1973; Zahlan 1970). There has been a traditionally high appreciation of learning in the Jewish culture and there has been a historically high tendency among Jews in Europe and North America to pursue higher education and scientific activities. Israeli society has an especially high demand for new and useful knowledge and for highly educated labor in several sectors, specifically health services, agriculture, industry, and the military in particular. The Israeli government and the academic institutions have had a policy of treating knowledge as a commodity that can be produced in a transnational market for research, notably by obtaining research grants and contracts from local and foreign funding sources. In short, science has in Israel been treated as a cultural endeavor as well as a social and economic investment, especially somewhat like an export industry.

Israeli science is institutionally integrated with higher education, seemingly more than anywhere else in the world. By the middle of this century the Israeli institutions of higher education were all converging on the nineteenth century German university model combining research and teaching and were also all modeling the American education of researchers through doctoral programs. This widely institutionalized training has produced a supply of researchers largely matching and occasionally even exceeding the demand for academic staff in the expanding Israeli system of universities (Ben-David 1986; Schott 1987a). By the early 1970s the Israeli research enterprise had crystallized as an essentially one-tiered set of seven universities and several university-related hospitals performing by far most of the research in the natural, mathematical, medical and technological sciences. The Israeli universities have been similar in so far as they all emphasize scientific research far more than teaching or direct service to the local community, provide research facilities and have a moderate teaching load. The self-governing faculty have been appointed largely on the basis of research accomplishment and the typical qualification for entry into an academic career has been a doctoral education and postdoctoral research training, frequently abroad, and some research experience. Likewise, advancement up through the several levels in the professoriate has been based chiefly on the criterion of accomplishments in research. These standards have been promoted by including foreign eminent scientists in the evaluation of staff, departments and universities, and also on the editorial boards of the journals published in Israel. Moreover, the universities and their affiliated hospitals have been providing facilities for research and have been promoting ties with foreign colleagues in several ways, by annual travel funds to each scientist and regularized sabbaticals and frequently granted leaves of absence for sojourns in foreign research institutes, and also by bringing visiting scientists from abroad. Actually, the policies of the Israeli authorities in government and the academic institutions have included establishing rather comprehensive bilateral scientific cooperation agreements with foreign institutions and countries, for example the U.S.-Israel Binational Science Foundation. These comprehensive institutional arrangements have promoted an uncommonly strong integration of Israeli research with the centers of world science which in turn has enhanced the research performance (Katz 1978; Schott 1987b).

The differences in institutionalization of science makes Israel a contrast to Brazil, a contrast that expectedly is informative insofar as it can be used to ascertain and explain developments in Brazilian research.

Concepts and their indicators based on the literature and a survey.

The concepts for describing the scientific research enterprise are either attributes or relations. Performance is an attribute, a characteristic of a scientist or, in the aggregate, of a national scientific community. Specialization is also an attribute, here a characteristic of a national scientific community. The other concepts are kinds of role-relations between scientists or, in the aggregate, between their national scientific communities (Burt and Schott 1989). I shall consider six analytically distinct kinds of role-relations - namely deference, travels, influence, collaboration, emulation, and concern for recognition. I shall briefly consider each concept and how the concept can be measured by one or two indicators.

Performance in scientific research refers to the creation of new public scientific knowledge. Performance in a country can be indicated by the articles in the world's major journals in science which are written by authors in the country. Another indicator is the extent to which the articles written in the country are subsequently cited in the literature. Two other indicators are the extents to which scientists in the country are named as principal contributors or as influencers on researchers surveyed in other parts of the world. These four measures are indicators of scientific performance.

Specialization refers to the substantive foci of scientific attention, the cultivation of some rather than other fields of research. Specialization in a country can be indicated by the concentration of publishing in some disciplines and subdisciplines.

Deference of researchers refers to their appreciation of others' performance. Researchers' deference toward performance can be indicated by asking them to name principal contributors to the field.

Travels by researchers can be indicated by asking them to report their visits to other institutions and their participation in meetings abroad.

Influence upon research refers to the transfer of intellectual material and its impact on research. Influence upon researchers can be indicated by asking them who influenced their research. Another indicator of influence upon researchers can be based on their bibliographic citations to earlier publications.

Collaboration refers to joint research. Collaboration between researchers can be indicated by asking researchers about their work jointly with others. Another indicator of collaboration is jointly authored publications.

Emulation refers to competition among researchers to excel in the performance of the scientific role. A researcher's emulation can be indicated by asking about felt competition with others to be first or best in research.

Recognition refers to the validation and acknowledgment of contributions to public knowledge, and as a social reward for role performance such recognition is often of great concern to a researcher. A scientist's desire for recognition from others can be indicated by asking about caring about others recognizing the research.

These indicators are based on data from two sources: the literature of world science and surveys of scientists in Brazil and other countries. Some of the above concepts have several indicators, based on different approaches. This enables methodological triangulation by which the imperfection of each approach is countered by using several approaches. Influence, for example, can be indicated both by survey data and by literature data. Questionnaire responses to a question asking about influence are not perfect, e.g. because the sample is not perfectly representative or because the respondent does not recall influences. Also citations in articles are far from perfect, e.g. because not all influence is reflected in citations and because not all citations reflect influence. But if surveys and citations show similar distributions then we consider the indicators rather reliable.

The literature-based indicators for this study are derived from the **Science Citation Index** which largely covers the world's important journals in the natural, medical and technological sciences, including journals published in the poorer parts of the world (Frame 1985; Garfield 1979, 1983a, 1983b; Stevens 1990). The main criterion for including a journal is its quality or impact, so the volume of indexed articles written by authors in a country is a reasonably good indicator of research performance in the country. Since 1973, the number of indexed articles has exceeded 260,000 annually. Annually, more than 4,400 of the articles were coauthored between people at different institutions. And the articles indexed in 1980-82 contained more than 1,835,000 citations refering to indexed articles published 1978-80. The citations and coauthorships are indicators of influence and collaboration occuring in collegial ties. These indicators derived from the scientific literature are far from perfect, especially when the focus is on the areas of the world where there may be considerable research for local dissemination but few journals are published with significant impact on world science (Eisemon and Davis 1989; Frame 1985; Moed 1989; Morita-Lou 1985). This is one reason for supplementing the literature-based indicators with survey data. In fact, the survey yields indications similar to the indications derived from the literaure and thereby validate the indicators based on the literaure.

The other indicators are derived from a survey of collegial ties among scientists in Brazil, elsewhere in Latin America, and in Israel, using a questionnaire administered during 1990-91. Focusing on collegial networks, the unit of analysis will not be a respondent but a relationship or a dyad of researchers within a country or in different countries. More precisely, the unit of analysis will be variously a travel (a visit to another institution or a trip to a conference), an expression of deference, a named influencer, a collaborator, a competitor, or another specific kind of role-relation. Brazilian, other Latin American, and Israeli participation in collegial networks will in the analyses be indicated by their reported 709 travels, 499 expressions of deference, and 1,228 influencers, etc., as listed in the tables. These relations were reported by 167 scientists, namely 64 in Brazil, 87 in other parts of Latin America (47 in Chile and 40 in Uruguay), and 16 in Israel.

Scientists were selected for the survey as follows. In each country I selected a geographically circumscribed site for survey. In Brazil, the site was a large city some distance from Sao Paulo with a large university with considerable research in the natural, medical and technological sciences. In the other part of Latin America, the sites were the capitals in Chile and Uruguay. In Israel the site was a city with a comprehensive university. These sites were selected because of availability of contacts and local interviewers. In each site the respondents were sampled mainly from a list, namely the list of authors of articles covered by the **Science Citation Index** which has a listing of authors in each city in the geographically arranged author index. The most recent list provided a sample of authors which was classified into disciplines according to the classification of journals they published in. This provided a classification of the sampled scientists into the disaggregate of science as eight disciplines: clinical medicine, biomedicine, biology, chemistry, physics, earth and space science, technology and engineering science, and mathematics. Each discipline is so broadly defined that the eight disciplines comprize all sciences. In each site the respondents were thus randomly sampled. However, this does not assure representativeness.

The restrictive selection of sites, one or two cities in each place, implies that the ties of the selected respondents are not assured to be representative of the ties of all scientists in Brazil, the other part of Latin America, and Israel. Representativeness can be gauged by methodological triangulation. It turned out, as will be shown in the tables, that in each place the respondents' reported collaborations and received influences are similar to the collaborations and influences indicated by the coauthorships and the citations in the articles by authors in the place. Therefore we can be reasonably confident that the ties reported by the respondents are rather representative of the ties of all the scientists.

The participation rate in the survey in each site exceeded 90% of the contacted scientists (except that I do not know the participation rate in Israel) and the response rate on any single item in the questionnaire was also above 90%.

A questionnaire was used for tapping ties of the respondents. The questionnaire briefly asked for attributes of the respondent such as education, career, research orientation (pure versus applied research), and research mode (experimental versus theoretical). Travels were tapped by two questions, *"Which institutions have you visited in the last 12 months?"* and *"To which conferences abroad have you gone in the years from 1985 to present?"* The respondent's deference was tapped by asking about contributors, *"Who are the people in the world who have performed the best scientific research in your field since 1985?"* noting also the place of each named contributor.

The main part of the questionnaire tapped the collegial circle around the respondent. The interpersonal circle around a respondent can be tapped by first identifying the significant others and then asking about their attributes and their relations, a procedure that has recently gained codification by adoption in the General Social Survey in the United States (Burt 1984).

In my survey, each scientist listed significant colleagues in response to the question, *"Who are the people whose specific ideas have influenced your research since about 1985?"*. The tie to each named colleague was tapped by the following questions,

"Through which media did their ideas influence your research?"
"To what extent has each person influenced your choice of problems for research?"
"To what extent has each person influenced your research through your reading of the person's publications?"
"To what extent has each person influenced your research through personal communication?"
"To what extent has the person been a collaborator on your research?"
"To what extent do you feel that you and the person are competing with one another to be first or best in research?"
"To what extent do you care about each person's recognition of your research?"

The attribute of a named colleague which is crucial for this study is of course the colleague's location, *"Where in the world is each person?"*

This questionnaire provides rather detailed information on collegial networks (for validation, see Schott 1992b). The surveyed scientists were mostly working in academic settings, in universities or in university-affiliated hospitals. Typically they had a doctoral level education and were performing research for publication in the literature gaining international circulation. In each place roughly half reported to be doing mainly pure research and roughly half reported to be doing mainly applied research. In each place, several were doing primarily theoretical work and several were doing primarily experimental work. The age composition was also similar across the places, most had obtained their highest degree in the 1970s or first half of the 1980s, a few were further in their careers and a few had less experience. The groups of respondents were thus rather similar in these personal background characteristics. They differed, however, in their participation in the international collegial networks, as will be shown in the later analyses.

Performance and specialization in research.

How much of the world's scientific research has been performed in Brazil and how does this compare to the size of the country in terms of population and economy? How much of the world's research in each discipline has been performed in Brazil? What have been the directions of specialization in Brazilian research? How have the performance and the specialization changed during recent decades?

Performance in Brazil and in every other place is here indicated by its scientists' share of scientific articles, the extent to which their articles are cited in other articles, other researchers' mentions of them as principal contributors, and mentions of them as influencers upon research elsewhere in the world. These four indicators of scientific performance are juxtaposed to two important conditions of science (Teitel 1987), namely the share of Brazil in the world's population and Gross National Product, as listed in Table 1.

Table 1. Scientific performance, juxtaposed to economy and population. Percentage distribution of articles, 1986; Percentage distribution of citations, 1980-85; Percentage distribution of contributors named in a survey; Percentage distribution of influencers named in a survey; Percentage distribution of Gross National Product, 1986. Percentage distribution of population, 1986.

	Performance in scientific research					
	Articles	Cites	Contributors	Influencers	GNP	Population
Brazil	.3 %	.2 %	0 %	0 %	1.7 %	2.8 %
Other LA	.8	.4	.1	.3	3.0	5.3
Israel	1.0	.9	2.0	.6	.2	.1
North America	40.9	54.8	49.0	45.9	31.3	5.4
Western Europe	30.8	30.8	35.2	33.9	22.7	7.2
Rest of world	26.1	13.0	13.7	19.3	41.2	79.2

Notes: The percentages in each column sum to 100% except for rounding. Sources: Articles (298,815) are from a dataset derived from the Science Citation Index for 1986 (Institute for Scientific Information) (dataset compiled by CHI Research; Stevens, 1990). Citations (exceeding 5 million) are derived from the Science Citation Index 1980-85 (Institute for Scientific Information) (data published by Schubert et al. 1989). Contributors (759) and influencers (2,159) are reported in a survey of scientists in Bangladesh, Czechoslovakia, Greece, India, Indonesia, Japan and the then Soviet Union (Schott 1992b). Their mentions of compatriots are excluded from the counts. Gross National Product is from World Bank, World Tables 1989-90 (Baltimore: Johns Hopkins University Press), P. S. Shoup, The East European and Soviet Data Handbook (New York: Columbia University Press, 1981) and C. L. Taylor and D. A. Jodice, World Handbook of Political and Social Indicators. 3rd ed. (New Haven: Yale University Press).
Population is from World Bank, World Tables 1989-90 (Baltimore: Johns Hopkins University Press) and United Nations, Demographic Yearbook 1987 (New York: United Nations, 1988).

Table 1 shows that Brazil is a scientifically small country, performing much less than 1% of the scientific research in the world, and this attracts much less that 1% of the citations in subsequent literature. No Brazilian scientist was among the nearly three thousands mentioned as principal contributors or significant influentials in a survey of scientists elsewhere. Brazilian research amounted to a little less than half of the research performed in the rest of Latin America and about a third of that performed in Israel where scientific performance was high as indicated by the rather frequent mentioning of Israelis as great contributors and influentials. In economy and population, Brazil is roughly half the size of the rest of Latin America, as in science. But Brazil is a whole order of magnitude larger than Israel in terms of the economy and even more in terms of population and yet far less research is performed in Brazil than in Israel. This shows that scientific performance in a country is not a reflection of the size of the country in terms of population or economy (there is only a very weak correlation with population and a weak correlation with the economy; see Schott 1991b). These differences in scientific performance seem shaped by differences in institutionalization of science.

Brazil and other Latin American countries have in recent decades been investing many human and material resources in expanding their scientific activities. So the question is not only one of the width of the gap to nations with higher scientific performance, but the question is also whether the gap is narrowing. The historical perspective is adopted by examining data from different years; Table 2. The available data covering different decades are unfortunately not compiled by exactly the same method, but they are from similar sources, so the different counting methods presumably do not alter the indications. The earliest data are counts of authors recorded in the **Current Contents** which is published by the Institute for Scientific Information that also publishes the **Science Citation Index** which has been used to count articles from the 1970s to the 1980s and to estimate the volume of listings up to 1993.

Table 2. Changes in scientific performance.
Authors in Brazil, in the rest of Latin America, and in Israel, as percentage of the world's authors in **Who is Publishing in Science**, annually 1967 to 1973. Articles by authors in Brazil, in the rest of Latin America, and in Israel, as percentage of world's articles in a fixed set of journals in the **Science Citation Index**, annually 1973 to 1986. Listings of articles by authors in Brazil, in the rest of Latin America, and in Israel, as percentage of the world's volume of listings in the **Science Citation Index**, 1975 to 1993.

	Brazil	Other LA	Israel
Authors			
1967	.17 %	.38 %	.92 %
1968	.14	.50	.87
1969	.18	.35	.87
1970	.19	.45	.77
1971	.19	.43	.86
1972	.24	.46	.90
1973	.28	.60	.91
Articles			
1973	.21 %	.73 %	.96 %
1974	.25	.71	.97
1975	.27	.65	1.00
1976	.31	.63	1.02
1977	.31	.63	1.07
1978	.31	.64	1.03
1979	.35	.67	1.01
1980	.36	.71	1.02
1981	.38	.76	1.00
1982	.33	.81	1.08
1983	.35	.81	1.07
1984	.36	.78	1.05
1985	.35	.79	1.08
1986	.35	.82	1.02
Listings			
1975-79	.40 %	1.07 %	1.05 %
1980-84	.49	1.19	1.11
1985-89	.54	1.22	1.10
1990	.63	1.25	.97
1991	.69	1.25	.96
1992	.71	1.29	.93
1993 (Jan-Feb)	.74	1.20	.96

Note: Total numbers of authors exceeded 125,000 and of indexed articles exceeded 265,000 annually. Source: Authors are from Who Is Publishing In Science (Institute for Scientific Information; the numbers of authors are listed in Price, 1986, pp. 203-205). Articles are from the Science Citation Index from 1973 to 1986 (Institute for Scientific Information); they are the articles in a set of journals that has been constant, namely fixed as those indexed in 1973 and articles are classified by address of author (dataset compiled by CHI Research; cfr. Stevens 1990).Listings are from the published Science Citation Index 1975 through February 1993; the percentage for a country is its percentage of the printed columns in the geographical section of the author index.

Table 2 indicates that Brazilian scientific performance grew considerably in its share of world science from the 1960s throughout the 1970s and the 1980s to the early 1990s. Research in the rest of Latin America grew slowly from the 1960s to the early 1980s but leveled off around the early 1980s and has been rather constant in the last decade. Israeli research grew during the early 1970s and was a rather constant share of world science from the mid-1970s through the mid-1980s but its share has been declining in recent years. Constant share of a place during a growth of world science of course means a continued growth of research in the place.

Another way to consider these shift is in terms of rank ordering. According to the listings, Israel ranked 15th among the nations in scientific activity in 1975-79 and was in the 1980s surpassed by Spain and the People's Republic of China, so that Israel moved down to 17th in science by the early 1990s. Brazil ranked 26th in 1975-79, trailing Austria, Norway, Finland, Czechoslovakia, Hungary and South Africa, which it surpassed in the 1980s during which it was surpassed by the People's Republic of China, so that Brazil moved up to be the 21st among the nations in scientific activity by the early 1990s.

Let me, however, reemphasize that the continued growth in Brazilian scientific activity as measured by this outcome up to 1993, does not fully capture the developments in the early 1990s because of the timelag between performance of research and its resulting publication. The precarious institutionalization of science in Brazil makes science very vulnerable to political and economic crises and the current turbulence, crisis and decay in Brazilian is quite likely to lead to some withdrawal of social support for science (Schwartzman, 1991, ch. 8). Following the decades of enthusiasm and growing support for science, which gave the scientists considerable self-confidence, the recent lessening of appreciation of science and a leveling of support is likely to lead, if not to contraction of the national endeavor, to a loss of sense of purpose and meaning among scientists, a situation of anomie (Ben-David [1971] 1984, ch. 9).

National research endeavors are not evenly distributed across fields of science, but are more or less concentrated in selected fields. The selection of foci of attention in a country entails a national specialization. Diversity among countries in national specialization entails a global division of labor in research. Specialization can be revealed when controling for the research performance of each place. I shall therefore indicate the specialization in a particular field in a country not only relative to the world effort in the field but also relative to the overall research effort of the country. Specialization in a particular field is high to the extent the measure exceeds 1 and it is low to the extent the measure is less than 1, as listed in Table 3.

Table 3. Specialization into eight disciplines and their subdisciplines, 1970s and 1980s. Ratio of the percentage of the articles from Brazil (from the other Latin America and from Israel) that are in the (sub)discipline to the percentage of the world's articles that are in the (sub)discipline.

	Brazil		Other LA		Israel	
DISCIPLINES and subdisciplines	1970s	1980s	1970s	1980s	1970s	1980s
CLINICAL MEDICINE	**.70**	**.58**	**1.39**	**1.13**	**1.02**	**1.15**
General and internal medicine	.4	.2	3.1	3.2	1.2	1.6
Allergy	1.8	.4	.8	.8	1.0	1.0
Anesthesiology	.2	.1	.1	.2	.7	.6
Cancer	.3	.2	.6	.6	1.0	1.1
Cardiovascular system	.4	.6	.6	.6	1.0	1.3
Dentistry	2.2	1.1	.8	.5	1.8	1.7
Dermatology and veneral diseases	.4	.6	.7	.4	1.1	1.0
Endocrinology	.6	.6	2.3	1.5	1.1	.9
Fertility	1.6	1.4	5.2	2.2	2.3	2.4
Gastroenterology	.8	.4	1.0	.4	.8	.9
Geriatrics	.1	.0	.2	.1	1.7	.9
Hematology	.2	.4	.7	.6	2.0	1.8
Immunology	.6	.7	.6	.6	1.5	1.2
Obstetrics & gynecology	.6	.3	1.6	.6	1.9	2.4
Neurology & neurosurgery	.6	.4	1.1	.9	1.0	1.1
Ophtalmology	.2	.3	.6	.4	1.6	1.3
Orthopedics	.2	.5	.4	.4	1.1	1.9
Arthritis & rheumatology	.4	.4	1.2	.8	.5	.8
Otorhinolaryngology	.2	.5	.3	.2	.9	2.1
Pathology	1.2	.9	2.2	.7	.8	.6
Pediatrics	.2	.3	.7	.6	1.2	2.0
Pharmacology	1.8	1.1	1.0	1.2	.7	.6
Pharmacy	.3	.1	.3	.1	.2	.3
Psychiatry	.2	.1	.4	.2	1.0	.9
Radiology & nuclear medicine	.3	.4	.4	.2	.5	.5
Respiratory system	.1	.5	.9	.7	.8	1.2
Surgery	.7	.6	.5	.3	.8	.9
Tropical medicine	9.2	10.8	6.6	6.5	.6	.9
Urology	.5	1.0	.3	.2	.7	1.1
Nephrology	2.8	.9	1.1	.4	1.8	2.1
Veterinary medicine	.5	.5	.6	.7	.6	.3
Addictive diseases	.7	.8	.6	1.0	.6	2.2
Hygiene & public health	2.1	.9	3.1	.5	.6	.6
Miscellaneous clinical medicine	.0	.1	.2	.3	1.4	1.7
BIOMEDICINE	**1.33**	**1.03**	**1.28**	**.98**	**1.13**	**.98**
Physiology	1.1	.7	3.5	1.7	.5	.4
Anatomy & morphology	4.5	2.4	1.7	1.6	1.0	.9
Embryology	1.1	.6	1.0	.7	.7	.8
Genetics & heredity	2.3	1.6	1.1	1.3	1.4	1.1
Nutrition & dietetics	1.2	1.4	2.3	2.1	1.0	.8
Biochemistry & molecular biology	.8	.6	1.0	.9	1.6	1.2
Biophysics	.6	.6	.6	.4	.6	.9
Cell biology, cytology & histol	1.9	1.9	1.1	.9	1.0	.9
Microbiology	.6	.7	.6	.8	1.1	1.0
Virology	.2	.2	.5	.7	1.5	1.2
Parasitology	6.0	5.9	2.7	2.1	.8	1.2
Biomedical engineering	1.7	1.0	.4	.6	1.1	1.6

Microscopy	1.4	.4	.8	.4	.2	.3
Miscellaneous biomedicine	.8	.6	.5	.4	.7	.6
General biomedical research	1.5	1.1	1.4	.8	.8	.8
BIOLOGY	**1.39**	**1.60**	**1.39**	**1.52**	**1.15**	**1.12**
General biology	2.9	2.4	.6	.5	.4	.6
General zoology	.4	.8	.7	.5	1.5	1.3
Entomology	1.4	1.8	1.2	1.4	.9	.8
Miscellaneous zoology	1.9	3.1	1.2	2.2	1.0	1.1
Marine biology & hydrobiology	.5	1.1	.8	.8	.5	.6
Botany	2.0	2.1	1.5	2.1	2.0	1.7
Ecology	.3	.2	1.0	1.5	.8	.6
Agriculture & food science	1.3	1.3	2.1	1.6	.9	.9
Dairy & animal science	.1	.4	.3	.4	1.1	1.2
Miscellaneous biology	.5	1.1	1.6	1.5	.8	.8
CHEMISTRY	**.72**	**.74**	**.61**	**.84**	**.71**	**.62**
Analytical chemistry	1.2	1.0	.5	.5	.4	.5
Organic chemistry	.7	.6	.6	.9	1.2	.8
Inorganic & nuclear chemistry	1.4	1.0	.5	.7	.5	.3
Applied chemistry	.2	.4	.3	.5	.3	.5
General chemistry	.7	.6	.7	.8	.5	.4
Polymers	.2	.4	.4	.7	.8	.6
Physical chemistry	.7	1.1	.8	1.2	.9	.9
PHYSICS	**1.60**	**1.82**	**.61**	**.91**	**1.11**	**1.105**
Chemical physics	1.1	1.0	.7	.9	2.1	1.6
Solid state physics	3.2	4.0	.6	1.2	1.4	1.0
Fluids & plasmas	.4	.7	.2	.6	1.3	1.0
Applied physics	.8	.9	.3	.5	.8	1.0
Acoustics	.1	.2	.7	.7	.8	.7
Optics	.6	.8	.7	1.1	1.0	1.6
General physics	1.7	1.8	.6	.9	.7	.8
Nuclear & particle physics	2.2	2.9	1.1	1.4	1.6	1.2
Miscellaneous physics	3.0	3.0	2.1	3.2	1.1	1.1
EARTH AND SPACE SCIENCE	**1.08**	**1.24**	**1.12**	**1.13**	**.85**	**.76**
Astronomy & astrophysics	1.3	1.5	2.2	2.3	.8	.5
Meterorology & atmospheric scien	.2	1.1	.2	.2	.7	.7
Geology	.8	.7	.8	.4	1.0	.8
Earth & planetary science	1.3	1.5	.7	.6	1.0	1.0
Geography	.0	.0	.0	.0	.0	.7
Oceanography & limnology	.4	.4	.6	.9	.4	.5
TECHNOLOGICAL SCIENCE	**.44**	**.63**	**.33**	**.48**	**.83**	**.95**
Chemical engineering	.3	.3	.6	1.1	.8	.8
Mechanical engineering	.3	.3	.2	.4	1.0	1.4
Civil engineering	.4	.5	.7	.5	2.0	1.9
Electrical enginee & electronics	.7	1.0	.2	.3	.7	.8
Miscellaneous engin & technology	.0	.0	.0	.0	.6	.0
Industrial engineering	.0	-	.7	-	1.1	-
General engineering	.1	.1	.1	.1	1.6	1.7
Metals & metallurgy	.5	.6	.4	.7	.3	.5
Materials science	.3	.6	.2	.4	.5	.6
Nuclear technology	.6	.5	.6	.6	.5	.9
Aerospace technology	.4	.3	.0	.1	1.2	1.4

Computers	.4	.9	.2	.5	1.3	1.4
Library & information science	.3	.9	.6	.2	.2	.8
Operations res & management sci	.8	.6	.3	.6	1.9	1.9
MATHEMATICS	**1.49**	**1.58**	**.49**	**.71**	**1.56**	**1.61**
Probability & statistics	.7	.9	.7	.7	1.1	1.5
Applied mathematics	.9	1.0	.4	.7	1.5	1.6
General mathematics	1.7	1.8	.5	.7	1.6	1.4
Miscellaneous mathematics	2.7	2.5	.4	.9	2.5	3.7

Notes:The 1970s denote 1973-79 and the 1980s denote 1980-86. Industrial engineering was not reported as a subdiscipline in the 1980s. Source: Science Citation Index from 1973 to 1986 (Institute for Scientific Information). (dataset compiled by CHI Research; Stevens 1990).

Table 3 shows that Brazilian research was somewhat specialized. Whereas the Brazilian cultivation of the disciplines of biomedicine and earth and space science was similar to their cultivation in the world as a whole, Brazilian research emphasized biology, physics and mathematics, with comparatively less research in clinical medicine, chemistry and technological science. This indication of specialization is similar to an indication obtained by a somewhat different classification procedure which shows a Brazilian specialization in physics and mathematics and a deemphasis especially in chemistry but also in engineering (but did not separately classify clinical medicine, biomedicine, biology, and earth and space science; Schubert et al., 1989, p. 401).

The discipline with most rapid growth from the 1970s to the 1980s was technological science. The increasing specialization in the discipline of technological science was largely concentrated in its subdisciplines of computers, information science and electrical engineering and electronics. These fields are known to have been expanding in Brazil, as a results of deliberate research policies (Schwartzman, 1991, pp. 232-236). Although these are fields of increasing specialization, they have not become the fields of major concentrations. Specialization shows concentrations mostly in tropical medicine and in parasitology (again, relative to the world distribution across fields) (also this subfield specialization is consistent with that obtained by another procedure; Schubert, 1989, p. 448). Conversely, Brazilian research has deemphasized the fields of geriatrics and acoustics.

By comparison, specialization has been somewhat different in the rest of Latin America where there has been more emphasis on the disciplines of clinical medicine and less emphasis on physics and mathematics. But, like Brazil, other parts of Latin America have concentrated on tropical medicine and to some degree also on parasitology. Israeli research is less specialized into particular disciplines except mathematics which is known to be exceptionally strong in Israel (Schott 1987b). But there are subdisciplines with particular concentrations in Israel, notably fertility. These indications of Israeli specialization is similar to that obtain by a somewhat different procedure (Schubert et al., 1989, p. 416 and 458).

These specializations can be partly explained as resulting from national needs and interests. Brazil and other Latin American countries have a considerable need for knowledge in tropical medicine and parasitology whereas Israel has an interest in enhancing the fertility of the Jewish population (and in reducing the high birthrate of the Arab population). But the scientists' research is also shaped by their attention to science done elsewhere.

Deference to world science.

Scientists continually evaluate work that they are aware of. They assess not only the truthfulness but also the worth of new knowledge. The appreciated contributions may become exemplars influencing their own research. Their deference toward contributions provides a mental map for orientation in the world of science. To indicate Brazilian and other scientists' deference, the respondents in the survey were asked to name those who had made the major contributions in their field in recent years and to report the location of each named contributor; Table 4.

Table 4. Deference to contributors to science.
Percentage distribution across places of people named as outstanding by respondents in Brazil, in other Latin America and in Israel.

Country of contributors	Country of respondents		
	Brazil	Other LA	Israel
Brazil	18 %	2 %	0 %
Other LA	1	6	0
Israel	1	.4	19
North America	41	47	60
Western Europe	34	36	15
Rest of world	6	9	6
N contributors	170	282	47

Note: The percentages in each column sum to 100% except for rounding. Source: Survey of scientists in Brazil, other Latin America and Israel.

Table 4 shows that Brazilian scientists have defered most to science in North America, second most to science in Western Europe and third most to science done in Brazil. Likewise, scientists in the rest of Latin America and in Israel also have defered most to science in North America, second most to science in Western Europe and third most to local science. Deference is thus toward the easily observed and intimately understood local work and toward work in the world centers of science. Despite Israel's spatial proximity to Europe, the Israeli scientists defer less to European science and more to North American science than the Brazilian and other Latin American scientists do. This can be explained by the embeddedness of collegial ties, including deference, in political and economic links which are especially strong between Israel and the United States.

The deference toward science in various places makes for attraction toward those places and we should expect scientists to travel mainly to those places.

Travels.

To what degree do scientists in Brazil travel to interact with colleagues and what are the destinations of their travels? Scientists in Brazil and the other countries were asked to report their visits to other institutions in the latest 12 months until the time of interview and to report their participation in meetings abroad from 1985 until the interview; Table 5.

Table 5. Travels to other institutions and to meetings abroad.
Percentage distribution of respondents' visits to other institutions; and percentage distribution of participation in meetings abroad.

	Brazil		Other Latin Am.		Israel	
	Visits	Meetings	Visits	Meetings	Visits	Meetings
Brazil	68 %	na	8 %	18 %	0 %	0 %
Other LA	1	9	48	38	0	0
Israel	0	0	0	.4	31	na
North America	11	31	17	16	54	56
Western Europe	10	49	26	27	15	34
Rest of world	9	12	1	1	0	10
Mean visits or meetings for a respondent.	1.5	1.9	1.8	3.1	1.7	4.9

Note: The percentages in each column sum to 100% except for rounding. Source: Survey of scientists in Brazil, other Latin America and Israel.

Table 5 shows that Brazilian scientists on average made 1.5 visits to another institution in the latest year and participated in 1.9 meetings abroad in the latest six or so years. This traveling frequency is somewhat less than that of scientists in the other surveyed Latin American countries (which are much smaller than Brazil and thereby encourage travel) and much less than that of Israeli scientists whose geographical location provides little opportunity for travel. This major difference in travel has rather little to do with geographically shaped opportunity but can be explained as a consequence of different institutional arrangements, notably the Israeli scientists' annual funds for travel as mentioned in the section on 'Institutionalization of science'.

The Brazilian scientists' visits to other institutions were mainly within Brazil. Their travels abroad were primarily to Western Europe and secondarily to North America. But travels were also frequent between Brazil and other Latin American countries, in both directions. Table 5 also shows that scientists in other Latin American countries also traveled more to Western Europe than to North America while Israeli scientists traveled far more frequently to North America than to nearby Western Europe. These destinations of traveling reflect their deference orientations.

The scientists' travels and deference should expectedly be reflected in the intellectual influence upon their research.

Influences from and upon world science.

To what extent has research in Brazil been influenced by results from within Brazil and from other places? And, reciprocally, to what extent has research in each place been influenced by the results of Brazilian research? Into which environment has Brazilian research been most cohesively integrated in terms of influence? How have influences from and upon Brazilian scientists changed in recent decades? Through which channels have Brazilian scientists been influenced? What are the origins of influence through publications and through personal communication? What are the sources of influence on selection of problems for research by Brazilian scientists? These questions will be answered here, comparing Brazilian influences with influences involving scientists in the rest of Latin America and in Israel.

Influences upon scientists in each place are indicated by the percentage distribution of the citations in their articles, as listed in a column in Table 6.

Table 6. Influence among national scientific communities; 1980.
Percentage distribution of citations in articles by authors in each place (column) across places of cited author (rows).

Influencing (cited) scientists	Influenced (citing) scientists					
	Brazil	Other LA	Israel	North America	Western Europe	Rest of world
Brazil	23.2	.8	.1	.1	.1	.1
Other LA	1.4	20.2	.3	.3	.3	.2
Israel	.7	.9	24.1	.8	.8	.8
North America	41.3	47.9	48.4	75.7	39.0	35.5
Western Europe	24.0	22.7	21.5	18.0	52.7	21.3
Rest of world	9.4	7.4	5.6	5.3	7.1	42.1
N citations	3,960	9,449	18,041	914,857	621,210	267,590

Note: The percentages in each column sum to 100% except for rounding. Source: Science Citation Index *(Institute for Scientific Information); citations in articles 1980-82 refering to articles 1978-80.*

The first column in Table 6 shows that Brazilian research was influenced mostly by results from North America and then by results from Western Europe and from within Brazil. Likewise, comparing to the second and third columns, scientists in the rest of Latin America and in Israel were also mainly influenced by results from North America and then from Western Europe and from within their place. These origins of influence are highly similar across the three compared places. The origins of influence upon the scientists follow the patterns of their deference more than the patterns of their travels. Notably, although Brazilian and other Latin American scientists have traveled much more to Western Europe than to North America, they have defered much more to North American science and have been much more influenced by science in North America than in Western Europe.

The first row in Table 6 shows that Brazilian scientific results exerted some influence on research in the rest of Latin America but very little on research in other continents. By comparison, the second and third rows show a little more influence from other Latin American science and much more influence from Israeli science upon research in North America, Western Europe and elsewhere.

Table 6 shows that influence has been rather strong between Brazil and the rest of Latin America, in both directions, relative to their small influence on research elsewhere. This suggests some regional integration in influence. Regional integration can be indicated as the occuring influence (in Table 6) relative to the influence that we should expect if influence were not embedded in particular links between countries but influencees were independent of influencers. If influence were not selective, influence would just be proportional to the influencer's tendency to exert influence and also to the influencee's tendency to receive influence. This conception of independent influence can be formalized (such formalization is considered in Schott, 1986, and used in studies of scientific influence in Schott 1987a, 1988, 1992a).

The conception of behavioral independence between influencers and influencees can be formalized by the model of statistical independence in a two-way table and involves computing expected values. The expected values are like those for the usual chi-square test of independence in a two-way frequency table except that we have no diagonal in the table of citations from each scientific community to the other communities. Under the model of independence, the expected number of citations from an influenced community **r** to an influencing community **c** is the product of two numbers $\mathbf{P}_r\mathbf{Q}_c$ where $\mathbf{P}_r$ is the tendency of **r** to cite others and $\mathbf{Q}_c$ is the tendency of **c** to be cited by others. The expected number can be computed from the observed frequencies of citations from each community to the other communities. The diagonal-less matrix of expected numbers has the same row-sums and column-sums as the diagonal-less matrix of observed citations (modeling of a diagonal-less table with formulas for use in computing expected numbers is in Haberman 1979, ch. 7, and is implemented in publicly available software, Eliason 1990, pp. 16-18).

The ratio of the observed citations to the expected number of citations is a measure of integration in the web of influence. The measures of integration are listed in Table 7. Integration has been weak to the extent the measure is less than 1 and integration has been strong to the extent the measure exceeds 1.

Table 7. Integration in influence among national scientific communities.

Influencing (cited) scientists	Influenced (citing) scientists: Brazil	Other LA	Israel	North America	Western Europe	Rest of world
Brazil		6.8	.8	1.0	.9	1.0
Other LA	4.4		.9	1.1	.9	.9
Israel	.7	.9		1.1	.9	1.0
North America	1.0	1.1	1.1		1.0	1.0
Western Europe	1.0	.9	.9	1.0		1.0
Rest of world	1.2	.9	.7	1.0	1.0	

Note: Influence within each place is here ignored. Source: Same as for Table 6.

Table 7 shows in the first row that Brazilian research has been highly integrated with science in the rest of Latin America, influence has been more than six times higher than expected. Reciprocally, as shown in the first column, other Latin American research has also been highly integrated with Brazilian science, influence has been more than four times higher than expected. Integration has been stronger between Brazil and the rest of Latin America, in both directions of influence, than between any other listed places. Such regional integration also exists among, for example, the Scandinavian national scientific communities (Schott 1992a). Contrasting the regional integration in influence, integration has been as expected between Brazil and the other major places such as North America and Western Europe but comparatively weak between Brazil and Israel that has been integrated with North American science. The Latin American regional integration in science can be explained by the embeddedness of scientific ties in integrative links among Latin American countries in other spheres of life such as education, religion, language, economy and politics. The scientific integration between Israel and North America can be explained by its embeddedness in the strong political, economic and educational links between Israel and the United States. Collegial ties between scientists in different countries, more generally, tend to be embedded in other links between their societies, notably in education, language, politics and economy (Schott 1988).

Influence can be indicated not only by citations but also by a survey asking scientists to report influence on their research (as discussed in the earlier section on 'Concepts and their indicators'). Scientists in Brazil, in the rest of Latin American, and in Israel named people who had influenced their research. Sources of influence are indicated by the distribution of these named influencers across their locations; Table 8.

Table 8. Influence upon scientists from local and distant colleagues. Circa 1990. Percentage distribution of influencers named by respondents in Brazil, in other Latin America and in Israel.

	Brazil	Other LA	Israel
Brazil	43 %	4 %	0 %
Other LA	1	35	0
Israel	1	1	26
North America	25	32	55
Western Europe	25	25	13
Rest of world	6	4	7
N influencers	408	710	110

Note: The percentages in each column sum to 100% except for rounding. Source: Survey of scientists in Brazil, other Latin America and Israel.

Table 8 shows, like the citations in Table 6, that influences upon scientists in Brazil, other Latin America, and Israel originate primarily from North America and secondarily from Western Europe, with considerable influence from local colleagues. These survey responses also indicate, like the citations, that there is a small but notable regional integration in influence among scientists in different parts of Latin America.

Influence seems to have changed from 1980 to 1990 as can be seen by juxtaposing Tables 6 and 8. Around 1980 North American influence upon research in Latin America was roughly twice as strong as the influence from Western Europe (Table 6) but by 1990 North American influence seemed only slightly stronger than influence from Western Europe upon research in Latin America (Table 8). Opposite changes seem to have occurred in the case of influence upon research in Israel, namely as follows. Around 1980 North American influence was roughly twice that from Western Europe but by 1990 North American influence was roughly four times the influence from Western Europe upon research in Israel. These changes in scientific influence may be explained as consequences of changes in the political-economic links between the places. During the 1980s, Latin American political-economic links seem to have grown more with Western Europe than with North America. Conversely, West European political-economic links with Israel have cooled during the 1980s. Explaining the main differences between Tables 6 and 8 as changes in influence resulting from changing geopolitical-economic links seems more plausible than attempting to attribute the differences between the tables to differences in the data sources (indexed journals for one table and sampled scientists for the other table) or in the indicators (citations in one table and a questionnaire item in the other table).

Influence is channeled through a variety of media, notably publications, preprints, lectures, discussions, telephone, facsimile messages, postal mail, and perhaps also through rumor. The interviewed scientists reported which one or more media channeled influence from each named colleague; Table 9.

Table 9. Media channeling influence upon scientists from colleagues.
Percent of the colleagues in each location who influenced through each medium.

BRAZIL

	Publications	Preprints	Lectures	Discussion	Telephone	Fax	Elec. mail	Post mail	Rumor	NUMBER OF COLLEAGUES
Brazil	48	19	31	89	10	2	2	12	5	177
Other LA	75	100	50	100	0	0	0	50	0	4
Israel	100	0	0	0	0	0	0	0	50	2
North America	94	22	16	24	1	1	1	6	12	101
Western Europe	97	19	26	50	2	3	6	17	9	101
Rest of world	91	29	9	22	0	0	9	0	0	23

OTHER LATIN AMERICA

	Publications	Preprints	Lectures	Discussion	Telephone	Fax	Elec. mail	Post mail	Rumor	NUMBER OF COLLEAGUES
Brazil	50	4	31	85	4	0	0	15	0	26
Other LA	42	11	25	96	4	2	3	9	0	244
Israel	75	25	25	25	0	0	0	50	0	4
North America	92	18	31	47	8	10	8	20	2	226
Western Europe	82	13	28	61	5	17	6	36	1	180
Rest of world	90	0	17	31	0	0	3	28	0	29

ISRAEL

	Publications	Preprints	Lectures	Discussion	Telephone	Fax	Elec. mail	Post mail	Rumor	NUMBER OF COLLEAGUES
Israel	50	44	43	82	29	7	18	18	4	28
North America	52	38	18	70	25	15	28	37	2	60
Western Europe	57	71	21	79	21	0	57	43	0	14
Rest of world	100	75	38	25	13	25	38	38	38	8

Notes: Number of colleagues in a location is the number of colleagues in that location who were reported to have exerted influence through one or more media. The Israeli respondents reported no colleagues in Brazil and the rest of Latin America. Source: Survey of scientists in Brazil, other Latin America and Israel.

The left-most column in the upper part of Table 9 shows that Brazilian scientists were influenced by publications by about half their significant colleagues in Brazil, publications by more of their colleagues in the rest of Latin America, and publications by the vast majority of their significant colleagues elsewhere. Publications were the most frequent medium of influence from colleagues outside Latin America. But influence from colleagues in Brazil and in the rest of Latin America was more frequently channeled through face-to-face discussions. Also other interpersonal media were channels of influence more frequently from local and Latin American colleagues than from colleagues outside Latin America.

Scientists in the other part of Latin America reported influence through the various channels to be rather similar to the channels of influence upon Brazilian scientists. Face-to-face discussion was the most frequent medium of influence from Latin American colleagues and publications were the far most frequent medium of influence from colleagues outside Latin America.

Brazilian scientists, however, differed from scientists in the other part of Latin America in that they less frequently were influenced through interpersonal media such as face-to-face discussion and postal mail. This difference indicates that Brazilian scientists, compared to scientists in the rest of Latin America, were slightly less integrated into networks of colleagues in the North American and European centers.

The bottom part of Table 9 shows that Israeli scientists differed considerably from scientists in Brazil and other parts of Latin America in that publications were a less significant channel of influence upon the Israelis, while the interpersonal media were highly utilized channel of influence, not only from local colleagues but also from colleagues in North America and Europe. Through a multiplicity of interpersonal media, Israeli scientists have been intensely integrated into circles of colleagues in the world centers, evidently far more integrated than Brazilian and other Latin American scientists.

The influence is exerted through the professional mass media, i.e. publications, and through interpersonal media, i.e. direct contact between scientists. Each respondent was asked to rate the extent to which each named colleague's publications influenced the research of the respondent. The influence from each colleague's publications was rated on a scale going from 0 for *'none'* through 1 for *'little'* and 2 for *'some'* up to 3 for *'great'* influence of the publications on the respondent (the questionnaire was described in the earlier section on 'Concepts and their indicators'). These ratings of influence of each named colleague's publications on the respondents can be used to indicate influence from the various places, namely as follows. The influence from a place is indicated by the sum of the rated influences from the colleagues in that place, as a percentage of the overall sum of influences from all the colleagues. A colleague whose publications had no influence, i.e. was rated 0, is ignored by the computation, and a colleague weighs heavily according to the rated influence. In other words, the computation is a weighted distribution across the sources; it is the distribution of the colleagues across places where the colleagues are weighted by the rated influence of each colleague's publications. This indication of sources of influence through publications is listed in the left side of Table 10.

The left-most column in Table 10 shows that Brazilian scientists were influenced through publications written by colleagues mainly in Brazil, North America, and Europe, and in similar amounts from these three places. Also scientists in the rest of Latin America were influenced through publications by colleagues from Latin America, North America, and Europe, and in similar degrees from these three places. The Latin American scientists differed from the scientists in Israel who received influence from publications by colleagues in North America much more than in Europe.

Table 10. Influence upon scientists from publications and from personal contacts. Percentage distribution of named colleagues, weighted by their rated influence through their publications. Percentage distribution of named colleagues, weighted by their rated influence through their personal communications.

	Influence from publications			Influence from contacts		
	Brazil	Other LA	Israel	Brazil	Other LA	Israel
Brazil	30%	3%	0%	65%	4%	0%
Other LA	1	21	0	1	45	0
Israel	1	1	24	.4	0	28
North America	28	39	51	11	23	53
Western Europe	33	31	15	22	25	17
Rest of world	8	5	11	2	2	3
N influencing through medium	324	564	96	256	501	88

Note: The percentages in each column sum to 100% except for rounding. Source: Survey of scientists in Brazil, other Latin America and Israel.

The respondent was also asked to rate extent of each named colleague's influence through personal contact, using the same scale from 0 to 3. The influence from a place through personal communication is then indicated by the sum of the rated influences from the colleagues in that place. In other words, influences from direct contacts in the various places are indicated by the distribution of the colleagues weighted by each colleague's direct influence, as listed in the right side of Table 10.

The right side of Table 10 shows that the personal contacts influencing Brazilian scientists were mainly with colleagues within Brazil whereas they were less influenced through personal contacts with colleagues in other places such as North America and Europe. In this respect, the Brazilian scientists differed from scientists in the rest of Latin America who were more influenced through personal contact with colleagues outside Latin America. But the Brazilians and other Latin Americans differed more from the scientists in Israel who were far more influenced by personal contact with foreign colleagues, especially in North America.

Influence is an encompassing concept. Influence on research in general encompasses influence on selection of problems for research, influence on conceptual frameworks, influence on methods of investigation, and influence on yet other aspects of research. The selection of problems for research is of most interest for understanding the direction of scientific research. Brazilian agricultural researchers have earlier reported to be much influenced by regards for national usefulness in their selection of problems for research (Velho, 1990). Here, the respondent was asked to rate each named colleague's influence on selection of problems for research by the respondent, again using the scale from 0 to 3 as described earlier. The sources of influence on problem choice are then indicated by the distribution of the ratings across places; Table 11.

Table 11. Influence upon scientists' problem selection.
Percentage distribution of named colleagues, weighted by their rated influence on the respondents' problem selection.

	Brazil	Other LA	Israel
Brazil	42 %	4 %	0 %
Other LA	1	34	0
Israel	1	.4	24
North America	24	32	55
Western Europe	27	25	10
Rest of world	5	4	11
N influencing problem choice	382	633	99

Note: The percentages in each column sum to 100% except for rounding. Source: Survey of scientists in Brazil, other Latin America and Israel.

Table 11 shows that the main source of influence on Brazilian scientists' selection of problems was their local colleagues. Secondarily, their problem choice was influenced by colleagues in North America and in Europe, with influences in similar amounts. Their sources were rather similar to the sources influencing selection of problems for research by other Latin Americans. The scientists in the rest of Latin America were influenced mainly by Latin American colleagues, secondarily by colleagues in North America, and third most by colleagues in Europe. The Brazilian and other Latin American scientists differed from the Israeli scientists who were less influenced by their local colleagues and more influenced by their foreign colleagues, especially North Americans, in their choice of problems for research.

The above analyses have disentangled sources and channels of influence on research in general and problem selection in particular. The analyses show that there has been a small but notable degree of regional integration in influence among scientists in Brazil and other parts of Latin America. But Brazilian science, like science done in other Latin America countries, has had little impact on research outside Latin America, in contrast to the notably larger impact of science done in Israel. Brazilian research, like research elsewhere in Latin America, has been influenced mainly by science done in North America and Europe. Earlier, North American influence was stronger than influence from Western Europe but during the 1980s the European influence has become equally strong. By contrast, research in Israel has continually been far most influenced by science in North America and this influence has become even stronger during the 1980s. These influences have been influences on research in general and on problem selection in particular. Brazilian scientists, like scientists in the rest of Latin America and in Israel, have selected problems under the influence of local colleagues and have been even more influenced by their distant colleagues. The influences have been channeled through a variety of media. Brazilian scientists, like scientists elsewhere in Latin America, have been influenced by Latin American colleagues most frequently by face-to-face discussions and other interpersonal media, while influences from outside Latin America have been mediated mainly by these distant colleagues' publications. Contrastingly, influences upon scientists in Israel from their foreign colleagues have been channeled through a multiplicity of media, not primarily through publications but mainly through multiple interpersonal media, especially face-to-face discussions, telephone, facsimile messages, electronic mail, and postal mail. The Israeli scientists have been more intensely integrated into circles of distant colleagues, especially in North America. Israeli scientists' strong international integration is in some degree a consequence of their past high performance, but the high integration has a separate and considerably enhancing effect on performance (the enhancing effect of integration on performance was estimated in another study; Schott 1987a).

Influence is the intellectual substance of collegial ties in science. Another kind of intellectual role-relation among scientists is collaboration.

Collaboration.

To what extents have Brazilian scientists been collaborating with local, Latin American and distant colleagues? Conversely, to what degrees have they been sought out for collaboration by scientists in various other places? Has there been a notable degree of regional integration among Latin American scientists in collaboration? How has Brazilian collaboration changed in recent decades, in science-as-a-whole and in each discipline? How does Brazilian collaboration compare to the collaboration of scientists in the rest of Latin America and in Israel? These questions will be answered in this section.

Scientists' collaboration will be indicated first by scientists' own reports about joint research. In the survey in Brazil and elsewhere, each respondent was asked to rate the extent of collaboration with each colleague named by the respondent (as discussed in the earlier section on 'Concepts and their indicators'). Each colleague's collaboration was rated on the scale going from 0 for *'none'* through 1 for *'little'* and 2 for *'some'* and up to 3 for *'much'* collaboration with the respondent. The respondents' extent of collaboration with colleagues in a particular place can then be indicated by the sum of the rated collaboration with colleagues in that place, computed as a percentage of the overall sum of collaboration with all colleagues. In other words, the extent of collaboration with various places is indicated by the distribution of the colleagues across places, where each colleague is weighted by her or his rated collaboration; Table 12.

Table 12. Collaboration with local and foreign colleagues.
Percentage distribution of named colleagues, weighted by their rated collaboration with the respondents.

	Brazil	Other LA	Israel
Brazil	66 %	5 %	0 %
Other LA	0	47	0
Israel	0	0	26
North America	9	21	55
Western Europe	25	24	18
Rest of world	1	3	1
N collaborators	190	425	71

Note: The percentages in each column sum to 100% except for rounding. Source: Survey of scientists in Brazil, other Latin America and Israel.

Table 12 shows that Brazilian scientists have been collaborating mainly with colleagues within the country, secondarily with colleagues in Europe and thirdly with colleagues in North America. Scientists in the other part of Latin America had about half of their collaboration with Latin American colleagues, and most of the other half with colleagues in Europe and North America. Israeli scientists had only about one fourth of their collaboration with local colleagues, most of their collaboration was with colleagues in North America, and a small fraction was with colleagues in Europe. A notable difference is that the Israelis have mainly been collaborating with the center in North America, whereas the Brazilians' foreign collaboration has been mainly in Europe.

Scientists' collaboration with others can also be indicated by the extent to which their publications are coauthored with people at other institutions, either within the country or in other countries. To detect change over time, the degrees of local and foreign collaboration are listed for both the earliest and latest periods for which data are available; Table 13.

Table 13. Collaboration among national scientific communities, 1970s and 1980s.
Percentage of the articles by authors in the scientific community (column) which have coauthors in other institutions (rows).

	Authors											
	Brazil		Other LA		Israel		North America		Western Europe		Rest of world	
Coauthors	70s	80s	70s	80s	70s	80s	70s	80s	70s	80s	70s	80s
Brazil	16.1	19.7	.8	1.1	.1	.2	.1	.1	.1	.2	.02	.05
Other LA	1.9	2.4	20.8	22.8	.1	.1	.2	.3	.1	.3	.06	.13
Israel	.3	.5	.1	.2	25.7	29.9	.3	.5	.2	.4	.03	.07
North America	12.8	13.6	12.8	14.1	10.3	17.0	31.0	36.9	4.2	6.9	2.4	3.9
Western Europe	8.5	12.4	6.1	9.7	6.0	10.6	3.3	5.5	26.1	35.9	2.7	4.5
Rest of world	2.0	3.2	2.1	3.9	0.8	1.5	1.5	2.5	2.1	3.6	17.1	22.0
N articles	6,149	8,452	14,252	18,523	20,916	24,534	814,350	873,649	628,527	696,177	500,696	561,055

Notes: The percentages in each column sum to less than 100% insofar as many articles are not coauthored. The 1970s denote 1973-79 and the 1980s denote 1980-86.
Source: Science Citation Index from 1973 to 1986 (Institute for Scientific Information) (dataset compiled by CHI Research; Stevens 1990).

The coauthorships in Table 13 are similar to scientists' reported collaborations in Table 12 which show that the indicators have satisfactory reliability. The Brazilians' most extensive collaboration with colleagues at other institutions has been with colleagues at other Brazilian institutions. An earlier study observed a rather extensive in-house publication (i.e. publishing in printed materials issued by the institution of the author) and that the publications had 13 to 20 percent of their citations to publications by scientists at other Brazilian institutions and on this basis concluded that there was very little communication between scientists at different Brazilian institutions (Velho and Krige, 1984). This percentage, however, is quite high compared to the less than 1 percent of the world literature that is written by Brazilian scientists, so the observed percentages actually indicate a considerable communication among Brazilian institutions. That Brazilians collaborate more with colleagues at other Brazilian institutions than with peers in any other country and that this percentage is not much lower than the percentage of other Latin American's publications that are with colleagues at other Latin American institutions (a pool of publications about twice that in Brazil) or the percentage of Israeli's publications that are with peers at other Israeli institutions (a pool of publications about twice that in Brazil), as shown in Table 13, also indicate considerable collegial ties among the Brazilian institutions, quite comparable to those among other Latin American institutions and among Israeli institutions.

Table 13 shows that the foreign collaboration has been concentrated in North America and Europe. The foreign collaboration from the 1970s to the mid-1980s was apparently mainly with North American colleagues (Table 13) but then became mainly with European colleagues (Table 12). The Brazilians' switch in collaboration from North America toward Europe is consistent with the switch in Brazilians' received influence, from mainly American influence toward mainly European influence (as was discussed in the preceding section).

Table 13 shows that Brazilian scientists' collaboration has increased from the 1970s to the 1980s, both with colleagues at other Brazilian institutions and with colleagues in every foreign place. But their foreign collaboration has increased at a faster rate than their local collaboration. This fast increase in foreign collaboration is not unique to Brazil but obtains in every place as shown in the table. The increasing transnational collaboration is part of the globalization of science, which may be partly explained by the embeddedness of scientific ties in links among nations in spheres such as the economy and the polity which are in a process of globalization (Schott 1991b).

Table 13 shows that Brazilian scientists have had some collaboration with colleagues in the rest of Latin America. Their Latin American collaboration has been small relative to their collaboration with colleagues in North America or Europe, but evidently large compared to, say, Israeli scientists' collaboration with colleagues in Latin America. This suggests some regional integration in collaboration within Latin America. To highlight this integration we can control for the tendency of each country's scientists to collaborate.

Integration in collaboration between places can be indicated by their actual coauthorships relative to their expected frequency if collaboration occured independently between scientific communities, that is, in proportion to each community's tendency for outside collaboration. The expected frequency of coauthorships between two communities can be computed from the diagonal-less matrix of coauthorships, like earlier described for influence. Integration in collaboration between two places is then indicated by the ratio of the actual coauthorships to their expected frequence. The resulting measures of integration in collaboration are listed in Table 14. Collaboration between two places is dense to the extent the measure exceeds 1 and collaboration is sparse to the degree the measure is less than 1.

Table 14. Integration in collaboration among national scientific communities, 1970s and 1980s.

Coauthors	Authors: Brazil 70s	Brazil 80s	Other LA 70s	Other LA 80s	Israel 70s	Israel 80s	North America 70s	North America 80s	Western Europe 70s	Western Europe 80s	Rest of world 70s	Rest of world 80s
Brazil			4.2	4.5	.7	.7	1.3	1.1	.9	1.0	.4	.6
Other LA	4.2	4.5			.3	.2	1.4	1.3	.7	.8	.5	.7
Israel	.7	.7	.3	.2			1.5	1.5	.9	.9	.3	.3
North America	1.3	1.1	1.4	1.3	1.5	1.5			1.0	1.0	1.0	1.0
Western Europe	.9	1.0	.7	.8	.9	.9	1.0	1.0			1.1	1.1
Rest of world	.4	.6	.5	.7	.3	.3	1.0	1.0	1.1	1.1		

Note: The 1970s denote 1973-79 and the 1980s denote 1980-86.
Source: Same as Table 13.

Table 14 shows that there has been a considerable regional integration in collaboration between Brazilians and scientists in the rest of Latin America, collaboration has been four times more frequent than expected. The regional integration in Latin America has exceeded the integration in collaboration between Israelis and scientists in North America which has also been strong. The integration in Latin America has even increased slightly from the 1970s to the 1980s. In the 1970s Brazilian researchers collaborated especially much with colleagues in North America, but that integration has weakened and instead Brazilians have intensified collaboration with colleagues in Western Europe and other parts of the world.

Collaboration varies from one discipline to another. Collaboration may be easier in some disciplines than in others, perhaps especially long-distance collaboration. Research in some disciplines may be so complex that it requires extensive collaboration. The extents of local and foreign collaboration in each discipline can be indicated by the frequency of coauthorships, listed in Table 15.

Table 15. Collaboration with local and foreign colleagues, by discipline, 1970s and 1980s.

The percentage of the articles involving scientists in Brazil (and in the rest of Latin America, and in Israel) which had coauthors at other institutions within the country, and the percentage which had coauthors abroad.

	Local collaboration						Foreign collaboration					
	Brazil		Other LA		Israel		Brazil		Other LA		Israel	
	70s	80s	70s	80s	70s	80s	70s	80s	70s	80s	70s	80s
Science-as-a-whole	**18**	**23**	**24**	**27**	**28**	**35**	**25**	**32**	**24**	**30**	**17**	**28**
clinical medicine	27	33	34	39	55	61	19	31	17	20	10	15
biomedicine	21	29	19	26	23	30	21	33	20	28	20	33
biology	22	25	16	21	22	26	34	36	35	41	11	22
chemistry	16	21	10	13	11	16	17	19	19	23	14	27
physics	13	17	18	23	16	15	28	31	37	35	27	50
earth & space sci	10	10	12	13	16	22	48	47	59	74	26	47
technological sci	12	20	16	23	12	13	35	44	29	38	17	28
mathematics	4	13	8	7	5	9	43	47	42	38	38	53

Notes: The 1970s denote 1973-79 and the 1980s denote 1980-1986. The number of articles involving Brazilian authors (and authors in each of the other two places) in each discipline in each period is at least 238. Source: Science Citation Index from 1973 to 1986 (Institute for Scientific Information) (dataset compiled by CHI Research).

Table 15 shows that collaboration varied considerably among the disciplines. In all three places collaboration in mathematics has been infrequent within the place but frequent with foreigners, which is undoubtedly due to the ease of long-distance collaboration in this discipline that does not depend on tinkering with apparatus for making empirical observations and experiments. The more experimental disciplines have higher degrees of local collaboration.

The increase in both local and foreign collaboration in science as a whole has occured in some disciplines more than in others. In Brazilian earth and space science there has been no increase in local or in foreign collaboration. But there have been considerable increases in local collaboration in mathematics, technological science and biomedicine and in foreign collaboration in technological science, biomedicine, and clinical medicine. The simultaneous increases in local and foreign collaboration suggest that a discipline may be both local and cosmopolitan in its collaborative orientations.

The above analyses of collaboration have shown that Brazilian scientists have had a considerable degree of collaboration with one another and with foreign colleagues, mainly in North America earlier and increasingly in Western Europe. They have also had a notable collaboration with colleagues in other Latin American countries, so that there is some regional integration in collaboration, but the regional collaboration is infrequent compared to the extensive collaboration with colleagues in the North American and European centers.

Communal attachments: Emulation and recognition.

The above analyses of influence and collaboration have examined the scientists' intellectual integration into collegial networks. A scientist lives not only from intellectual material. The intellectual integration is also sustained by a social integration, by the scientist's communal attachments to her collegial circle which in turn integrates her into wider circles in the world scientific community. A scientist's social integration will here be examined in terms of her emulation with colleagues and her caring about receiving collegial recognition of her work.

Emulation refers to the desire to excel, the ambition to equal or surpass others (the word emulation also occasionally denotes imitation but that is not the meaning used here). A researcher competes with others in the performance of the scientific role, and competes with others in the creation of contributions to public knowledge, specifically for rewards for making contributions. Emulation was tapped in the survey of scientists in Brazil, in other parts of Latin America, and in Israel by asking each respondent to rate the degree of felt competition with each named colleague to be first or best in research. The respondent rated competition with each colleague on the scale from 0 for *'none'* up to 3 for *'much'* competition with the colleague. Sources of emulation are then indicated by the distribution of the colleagues, weighted by their degree of competition; Table 16.

Table 16. Emulation of local and distant colleagues.
Percentage distribution of named colleagues, weighted by their rated extent of competition with the respondents.

	Brazil	Other LA	Israel
Brazil	64 %	3 %	0 %
Other LA	0	35	0
Israel	2	0	25
North America	5	40	48
Western Europe	27	21	15
Rest of world	3	1	11
N emulators	75	158	53

Note: The percentages in each column sum to 100% except for rounding. Source: Survey of scientists in Brazil, other Latin America and Israel.

Emulation is seen, from Table 16, to originate partly from the local environment and partly from abroad, but the scientists differ in their feelings of local versus foreign competition. The Brazilian scientists feel competition mainly from their local colleagues, some from their European colleagues but little from their North American colleagues. Scientists in other parts of Latin America feel less competition from their local colleagues but feel much more competition from their North American colleagues.

Scientists in Israel feel even less local competition and even more competition from North American colleagues. Therefore, also in terms of emulation, Brazilian scientists seem less integrated into the world scientific community than other Latin American scientists and, especially, than scientists in Israel.

Social integration can also be ascertained in terms of caring for collegial recognition as a validation and a social reward available for the performance of the scientific role. Scientists often care about receiving recognition for their work, but they consider recognition more important from some than from others. Each respondent rated her/his caring about receiving recognition of her/his work from each named colleague, using the scale from 0 to 3. The distribution of the colleagues, weighted by the salience of their recognition, indicates the salience of various places as valued sources of recognition; Table 17.

Table 17. Importance of receiving recognition from local and distant colleagues.
Percentage distribution of named colleagues, weighted by their rated importance as recognizers of the respondent's work.

	Brazil	Other LA	Israel
Brazil	51 %	4 %	0 %
Other LA	1	35	0
Israel	.4	1	28
North America	20	32	49
Western Europe	23	26	15
Rest of world	5	3	8
N recognizers	338	629	100

Note: The percentages in each column sum to 100% except for rounding. Source: Survey of scientists in Brazil, other Latin America and Israel.

Recognition is valued from local colleagues and from foreign colleagues. But the salience of the local environment and of foreign places as sources of recognition differ among the respondents. Brazilian scientists attach about the same importance to local and foreign sources of recognition. Scientists in other parts of Latin America attach less importance to local recognition and more importance to recognition from colleagues in North America. Israeli scientists attach even less significance to local recognition and care even more about recognition from their collegues in North America.

In short, the scientists are not only intellectuallly but also socially integrated in terms of emulating and desiring recognition from local and distant colleagues. Brazilian scientists seem a little more integrated with local colleagues and a little less with distant colleagues than do scientists in other parts of Latin America and, especially, than do scientists in Israel.

Audience-orientations.

The last kind of role-relation among scientists to be examined here is the orientation towards collegial audiences. A scientist makes her/his findings common property by publishing them and may often want to reach the widest possible audience, namely the global scientific community in the scientist's specialty, but a scientist also has a primary audience, the colleagues that are primarily addressed.

Scientists' addressing of audiences can be indicated by where they publish their articles. They publish some works in locally published journals and some in journals published in various other places. The distribution of articles written by authors in a scientific community across places of publication is listed in a column in Table 18. As emphasized at the beginning of this essay, however, this study does not examine research for local consumption, but focuses on research contributing to world science. Specifically, for example, the distribution in the first column of Table 18 largely ignores Brazilian authors' works in Brazilian journals published mainly in Portugese and in other Latin American journals publishing mainly in Spanish. Rather, the first column shows the primary audiences that Brazilian authors address when they present their contributions to world science.

Table 18. Audience-seeking among national scientific communities; 1982. Percentage distribution of the articles written by authors in the scientific community (column) across places of publication (rows).

	Author							
Place of publication	Brazil	Other LA	Israel	North America	Western Europe	Rest of F.World	Second World	Third WexLA
Brazil	13.5	.04	.0	.00	.00	.00	.00	.00
Other LA	.5	20.9	.0	.03	.01	.01	.00	.04
Israel	.0	.3	11.1	.04	.07	.00	.01	.06
North America	44.1	41.4	46.1	77.6	24.2	26.3	6.3	24.8
Western Europe	39.1	35.6	41.0	21.1	73.5	39.0	16.3	39.2
Rest of First World	.4	.3	.4	.4	.3	33.8	.6	.7
Second World	2.1	1.5	1.0	.8	1.8	.8	76.8	4.3
Third World (ex LA)	.5	.0	.3	.1	.1	.1	.0	31.0
N articles by authors in place	1,060	2,233	3,795	187,054	135,028	8,987	33,350	15,689

Notes: The percentages in each column sum to 100% except for rounding. Rest of First World denotes Japan, South Africa, Australia, New Zealand; the Second World denotes the then communist East Bloc of the Soviet Union and Eastern Europe; and the Third World, excluding Latin America, denotes most of Asia and Africa. Source: Science Citation Index for 1982 (Institute for Scientific Information).

The first column of Table 18 shows that Brazilian authors had their primary audiences in North America and Europe. Also authors in the rest of Latin America and in Israel addressed these primary audiences. Authors in North America and in

Western Europe addressed their works primarily toward their local colleagues. Authors in the rest of the so-called First World addressed themselves toward local audiences and audiences in Europe and North America. Works by authors in the then communist countries, the so-called Second World, were addressed mainly to local audiences, much less often were their primary audiences in Western Europe and even far less frequently in North America. Authors in the so-called Third World (here excluding Latin America listed in other columns) addressed local audiences and audiences in Europe and North America. Nowhere outside Brazil did authors notably address colleagues in Brazil. And nowhere outside Latin America did authors notably address colleagues in Latin America. Only to a very small extent did Brazilian authors address collegial audiences in the rest of Latin America and to an even lesser extent did authors in the rest of Latin America address a Brazilian audience. The smallness of this orientation is probably due to the difference in language, Portugese in Brazil and Spanish elsewhere in Latin America.

The phenomenon of audience-orientation can of course also be viewed from the other end of the tie, the audience. The attraction of each national scientific community as a primary audience can be indicated by the extent to which their locally published journals are outlets for works by authors around the world. This is indicated by counts of articles by various countries' authors published in journals in various countries as for Table 18, but now percentaging across countries of authors, as listed in a row in Table 19.

Table 19. Audience-attraction among national scientific communities; 1982. Percentage distribution of the articles published in each place (row) across countries of the authors (columns).

Place of publication	Author: Brazil	Other LA	Israe	North Ameri	West Europ	R.of F.Wor	Second World	Third WexLA	N articles in journals in place
Brazil	94.1	.7	.0	2.0	2.6	.0	.7	.0	152
Other LA	.9	84.8	.0	10.5	2.4	.2	.0	1.3	551
Israel	.0	1.0	68.7	13.4	15.1	.0	.3	1.5	614
North America	.2	.5	.9	76.7	17.3	1.3	1.1	2.1	189,240
Western Europe	.3	.5	1.0	25.2	63.4	2.2	3.5	3.9	156,661
Rest of First World	.1	.1	.4	14.9	9.2	68.6	4.4	2.3	4,422
Second World	.1	.1	.1	5.0	8.0	.2	84.3	2.2	30,376
Third World (ex LA)	.1	.0	.2	2.7	2.7	.2	.3	93.8	5,180

Note: The percentages in each row sum to 100% except for rounding. Source: Same as Table 18.

The first row in Table 19 shows that Brazilian scientists have been a primary audience only for work by local authors. They have not been an audience addressed by foreign authors. The second row shows that scientists in the rest of Latin America have been an audience for work by Latin American authors and also somewhat of an audience for work by authors outside Latin America, notably work by authors in North

America. Scientists in Israel have also been an audience for local work and also rather frequently a significant audience for work by foreign authors. Likewise, scientists in each part of the First World have been an attractive audience for local work and also for work by others. Scientists in the Second World were an audience mainly for local work and much less for work by authors in the First or Third Worlds. Scientists in the Third World have been an audience mainly for local work and, like Brazilian scientists, have hardly been addressed by other authors.

Audience-seeking and audience-attraction result partly from the performance of authors in the various scientific communities, partly from the volume of mainstream publications published in the various countries, the preferences of authors in certain places for publishing in certain places, and of course also the quality of the journals through which the audience-seeking is expressed.

Journals.

The last aspect of the research enterprise to be examined here is the journals through which the scientists present their contributions to the common stock of knowledge. I shall examine the influence of a journal on subsequent research. Brazilian journals shall be compared to journals published in the rest of Latin America, in Israel, and to the mainstream journals in the world (whether or not to include a journal of course occasionally becomes a conflict; for a Latin American case, see Vessuri, 1987). The journals to be examined are those that have been covered by the **Journal Citation Reports** of the **Science Citation Index** during 1975-88. The Brazilian journals are,

Revista Brasileira de Medicina in Internal and General Medicine,
Revista Brasileira de Pesquisas Medicas e Biologicas in Internal and General Medicine,
Brazilian Journal of Medical and Biological Research in Experimental and Research Medicine,
Memorias do Instituto Oswaldo Cruz in Experimental and Research Medicine,
Revista do Instituto de Medicina Tropical de Sao Paulo in Tropical Medicine,
Arquivos da Escola de Veterinaria da Universidade Federal de Minas Gerais in Veterinary Medicine,
Revista Brasileira de Genetica in Genetics and Heredity,
Anais da Academia Brasileira de Ciencias in Multidisciplinary Sciences, and
Pesquisa Agropecuaria Brasileira in Multidisciplinary Sciences.

Their six fields are classes constructed by the source of these data which also provided the classification of the Brazilian journals except two (**Revista Brasileira de Medicina** and **Pesquisa Agropecuaria Brasileira**) which we classified into one of these six fields mainly according to the provided clasification of journals that they refered to.

These Brazilian journals shall be compared to the journals in their field which were also covered by the Science Citation Index. The index in the period 1975 to 1988 included 433 journals in these six fields, namely 109 journals in Internal and General

Medicine, 55 in Experimental and Research Medicine, 14 in Tropical Medicine, 93 in Veterinary Medicine, 74 in Genetics and Heredity, and 88 in Multidisciplinary Sciences, but not all these journals were included in a particular year.

These fields in the index also included seven journals published in the rest of Latin America, namely

Archivos de Biologica y Medicina Experimentales in Internal and General Medicine.
Medicina - Buenos Aires in Internal and General Medicine.
Revista de Investigacion Clinica in Internal and General Medicine.
Revista Medica de Chile in Internal and General Medicine,
Archivos de Investigacion Medica in Experimental and Research Medicine,
Interciencia in Multidisciplinary Sciences, and
Acta Cientifica Venezolana in Multidisciplinary Sciences.
The six fields in the index also included four journals published in Israel, namely
HaRefuah in Internal and General Medicine,
Israel Journal of Medical Sciences in Internal and General Medicine,
Refuah Veterinarith in Veterinary Sciences, and
Israel Journal of Technology in Multidisciplinary Sciences.

These journals will be compared to the journals published in Brazil with respect to their influence. The influence of a journal refers to the impact of its articles on further research, like the phenomenon of influence of people examined earlier in this study. Influence of an article can be indicated by its subsequent citations, citations in subsequent publications refering to the article (as influence was also operationalized for Table 6). Such frequency of citations to the articles appearing in the journal have been listed in the **Journal Citation Reports** (Institute for Scientific Information, annually) published together with the **Science Citation Index**. More precisely, this measure of impact of a journal in a year is the ratio of the number of citations given in the year referring to articles that appeared in the preceding two-year period to the number of these articles in that period in the journal. The influence of a journal is hereby measured as the average impact of its articles and is thus not affected by the number of articles appearing in the journal (considerations of this impact measure are provided by Sivertsen 1991, 64-68).

A journal may be compared each year to the other journals in its field which are reported in the **Journal Citation Reports** in the year. The reported journals can be ranked according to their impact each year. The percentile rank of a particular journal denotes the percentage of the reported journals in its field that have impact at or lower than the particular journal. The annual percentile rank of each Brazilian, other Latin American and Israeli journal, within their fields, are listed in Table 20. A journal is of course ranked only for those years in which its impact measure was reported in the data source.

Table 20. Influence of journals, by field and year, 1975-1988.

Percentile rank of each Brazilian, other Latin American and Israeli journal.

	1975	'76	'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88
Internal and General Medicine														
Revista Brasileira de Medicina	.	.	1	2	1	2	2	1	2	1	1	1	1	1
Revista Brasileira de Pesquisas Medicas e Biologicas	.	.	.	4	2	8	6	7	.	.	.	.	.	.
Archivos de Biologica y Medicina Experimentales	.	.	.	.	.	47	65	69	50	63	60	59	59	58
Medicina - Buenos Aires	43	17	57	47	49	52	53	40	40	27	35	34	42	29
Revista de Investigacion Clinica	14	33	21	27	31	23	38	27	13	19	13	19	3	4
Revista Medica de Chile	11	20	31	26	13	20	24	17	35	20	33	21	22	12
HaRefuah	.	.	3	5	.	.	.	.	.	.	.	.	.	.
Israel Journal of Medical Sciences	53	57	69	63	60	67	59	53	62	45	42	40	38	41
Experimental and Research Medicine:														
Brazilian Journal of Medical and Biological Research	.	.	.	.	.	.	.	28	47	31	25	29	28	30
Memorias do Instituto Oswaldo Cruz	12	.	.	.	.	.	.	.	.	.	.	.	.	.
Archivos de Investigacion Medica	8	7	17	12	6	38	10	21	5	8	2	2	2	6
Tropical Medicine:														
Revista do Instituto de Medicina Tropical de Sao Paulo	.	.	.	.	.	.	.	.	.	.	16	28	21	30
Veterinary Medicine:														
Arquivos da Escola de Veterinaria da Universidade Federal de Minas Gerais	.	.	.	.	2	2	3	5	2	1	.	.	.	.
Refuah Veterinarith	.	.	.	32	25	.	.	.	.	.	.	.	.	.
Genetics and Heredity:														
Revista Brasileira de Genetica	.	.	.	.	.	.	.	4	4	6	7	.	1	1
Multidiciplinary Sciences:														
Anais da Academia Brasileira de Ciencias	28	5	15	51	34	29	29	41	22	49	23	17	10	12
Pesquisa Agropecuaria Brasileira	.	.	.	.	.	.	.	.	10	3	3	5	6	5
Interciencia	.	.	.	29	52	52	26	20	33	45	51	60	37	29
Acta Cientifica Venezolana	33	22	50	42	42	38	20	.	.	.	.	.	.	.
Israel Journal of Technology	45	49	25	7	19	8	12	23	1	11	.	.	.	.

Note: Years in which influence was not reported are indicated by a dot (.) Source: ***Journal Citation Reports*** *for 1975 to 1988 (Institute for Scientific Information).*

Before interpreting the rankings in Table 20, I reemphasize that the journals included in the **Journal Citation Reports** (as in the **Science Citation Index**) are largely the journals that are of eminence. Therefore, the listed journals and their comparisons are largely journals with considerable influence, so the ranking is among influential journals. A journal listed with a low percentile rank is thus a journal which seemingly is influential and much more influential than most journals in the world (largely those that are not included in the data source) but is not among the few most influential journals in its field. Table 20 shows a tendency for the least influential ones to be included only occasionally, notably the two Israeli journals with titles in Hebrew for medicine and veterinary medicine (in **HaRefuah** the articles are published in Hebrew and the abstracts are also published in English).

The first row of Table 20 shows that the **Revista Brasileira de Medicina** has not been one of the top journals among the covered journals in Internal and General Medicine which were reported in the **Journal Citation Reports**. Another Brazilian journal in the same field, **Revista Brasileira de Pesquisas Medicas e Biologicas**, has also not been among the top journals. The four journals published elsewhere in Latin America have ranked somewhat high while one Israeli journal ranked low and one Israeli journal ranked rather high among the covered journals in Internal and General Medicine.

In Experimental and Research Medicine, the **Brazilian Journal of Medical and Biological Research** has been quite influential while another Brazilian journal, **Memorias do Instituto Oswaldo Cruz**, was less influential (and was probably found not to be so influential as to be covered since the 1970s). A journal published elsewhere in Latin America has been among the rather influential journals in Experimental Medicine.

In Tropical Medicine, the Brazilian journal **Revista do Instituto de Medicina Tropical de Sao Paulo**, has been quite influential.

In Veterinary Medicine, the Brazilian journal, **Arquivos da Escola de Veterinaria da Universidade Federal de Minas Gerais**, has been one of the less influential ones and also the Israeli journal **Refuah Veterinarith** has been one of the less influential ones among the covered journals in the field.

The journal **Revista Brasileira de Genética** has been among the less influential ones in Genetics and Heredity.

In the Multidiciplinary Sciences, the **Anais da Academia Brasileira de Ciencias** has been of changing influence, apparently more influential around the first half of the 1980s than earlier and later. The other Brazilian journal in this field, **Pesquisa Agropecuaria Brasileira**, has been among the less influential one. The two journals published elsewhere in Latin America have been somewhat more influential while the Israeli journal has apparently become less influential over time.

To summarize these rankings among the influential journals within each field, about a handful of Brazilian journals have evidently been among the highly influential journals in the world, and a couple of these Brazilian journals have actually been especially influential. Another handful have been somewhat influential. Apart from annual fluctuations which may be due to just an occasional influential article, the influence of each Brazilian journal has apparently been rather stable over the years, with the exception of one journal that apparently had an especially influential period. Among the other Latin American and Israeli journals in these fields, some were more and some were less influential, and most were stable but several were apparently of declining influence. Compared to the mixed stable and declining influence of journals published in the rest of Latin America and Israel, the stability of influence of the Brazilian journals appears as a slight comparative increase.

Conclusions.

The above series of analyses were undertaken to answer the question of how Brazilian scientific performance, specialization and ties with local, regional and central colleagues have been shaped by the institutionalization of science in Brazil. Therefore trends in Brazilian research were ascertained and Brazil was compared to the other Latin America and to Israel which have had similar and different, respectively, institutional arrangements.

Science has become institutionalized in Brazil in so far as it has become rather appreciated and been granted considerable autonomy and some support. Scientific activities such as research and training of researchers, however, have been concentrated in a fraction of the universities in Brazil and elsewhere in Latin America, unlike in Israel where scientific research and training has been the primary purpose at all the universities.

This difference between Brazil, or Latin America more generally, and Israel in their institutional arrangements for science has enhanced scientific performance in Israel so that research performance has been higher in Israel than in Brazil and in the rest of Latin America. Israeli performance has been higher not only relative to population and the economy but also in total, despite the smallness of the country. But scientific research has expanded in Brazil, and the Brazilian rate of increase was higher than in the rest of Latin America, in Israel, and in the world as a whole. The Brazilian performance has been increasing throughout the 1980s. A decline in social and human investment in scientific activity takes some years to cause a decline in the outcomes of research. The recent Brazilian crisis has not showed up as a decline in the Brazilians' publications by 1993 but will probably entail a decline within a few years.

Brazilian research has been specialized in so far as certain disciplines and specialties have been foci of scientists' attention in Brazil more than elsewhere. Brazilian specialization has emphasized the disciplines of physics, biology and mathematics, it has been more typical in biomedicine and earth and space science, and has deemphasized clinical medicine, chemistry and technological science. Within medicine, though, tropical medicine and parasitology have been fields of strong specialization in Brazil, like in other parts of Latin America, but unlike in Israel where specialization has focused on mathematics and fertility. Brazilian growth has been highest in technological science, especially in fields of computing. These directions of Brazilian specialization seem shaped by national needs and research policies.

Brazilian scientists have been tied to colleagues who have influenced their research, and also been variously collaborators and competitors in research, and often also been significant recognizers of their work. None of these ties have been confined within Brazil but have also been rather extensive with foreign colleagues. Brazilian research has been integrated with science in the rest of Latin America insofar as regional influence and collaboration have been higher than expected. This integration in collegial ties has been promoted by their embeddedness in the strong links between Brazil and the rest of Latin America in other spheres of life. The regional integration has been notable but has been overshadowed by the attachment to the centers of science, located in North America and Western Europe. Scientists in Brazil, like elsewhere, have defered mainly to these centers, have traveled there, been influenced by science in the centers, occasionally collaborated there and valued recognition from colleagues in the centers. The involvement of Brazilian scientists with the centers, though, has been slightly less than the involvement of other Latin American scientists and much less than the participation of Israeli scientists in the centers. The Israeli ties with the centers, especially the North American center, have been enhanced by their embeddedness in the strong political and economic links between Israel and the United States and also by institutional arrangements for science such as comprehensive scientific cooperation agreements with the centers and travel funds which are results of Israeli research policies enhancing research performance through integration with centers of science.

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