Laying the Foundation

The Institutions of Knowledge in Developing Countries

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Edited by Benjamín Alvarez and Hernando Gómez

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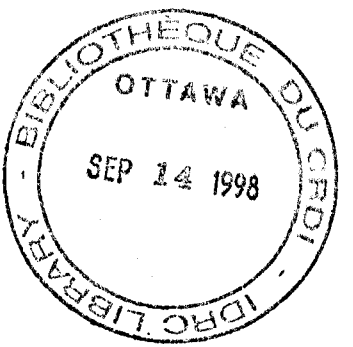

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FOREWORD

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Latin America has undergone a marked transformation in the last few years, one that is characterized by a shift toward market-oriented economies, a new role for the state, and the opening up of markets to international trade. There have also been important changes at the international level, such as the globalization of economies and rapid technological development.

This, then, is a particularly appropriate moment for the publication of a book on institutional development in research centres. It is an opportune time to examine the potential and performance of research centres and to pose some key questions. How can they help Latin America to adapt to the new global order? How can they increase their efficiency and social impact?

The development of institutions has proven to be one of the most complex aspects of development strategy. Here we define institutional development as the process by which an institution makes the best use of available resources within the rules that govern it. Although much progress has been made in improving the design and implementation of investment and policy, efforts to enhance the performance of most agencies and state enterprises have met with less success.

Research centres are complex institutions that offer great management challenges. These centres differ from institutions whose products can be easily identified and quantified. It is difficult to measure and compare the products of research because they are heterogeneous and of such varied quality. The impact of research is also hard to define, because it usually becomes obvious only over time.

Other features of research institutions also contribute to their complexity. One of the most important is their tendency to have too many bosses and too few workers. Few things are more difficult to manage than an organization with a large group of prima donnas on staff.

Aside from this, it is not easy to make generalizations about institutional problems in research centres because they differ so much from each other. For example, a research centre engaged in agriculture is quite unlike one concerned with atomic energy or economics. That being said, scientific and technological organizations do share some important features, as the second part of this book illustrates.

The studies in this book cover a wide range of important cases and topics. They look at the political and professional context of research centres in different countries, with special emphasis on policy approaches, the availability of qualified researchers, remuneration, and opportunities for international networking and support.

This collection also deals with the demand for the products of research centres, an issue that is frequently overlooked because research is usually defined by the nature of its supply. Demand is analyzed in terms of the need of the public and private sectors for both pure and applied research. The analysis is linked to levels of development and to recent changes on the world stage. For instance, the move from open to closed economies has a major impact on most areas of science and technology.

The roles of both the public and private sectors are also explored. The Latin American tradition of confining research to state institutions is addressed, as are alternatives for greater private sector participation in the execution, funding, dissemination, and application of research. Many articles underline the crucial role of the state in promoting science and technology within the current context of decreased intervention.

This book makes a critical contribution to the literature with its discussion of institutional structures and efficiency, topics often missing from the literature on science and technology. With respect to structure, the sector in which a research centre operates seems to make a difference. For example, centres specializing in social science can probably exist in relative isolation; whereas, those devoted to agricultural research benefit from linkages with national and international networks. The book also

attempts to identify the techniques that have proven to be most successful at increasing the efficiency of institutions as complex and unique as research centres. Lastly, several chapters try to assess the impact of research centres on the overall development of Latin America.

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PREFACE

This book is about the development of institutions of knowledge in developing countries. These institutions include research centres, universities, museums, laboratories, and units of larger organizations that specialize in generating and using scientific knowledge. Although these institutions date back to the very beginnings of scientific knowledge, and although they have played a decisive role in the evolution of all societies, never before have they been so critical to the success of nations.

Like individuals, all institutions in our time (and particularly those devoted to knowledge), live in a continuous cycle of assimilation and adaptation, change and learning, and evaluation and forgetting. We are all aware of the extraordinary dynamics of the interaction between scientific institutions and their changing environments, although our understanding of the forces involved and their potential is quite limited. St Agustin's comment on the nature of time seems quite apt in this context: "If no one asks us about it, we know, but if we are asked to explain, we do not know."

Despite their differences, industrialized nations, the former Soviet bloc countries, and developing nations all recognize the urgent need to reorganize their scientific, technological, productive, and educational institutions. Whereas some countries are motivated by a desire to improve their position on the world scene, others are motivated by the need to adapt and modernize. For yet others, the key issue is gaining access. Nevertheless, the same basic questions apply to the institutionalization of science in all societies. What is the right institutional configuration to promote the development of science and technology? How can efficiency be enhanced within existing institutional structures? And, finally, how

can we foster the competitiveness needed to expand the frontiers of knowledge as well as use its production?

Although many factors are coming together to stimulate a reassessment of the role of knowledge institutions, research on the subject is extremely limited. Literature on scientific organizations is scarce, and what little there is deals mainly with developed countries. Very little has been written about research institutions in developing countries.

This book breaks new ground by looking at the subject in two ways. It explores both the institutionalization of science and the development of institutions. Although examples are taken from certain disciplines and the analysis is focused primarily on Latin America, many of the issues, problems, and challenges raised are shared by other sectors and regions of the world.

This collection of articles looks at the development of science and knowledge from a social perspective because they have no valid existence outside society. This volume has two goals. The first is to advance theory by contributing to a better understanding of scientific institutions in rapidly modernizing societies — their nature, function, and future. The second goal is more practical — to identify factors linked to the success and failure of institutions of knowledge.

The first part of the book examines the context in which scientific organizations in developing countries are situated and reviews the lessons offered by past research. The second part contains summaries of case studies on the institutionalization of science in Latin America in the basic sciences, economics, health, education, agriculture, and industrial technology. The third and final part brings these findings together with additional evidence and puts forth a research agenda. It also provides practical suggestions for facilitating institutional development through the preparation of evaluation criteria and the promotion of a research and development capacity.

Several people have contributed to this collective work. The authors and editors are particularly indebted to Gerald Bourrier and Paz Buttedahl of the International Development Research Centre (IDRC, Canada) for providing valuable support to the ideas that originated this work, Hernán Jaramillo for his constant and generous advice, Marcela

Cárdenas and Alicia Richero for summarizing the case studies, and Alejandra Francis for carefully preparing and revising the manuscript. All of us are aware of the temporary nature of this effort. Nevertheless, we are also cognizant of the urgent need of developing nations for information that can help them to reassess the role of institutions of knowledge at a time of severe constraint and unexpected change, which, paradoxically, also offers new room for hope.

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PART I

THE INSTITUTIONS OF KNOWLEDGE

CHAPTER 1

INSTITUTIONS AND THEIR CONTEXT

Benjamín Alvarez

Knowledge and Development

The recent history of international conflict and the growth of influential new centres of science and technology have shown knowledge to be a far more powerful instrument of social transformation and control than ever predicted by philosophers and historians. Aristotle, for one, never imagined the boundless possibilities of practical knowledge for a society. In contrast to speculative knowledge (De Anima III, 433 a.13), which values knowledge for its own sake, practical knowledge strives for a concrete and useful result such as a technology or the testing of a policy.

According to Aristotle, the creation of practical knowledge required far more than intellectual faculties. It also demanded creative ability, the capacity to innovate, the ability to produce and organize, and the desire to act. The purpose of practical knowledge is not only to confirm theory but also to act with efficacy on people and things. The concept of practical knowledge is perhaps better than that of applied research to explain the role of science in society. The first step in any complex problem-solving process, such as developing a new technology, vaccine, or policy is usually basic research.

Thinkers have long studied the relationship between knowledge and action, and that relationship is now a permanent part of human consciousness. The economic value of practical knowledge has increased as

it has become increasingly essential to progress, as well as to individual and collective survival.

Standard economic theory describes a product as a function of two basic factors of production: capital and labour. Land, or natural resources, is sometimes added as a third factor. Although this theory may hold true for a single enterprise, a set of industries, or even a country, it does little to explain long-term changes in a country's economic growth, or income differences between rich and poor countries. Capital, labour, and natural resource endowment typically account for half or less of the difference in total domestic product within a country or between countries. The rest of the variation, called the "total productivity of factors," results from technological change, that is, from using a certain amount of capital, labour, and natural resources in concert with a productive technology.

Applied knowledge has always been central to economic development. The performance of many recently industrialized countries suggests that a country's geographic position, size, and natural resource base play a far less important role in its development than do political stability, flexibility, institutional adaptability, and human efficiency. It appears that institutional and human capability, along with appropriate macroeconomic policies, are the basic ingredients for progress (Naya et al. 1989).

It is clear that economic policy by itself is no panacea. Adopting a new economic model guarantees neither stable growth nor improved living standards. Nor does it assure a place on the complex map of world power. Government, industry, and education must also make a competent contribution to economic development. In other words, they must possess the capacity to absorb, produce, and use knowledge and have the institutional capacity to adapt to attain collective goals. One writer has gone so far as to claim that "Minerals, oil or capital are irrelevant; infrastructure for production matters very little; the only essential is knowledge" (de Closets 1967).

The international situation may help or hinder a country's development. Latin American and Caribbean countries can ill afford to ignore the process of global restructuring currently underway. Indeed, that process is providing countries in the region with new opportunities in

the global marketplace. But while the wind of change may bring some countries access to advanced technology, financial resources, and wider markets, it may also serve as a cold reminder of the crucial need to increase discipline, capabilities, and knowledge.

Given the move away from agriculture and the changes to terms of trade, most economies in the region will find themselves relying increasingly on industry and services. Because this type of economy leans heavily on information networks and the intensive use of knowledge, scientific and technological capacity will be a critical determinant of its success.

The adaptation of the means of production has been called technological change, a term that includes workforce training, the application of new knowledge, as well as changes in the production process. Research, innovation, and education are all key elements of technological change.

Technological change accounts for more than half the growth of both developed countries and those that have adopted open commercial strategies. Comparative studies (such as Chenery et al. 1986) have found that technological change contributes somewhat less — about 30% — to the growth of inward-looking economies. Evidence also suggests that inward-looking trade policies tend to curb the productivity of developing countries. Given the same parameters of investment and employment, these countries tend to grow more slowly than developed countries and those with more open economies (Jaramillo 1991).

Knowledge is the driving force behind the fourth technological revolution now in progress, just as it was in the previous three revolutions. Knowledge has overtaken factors such as natural resources in importance and has radically changed the way in which goods are produced, labour is organized, trade is managed, and wealth is distributed.

The factors that most inhibit a country's technological development are the scarcity of trained human resources and a difficulty staying at the forefront of innovation. Latin American entrepreneurs often complain of being blocked in this way, facing as they do a new kind of international competition that requires flexible models for organizing production. Mass production models no longer satisfy the needs of postmodern

enterprise. Products and processes as well as distribution and sale all require increased knowledge and capacity to innovate as well as more extensive use of technology.

Flexible production models require five essential ingredients: the automation of machinery to support product diversification; a reorganization of labour to make the best use of trained personnel and new approaches to technology management; improved competitive strategies to penetrate increasingly segmented and sophisticated markets; increased local and international subcontracting; and new relationships with suppliers.

New production models will call for better trained and more critical workers, qualities that were previously required only by top management. They will also dictate changes in the organization of labour, in relationships between workers, in institutions, and, indeed, in society as a whole.

Today, as in the past, industrial productivity is linked to economic policy. It is also closely related to the two factors mentioned earlier: scientific and technological research and the knowledge and abilities of the labour force. Some, such as Kellaghan (1991), would put research first; from this standpoint, the training of top management and its relationship to research warrants greater attention than in the past. The infrastructure of scientific institutions and their relationship to production, policy, and education are also decisive factors in international competitiveness.

Competitiveness is the ultimate expression of the capabilities of a firm, an industry, a firm, or a country. Comparative analyses of industrialized countries (OECD 1987; Porter 1990) suggest that success in international competition is related to the interaction of capabilities, incentives, and institutions.

Capabilities (which include human resources, capital, and organizational and technical skills) define what is possible to achieve; incentives drive capabilities by introducing a dynamic element; and institutions provide the general frame in which the other two factors operate. Institutions establish the rules of the game and modify both capabilities

and incentives. Economic results cannot be separated from the life of institutions and the cultural factors supporting them.

In contrast, most recent research on industrial competitiveness in developing countries has focused on the export orientation of various economic models. It has taken only a slight interest in the way that critical variables such as human resources, industrial strategies, institutions, and science and technology contribute to the mastery of technological change (Lall 1990). The ability to learn is clearly a nation's most valuable resource in adapting to new global conditions, one that is absolutely essential to countries seeking to join the mainstream quickly. Ballesteros (1991) states unequivocally that:

> In every case of internationalization and industrialization, today as in the past, human capital has played the leading part. There is no other explanation for the good performance of an economy, its industry, its business in both public and private sector and indeed in all sectors of that economy ....

Human competence and institutional capacity have become more closely linked than ever before. The ability to assimilate and adapt, which depends so much on the quality of human resources and the efficiency of institutional infrastructure, may in future mark the difference between countries that learn slowly and those that learn quickly.

Institutions of Knowledge in Developing Countries

Institutions of knowledge make a useful contribution to society, creating a demand for advanced knowledge and laying a permanent foundation for the maintenance of a nation's position on the world stage. The Museum (or Temple of the Muses) of Alexandria was one of the best known institutions of knowledge in the ancient world. Western culture has borrowed the word "museum" with enthusiasm, but its modern meaning does not do justice to the spirit of the original organization, which was a forerunner of today's scientific and academic research centre. There, the quest for knowledge and the training of new generations of researchers went hand in hand.

The tradition of institutions that promote speculative and practical knowledge has continued down through the ages and has become enriched by the growing importance of science. Today, these institutions are the visible face of science in society, and they are vital to understanding the nature of the scientific endeavour. Research activity needs to be housed in institutions for several reasons. It has become increasingly complex and time consuming, requiring ever increasing levels of technology and the contribution of many disciplines, methods, and approaches for solving problems.

Although research organizations are now using the instruments and procedures of industry more than ever before, they still tend to view themselves as complex learning operations rather than rational productive structures. At the same time, there is a growing social awareness that knowledge is a basic tool for improving production, sales, and service. The activities and culture of science have seeped into the world of business, profoundly affecting its concepts, practices, and relationships.

Although the university is still the prototype of an institution of learning, it no longer has a monopoly over research or teaching. Research centres, government bodies, and modern businesses have all joined the university as important components of a society's scientific, technological, and development capital, along with the society's overall capacity to make use of scientific discoveries, procedures, and tools.

Institutions of knowledge can be analyzed in two ways. First, they can be analyzed as a complex of units, or social system that creates, experiments, communicates, and uses knowledge. The second way is to look at them as organizations with specific missions. The former, or macro view, focuses on the institutionalization process and looks generally at the establishment, introduction, and influence of science in society. The latter, or micro view, looks at the types of institutions that have grown up around knowledge and examines their evolution, productivity, and social impact.

Scientific expeditions, learned societies, schools, museums, observatories, universities, and arts academies are all institutions that have played host to the development of knowledge for centuries. The process of consolidating and institutionalizing scientific activity has been under-

way for less than 100 years. Universities have expanded, research centres have mushroomed, and industry and trade have created a multitude of research units. In addition, social and economic needs have intensified an exchange of knowledge, which has grown with increased interdisciplinary activity. We no longer talk simply of expanding information networks between researchers and research centres, but of expanding information networks between research systems, productive enterprises, and society as a whole.

Laboratories, research centres, scientific associations, foundations promoting science and technology, universities, industrial research departments, consulting groups, museums, and specialized government agencies share many characteristics of a typical institution of knowledge. The most traditional of them — the universities and research centres — are currently being forced by circumstances to reconsider their missions, methods of work, and relations with the outside world. Other institutions less closely related to the creation of knowledge, such as business, are also being faced with the challenge of making increasingly complex goods that require more intensive use of technology and knowledge.

There are at least three good reasons for taking a fresh look at the institutions of knowledge in developing countries. The first is ethical, in that development depends on the capacity for stable and independent management. The second is that international changes are forcing countries to learn how to compete in highly uncertain situations. Lastly, countries without a science and technology infrastructure will find themselves deprived of the most important resource of the future: knowledge.

It is well known that scientific activity is an important indicator of productivity in industrialized countries. Despite institutional traditions dating back to colonial times, Latin America has still fallen behind the rest of the developed world with respect to scientific capacity. The region does, however, possess a basic, if limited, scientific infrastructure of graduate programs and research units.

Although Latin America has more than 500 universities and an ever-increasing number of research and postgraduate programs, it produces few scientific articles. According to estimates based on university

publishing catalogues for Latin America and the Caribbean (CERLALC 1991), university publishers produced 3 248 works in 1990. Of these, 42% were general or in the humanities, 34% were in the social sciences (including law), 7% were in the basic sciences, 11% were in technology, and 6% were in health. Between them, these 500 universities publish only 88 journals; 68 of which come from Brazil, Colombia, and Mexico.

The intellectual life and scientific environment of countries such as France, the United Kingdom, and the United States are closely linked to their postgraduate education programs. In France, for example, roughly 4 500 doctoral theses are produced annually, accounting for about 50% of its new knowledge (Dollfuss 1991). In contrast, the influence of postgraduate schools in Latin America is minimal, partly because of their small number but more so because of their poor quality.

Most postgraduate programs in Latin American countries (with the exception of those in Brazil) did not emerge during the second half of this century as the result of strategic thinking, explicit government policies or research dynamics. Instead, programs developed rather spontaneously out of an interplay between national and international education systems through fellowships, visiting scholars, and contact with the international literature on education. Other contributing factors were the rapid expansion of school levels and the growing demand for educational credentials.

Several Latin American countries offer postgraduate programs at the master's level but very few offer doctoral programs. In 1989, there were 1 324 postgraduate programs in Brazil (399 at the doctoral level), 1 594 in Mexico, 616 in Colombia, and 123 in Chile. The majority are weak in research, information systems, and teaching. These weaknesses hamper the development of established schools of thought and research, which, in turn, negatively affects other levels of education.

The seven countries most active in research are Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico, and Venezuela. Their 6 000 or so research centres are engaged in 42 000 studies (Sagasti and Cook 1985). National Science and Technology centres classify 674 of these centres as high quality, with a potential for training new generations of researchers (Aguiar 1991). It should be noted, however, that there are serious doubts

about the coverage, validity, and reliability of information collected by international and national bodies (Filgueira 1991).

Aguiar proposes a strategy to improve communications and cooperation between research centres in Latin America and the Caribbean. The plan entails exchange programs run by specific disciplines rather than by national policy bodies, subregional integration, and increased cooperation around institutional development. He also advocates more research based on a case-study approach, which would allow in-depth examinations of factors related to institutional structure in general and the recruitment and motivation of scientists and relationships between research units and their local environment in particular.

It is more important than ever to put an end to the stagnation now evident in many research centres and universities in Latin America. If the region is to succeed in joining the mainstream of world activity, its institutions of knowledge will have to play a major role in these efforts.

Many developing countries have begun to develop a research infrastructure. The universities are home to the basic sciences. Health research takes place in a more diffuse institutional context: spread between national centres, private foundations, health service organizations, and universities. Agricultural research is conducted mainly in national and international centres. Private centres have provided significant support for social and educational research in Latin America. Increasingly, industry is turning to universities, private institutes, and government centres for research on technology and industrial processes.

With few exceptions, international cooperation has played a crucial role in the development of institutions of knowledge in developing countries. International assistance was responsible for training thousands of agricultural researchers in Latin America in the 1970s. These professionals formed a critical mass that led to the establishment of national agricultural research centres. The Ford Foundation and United States Agency for International Development (USAID) in the United States, along with IDRC in Canada, have provided essential support to social research in general and educational research in particular. A similar pattern can be observed in the basic sciences.

It was the international donor agencies who coined the term

"institution-building." When the agencies first started providing technical assistance after World War II, they attempted to transplant solutions from industrialized countries to developing ones, applying them by trial and error. It soon became evident that more knowledge was needed on how institutions develop if interventions were to stand a better chance of success. The metaphorical reference to "building" was used as a starting point for the planning and development of institutions. Existing research on complex organizations served as the basis for a new literature on institution-building, one primarily designed to respond to the specific needs of donor agencies. This material usually took the form of notes or documents with limited circulation.

Analyzing Successful Institution-Building

According to Blase (1986), the literature on institution-building takes a micro and macro approach. The former focuses on individual institutions and deals with theories and explanations drawn from an analysis of organizational behaviour. The latter examines the role of institutions in society.

With respect to the institutions of knowledge, the micro approach looks at the capacity of each institution to adapt and change. It analyzes the internal and external factors that influence its evolution, as well as the similarities and differences with other organizations. It also considers an institution's relationships with others in society, especially those that give it technical or financial support and provide it with legitimacy, along with those that use the knowledge it produces. The term "institution-building" refers to the conscious process of creating a new institution or changing an existing one to achieve a specific set of goals.

The factors identified by research on complex organizations as essential to an institution's success have been used as the starting point for framing intervention strategies. For institutions of knowledge, these variables tend to be related to internal structure and incentives; they have a different configuration and relative importance than for other organizations.

The macro approach to institution-building analyzes the way in which systems of institutions support development in broad social and economic sectors. For institutions of knowledge, this could take into account how different sciences become institutionalized in society. Obviously, as science penetrates further into society, institution-building will become less accurate as a metaphor for describing the development of knowledge institutions.

There is a wealth of literature on the most important characteristics of successful or efficient organizations (Gómez 1990). Israel (1987) has made a significant contribution to the knowledge base by identifying important sources of motivation for good institutional performance. An analysis of 159 cases in developing countries uncovered three in particular: specificity, competition, and management.

Specificity has two aspects: first, an institution's capacity to specify and achieve its objectives and control results; second, its system of rewards. Competition refers to the institution's relationship with its environment and with the various pressures applied to its members. Some institutions are highly specific about their work internally, experience substantial competition, and have a motivating management. However, most institutions of knowledge in the "soft" sciences in developing countries are less specific and evolve in a less than competitive environment.

Other features of institutions of knowledge tend to vary with organizational climate and performance. Examples include an organization's values, which characterize institutions that seek knowledge for its own sake (such as Plato's Academy and the universities); the type of staff employed, their autonomy and relationship with international networks; and working style.

Institutions of knowledge differ from one another based on the following factors: the type of knowledge produced (agriculture, sociology, physics...); the strategy adopted to produce it (basic research, technology, interdisciplinary work...); the source of authority and funds (the state, private interests, religious institutions, business...); and the decision-making system (hierarchical lines of authority, a flat pyramid, or something in between).

The environments of research organizations in developed and developing countries are also quite dissimilar. The industrialized world has an established scientific community, a regular system of peer review, channels through which scientific activity is shared, higher levels of education, and easy access to information. The market for researchers is larger and more varied, and a career as a researcher is an attractive one. In the developing world, variations between institutions seem to depend more on a country's size, degree of development, and prevailing view of the state's role.

The climate of complex organizations described in the classical literature differs markedly from that of research centres. The creation of knowledge is not an activity that can be contracted and supervised by independent entities in a bureaucratic way. It is a unique, highly absorbing process, not easily controlled from outside, that requires the intense dedication of the researcher (see Chapter 2). This raises the question of how to motivate personal efficiency and organizational success in an institution of knowledge. What are the key factors or tools that will promote the creation and development of institutions of knowledge in a developing region such as Latin America? The main purpose of this book is to help find answers to these questions. This is also the book's contribution to "theoretical or speculative knowledge."

There are many reasons why countries in Latin America and the Caribbean should review and modernize their policies on science and technology, and restructure, reorganize, reform, and integrate their institutions of knowledge. Here are six.

- The success of economic liberalization programs now being introduced in most countries will depend heavily on the local availability of human and institutional resources.
- The adaptation and modernization of production cannot be achieved without a solid foundation in scientific and technological research and efficient communication between research and production.
- The current rethinking of the relationship between the state and society will force a review of the nature and role of government research institutions.

- Rising costs and stretched budgets in universities and private research centres will increase the pressure to find alternatives.
- Solutions to pressing social problems can no longer be delayed and require the combined efforts of business and academia.
- The redistribution of wealth — the goal of many social policies — will never be achieved without the redistribution of knowledge, and this can only occur with the active participation of the institutions of knowledge.

CHAPTER 2

INSTITUTIONS OF KNOWLEDGE AS FORMAL ORGANIZATIONS: AN INITIAL BALANCE

Hernando Gómez

It is hard to dispute the notion that teaching people to fish will be more useful to them in the long run than giving them fish. Likewise, building a solid research capacity in Latin America will be more beneficial to the region over the long term than supporting individual research projects.

Yet, national and international donor agencies have long been biased toward funding individual research projects in developing countries rather than the institutions that conduct them. There are two reasons for this. The first is that we know, or think we know, more about designing and evaluating research projects than we do about building and strengthening research institutions. The second is that we feel we can exert more control over the success of a research project than over the success of a research institution, whether or not this is in fact the case.

In other words, doing the appropriate things is more adequate than doing things appropriately. This consideration would be sufficient for going back to the theme of institutions; however, our knowledge of them is more limited than our knowledge and skills on the management of single research projects.

Research on Institutions: The State of the Art

The capacity to promote the development of research institutions requires a thorough understanding of the institutions themselves. Granted, we do know some things about institutions, which we also refer to as complex organizations. In fact, we have many insights and many convincing (if partial) explanations.

The literature on institutions covers many different types of institutions and employs theoretical perspectives from a wide range of disciplines. The institutions examined include public firms, government agencies, nonprofit organizations, community institutions, and social movements with a certain degree of rational bureaucratic organization. There is also an extensive anthropological and historical literature on institutions as "recurrent or internalized interaction patterns." (We refer here to literature on the institutionalization of science, which is closer to the anthropological definition of institutions and which is helpful in identifying the contextual or macro factors that determine the success or failure of research institutions.)

At the theoretical level, we can distinguish between approaches that characterize the organization-as-machine versus the organization-as-culture, as well as perspectives that place an emphasis on explanation versus an emphasis on management. Disciplines range from the formal legal school (of Comte and Maine) and the industrial engineering school (of Taylor) to business administration, public administration, and social science perspectives, as well as to cybernetics, systems, and chaos theories.

Many of the central concepts of institution-building theory, although understood by most researchers, are still somewhat vague. For example, the terms "institution" (or organization) and "building" (or development) can be understood in different ways, and what seem to be minor nuances may be magnified when used in lengthy, complex, and self-referring texts. This ambiguity is exacerbated by the lack of definitional precision (in epistemology, methodology, purpose, and specific subject matter) that characterizes so much "soft" social research.

The literature on institutions also tends to rely heavily on paradigms. Some of the most influential paradigms used in the description of complex organizations include technological division of labour, hierarchical division of labour, information networks and flows, social control, face-to-face interaction, rational self-serving individuals, efficiency maximizing, and shared value-enhancing. This abundance of paradigms or quasi paradigms — which sometimes compete or overlap with each other — has fuelled efforts to develop superior languages, or metalanguages and general theories. However, many of these have a comparable degree of apparent elegance and coherence, and the problem is slightly biased toward the sphere of metaparadigms.

Hence, state-of-the-art theory can be described as a set of different-order paradigms and subparadigms, each of which selects an independent or major explanatory variable, develops a typology of institutions according to the main categories of the chosen variable, and explains or predicts a range of dependent variables or structural and behavioural features of the identified institutional types. Table 1 illustrates some of the most commonly selected variables.

Bureaucracy is too important a part of everyday life to be merely a topic of theoretical controversy. A literature has evolved that focuses on complex sets of partially overlapping, partially excluding paradigms of strategic intervention in a wide variety of organizational contexts. These approaches are broadly framed within one or another of the theoretical

Table 1. Some commonly selected variables.

Explicandum		Explicanda	
Variable	Main categories	Structural	Behavioural
Goals	Specialized–diffuse	Complexity	Effectiveness
Technology	Routine–creative	Stratification	Efficiency
Sanctions	Individualistic–collectivistic	Formal–informal networks	Morale
Environment	Placid–competitive systems	Decision-making	Adaptiveness

paradigms. They also tend to select as the independent variable the easiest one to manipulate.

Some of these variables include administrative relationships (such as organizational charts, fluxes, and processes); legal frameworks (especially for public institutions); incentives, time, and motion (the industrial engineering perspective); planning and monitoring systems (such as quality-control techniques and strategic decision-making); leadership styles (such as management by objectives or participatory management); the human factor (T groups, Z theory); the environment (interinstitutional awareness, strategic linkages); and the role of donor agencies (the blueprint model, logframe, second and third generation, direct support, and learning process approaches).

Building Research Institutions in Latin America

General theories on institutions can be used to identify some of the factors that might affect the success of research institutions in Latin America. The best way to identify helpful questions is to focus on those aspects of general theory that are most relevant to the subject under consideration. This discussion will now turn to the topics of institution building and research institutions in Latin America.

What constitutes a "built" institution depends to a large extent on what is meant by "building." Is it an institution's ability to survive, grow, and undertake new programs, or its ability to contribute to overall social well-being? Is it the capacity to satisfy relevant actors (owners, politicians, employees) or to maximize rationality and achieve stated goals? Is it the capacity to change the environment or to adapt to it? If institution building is recognized as a multidimensional concept, as it should be, how do we measure components such as effectiveness, efficiency, morale, and adaptability?

Institution building should be recognized as an extremely relative concept. Max Weber (1947) theorized that the bureaucratization of social life resulted from the rationalization of Western society. According to his theory, if the formal or bureaucratic organization of human activity is

viewed as a mechanism for achieving collective goals, then an institution can be considered more or less "built" when it achieves those goals. It is also known that some institutions achieve their goals more efficiently than others.

Price (1978, pp. 203–204) provides an excellent summary of factors contributing to the success of institutions:

> Organizations which have the following mechanisms are much more likely to have a high degree of effectiveness than organizations which do not have the mechanisms:
>
> a) The organization's economic system should be characterized by: i) high degrees of division of labour, ii) specialized departmentalization (except where there is a high degree of complexity), iii) mechanization (except where there is a high degree of professionalization), and iv) continuous systems of assembling output.
>
> b) The organization's internal political system should be characterized by: i) high degrees of legitimate decision making, ii) rational-legal decision making, iii) centralization with respect to tactical decisions (except where there is a high degree of complexity), and iv) maximum degree of centralization with respect to strategic decisions.
>
> c) The organization's external political system should be characterized by: i) a high degree of autonomy; ii) an ideology with high degrees of congruence, priority, and conformity; iii) cooptation; iv) major elite cooptation; v) a high degree of representation; vi) major elite representation; and vii) a major elite constituency.
>
> d) the organization's control system should be characterized by: i) a high degree of sanctions; ii) a norm enforcer-norm conformer relationship which is basically secondary; iii) a sanction system with a high degree of grade; iv) a collectivistic sanction system; v) high degrees of vertical communication and horizontal communication; and vi) a communication system which primarily is instrumental, personal, and formal.

This organizational profile may be understood as a general version of the specificity that Israel (1987) identified as one of two basic incentives to performance in a recent World Bank survey of 159 developing countries. The other incentive — competition — refers to an institution's relationship with its environment and the pressures brought

to bear upon its personnel (Table 2). In short, there are good reasons to believe that complex organizations are more likely to attain their goals when they meet the criteria of specificity and competitiveness as set out here.

"Building" is a purposeful, voluntaristic activity in which deliberate effort is made to strengthen an institution. Thus, although specific, competitive organizations are easier to build than their nonspecific, noncompetitive counterparts, there are still certain features that can be manipulated to increase the probability of success. These more controllable variables are the subject of the specialized literature on institution building. Milton J. Esman's *Institution Building Concepts* (1967) remains the classic in this field (Table 3).

Several sophisticated measuring techniques have emerged in the literature on institution building based on Esman's concepts (see Bjur 1983). So have sets of bivaried hypotheses (Duncan 1975) and detailed action guidelines (see, for example, the 38 strategies recommended by Derge 1968). This specialized literature is extremely pertinent to our

Table 2. The second incentive: competition.

	Predominant category of pressure		
Source	Economic	Political	Administration
Economic competition			
Competitors	X		
Competition surrogates			
Suppliers		X	
Clients	X	X	
Politicians	X	X	X
Regulators		X	X
Internal		X	X

Table 3. Esman's classic model.

Variables		Linkages
Leadership		Enabling
Doctrine	Transactions	Functional
Program		Normative
Resources		Diffused

analysis of scientific and technological research institutions in Latin America.

At the heart of bureaucracy is a dilemma that has been discussed in many classic texts. Two of the key determinants of institutional success may in fact work at cross purposes. An institution's success in achieving collective goals depends on its ability to reduce uncertainty by dividing complex processes into routine components. At the same time, an institution's competitiveness depends on its ability to create an environment that motivates and stimulates its personnel.

It is clear that scientific research is one of the most uncertain of endeavours. There is no such a thing as an "art of invention" (or *ars inveniendi*), although natural philosophers pursued it until the 18th century. This means that formal organization, although still necessary, is less likely to be crucial to modern science than to other fields such as industry or the military. Furthermore, the "soft" organizational style of most research institutions is less conducive to success. (We might conclude that bureaucracy does kill creativity.)

Hence, it would appear that it is the control and external political systems that make or break research institutions. The evidence does suggest, although not conclusively, that both motivation and environment are critical to the success or failure of scientific organizations.

Motivation

The creation of knowledge cannot be monitored, hired by the piece, or externally controlled like many other bureaucratic activities. Rather, it is a unique and absorbing process that demands the intense, voluntary dedication of the researcher.

Historically, values and motives have played a vital role in scientific development. Here are some examples from different contexts:

- The social value placed on scientific knowledge (see Bernal 1974);
- The impact of specific sets of cultural and religious values on scientific attitudes (see Merton 1957);
- The importance to scientists of peer recognition (see Stein 1982);
- The finding that scientific creativity increases in an atmosphere that

"avoids isolation and domination and provides frequent stimulation combined with autonomy of action" (Pelz 1976); and

- The psychoanalytical hypothesis that scientific vocation is a "neurotic search of substitutes to aggressive and sexual instincts" (Kubie 1954, p. 109).

For our purposes, the most important motivational issue surrounding scientific activity relates to institutional incentives. This refers to the way an organization's system of rewards and punishments encourages or discourages certain behaviours. Many research institutions in Latin America appear to reward behaviours other than scientific creativity. Examples include teaching ability (or is it popularity among students?), conformity (or is it skill at playing in-house politics that can exert pressure not to produce, lest colleagues lose face), and the popularization (or is it "ideologization"?) of knowledge, rather than its creation. It is critical that an institution's reward structure be well understood before it can be changed to better support scientific creativity.

Environment

With respect to institutional environment, Price's emphasis on cooptation (see his description of the external political system) seems to conflict with Israel's emphasis on competition. However, what appears to be a contradiction also suggests a general hypothesis that could be used to guide research on scientific institutions. The hypothesis is that the success of a research organization requires both a high degree of social legitimization (Price's emphasis) and a high degree of competition among organizations and research staff, which serves to provide momentum (Israel's emphasis).

This hypothesis can be demonstrated with historical and cross-sectional evidence. Here are several important contributions. Israel (1987, p. 132) has described political commitment (social legitimacy) as "an essential ingredient in the success of an institutional development program" and the critical influence of "macropolicies" on institutional development. Ben-David (1960) has provided a classic analysis of how decentralization and competition advantaged German and American medicine over the British and French models. Schultz's (1975) work has

shown how institutions rise and fall in response to changing social demands. Powelson (1972) has explained how leading elites create new institutions to "model" development.

Therefore, it is suggested that the following environmental issues be placed on the research agenda:

- Political commitment to scientific development;
- Macropolicies and national strategies affecting science;
- Interinstitutional competition for research resources (recognition and prestige, human, and financial resources);
- The social demand for science and its products; and
- Roles and perceptions of national elites concerning science.

These should be accompanied by an assessment of the institutional effectiveness of external systems relating to the environment (such as information gathering, planning, marketing, feedback collecting, and extending linkages).

It could be argued that institutionalization is just another name for development. However, institutions in developing countries have only begun to be studied. Little attention has been paid to research institutions and even less to the factors identified here as critical to their success. Because the guidelines suggested in this chapter have been derived from the experience of developed countries, they require careful adaptation to be meaningful to the Latin American context.

Of course, science is universal (although scientists are not, as Pasteur has reminded us), and scientific production is subject to an international division of labour. This brings us to a tricky question, which is both empirical and normative. What kind of scientific research do we want for Latin America? Is it realistic, or indeed wise, to aim for high quality, pioneering scientific research in our countries? Or, should we concentrate on borrowing and adapting from others, taking advantage of our position as late-comers to the field? I lean toward the second approach with several qualifications. First, there should be a large enough pool of highly trained scientists to ensure a scientifically minded society, proper teaching of the basic sciences, and the efficient adaptation of world knowledge. Second, the arts, humanities, and social sciences should

remain unique to our countries because culture and nationality do make a difference. Third, another exception is science or technologies capable of playing a strategic role in national development in areas such as agriculture, tropical medicine, and the new industries of knowledge for the world market.

Another key question is whether an institution's success should be judged on the inherent intellectual value of its products or on the potential of these products to contribute to the transformation of the natural or social universe.

This leads to two more variables that affect institutional success. The first is the type of research design normally employed by an institution. Van de Vall and Bolas (1978) have shown that some research designs tend to yield more applicable results and others tend to advance substantive knowledge. The former are broad in scope, employ ideographic concepts, strive for less logical elegance, and have a wider implemental span. The latter have a narrow scope, employ nomothetic concepts, tight logical deduction, and shorter implemental spans.

The second concerns institutional networks. Formal organizations interact with other social actors in complex and unique ways. Relationships may be complementary, competitive, or regulatory. Institutions dedicated to pure and applied science establish linkages with other institutions that can contribute to their success. (To confirm the importance of this variable, we have only to observe the differences among research units that are attached to universities, attached to private enterprise, or are independent.)

The question of pure versus applied research keeps bumping up against the larger issue of Latin America's proper position within the international order of science. Science is a circuit of many steps and institutions that endlessly (if partially) feed upon one other. These include basic research, technological research, the training of new scientists, the development of academic and professional communities, and the diffusion and production of goods and services.

The circuitous, multistage nature of science has two major implications for the agenda proposed here: when evaluating and explaining the success of a given research organization, consideration should go beyond

national institutions to international networks of associated agencies. For example, it could be that the cost–benefit ratio for a host country turns out to be quite different from that of a third country and the wider international community.

A nation's capacity to make truly significant contributions to science depends largely on the critical mass of cultural, human, and financial resources that it can devote to the effort. Science is a long-term process that is nourished by patient trial and error, by diverse and heterogeneous approaches, and by accumulation, feedback, and acceleration. Without such a critical mass, a country is in no position to fully use the fruits of knowledge.

Summary

The existing literature on complex organizations, particularly that on the institutional development of Latin American scientific and technological research institutions, suggests that priority should be given to the following institutional components:

- Specificity (including types, degrees, determinants, and implications);
- Competitiveness;
- Values and motivational structures of the scientific community (with an emphasis on institutional incentives);
- The relationships between an institution and its environment (including legitimacy, competition, and external systems);
- The basic orientation of research (including research designs and institutional networks);
- The position of an institution in the international scientific order (including relevant networks of world institutions and its stage in achieving a critical mass of resources).

PART II

THE INSTITUTIONALIZATION OF SCIENCE IN LATIN AMERICA

CHAPTER 3

INSTITUTIONAL DEVELOPMENT OF BASIC SCIENCES

Hebe M.C. Vessuri

✦

Over time, scientists and others in Latin America established splendid societies, museums, schools, institutes, foundations, research units, and specialized journals and publications. These institutions are critical to understanding the nature of science and its relationship to social, political, and economic life. They have had a powerful impact on urbanization, the communications revolution, and the growth of the state. They have also influenced the resources available for research from agricultural and industrial interests and from international cooperation.

Examining the growth of scientific and research institutions helps to identify important patterns in institution-building in Latin America. This chapter focuses on the basic or exact sciences (those in which advanced mathematics plays a central role) and the descriptive, experimental, or Baconian sciences such as geology and certain branches of biology (Kuhn 1977).

Although the basic sciences are driven less by ideology than other fields of knowledge, it is still possible to observe how a variety of schools, traditions of thought, and theoretical perspectives originating in some countries were transferred and adapted to the specific contexts of others. This has resulted in archaic forms of scientific research being practiced in some places and more modern forms in others.

Given that institutions are so intimately connected to their social context, it is difficult to transfer institutional models from country to country. An institution's success cannot be reduced to a simple formula.

Rather, each institution is a unique product of strategic adjustment between an ideal institutional model and the particular social dynamics of its context.

Although scientific institutions are composed of actual individuals occupying physical space, their real essence is contained in achievements of thought formulated and communicated as ideologies, roles, and institutional functions (Adler 1987). An institution is merely a vector for transmitting a collective understanding that has specific consequences. An institution's leaders provide direction by defining the beliefs, expectations, and objectives that determine problems and solutions.

Although an analysis of institutional development must take into account the unique economic and political constraints and opportunities of each context, it must also consider how institutions and ideological groups themselves stimulate the processes of scientific development, and how they constitute the necessary if not sufficient conditions for its success or failure.

Institutional agents in the basic sciences (mathematics, biology, physics, and chemistry) have been known to convince policymakers that a research capacity could make a vital contribution to solving national problems related to public health, economic growth, or national security. In such cases, these agents used their scientific knowledge and expertise within a political framework and converted their work into national projects, thus helping to reduce unemployment and to achieve certain national goals in the process. Good examples include Oswaldo Cruz and the Instituto Manguinhos in Brazil, Monge Medrano and high-altitude biology in Peru, and Theodosius Dobzsansky and genetics in Brazil (Glick 1991).

Although enthusiasm for the study of science in Latin America is growing, knowledge of institutional traditions and intellectual habits is still quite limited. The existing literature looks at institutions mainly as landmarks for identifying socially significant forms on which to base more interpretative studies. This chapter provides a preliminary overview of the institutional characteristics in the basic sciences, the intellectual and organizational models used, and their main strengths and weaknesses. It is based on the premise that institutional development,

although not the same as cognitive change, nonetheless reflects its changing patterns.

Over time, the basic sciences have been organized in the following institutional contexts: the university, the research institute dedicated solely to the production of scientific knowledge, the research institute devoted to supporting the requirements of the productive sector, the institution that has been adapted to scientific research, the science museum, the observatory, the scientific journal, and the scientific association.

The Institutional Development of Basic Sciences in Latin America

From colonial times, Latin America has played host to individual scientists — both European and indigenous — who developed schools of mathematics, navigation, chemistry, and astronomy in relative isolation. The institutionalization of the basic sciences came much later, beginning timidly in the 19th century and expanding only in recent years. The bulk of this chapter outlines the history of scientific institutionalization in Latin America, beginning with a discussion of the decisive role played by international cooperation in this process.

International cooperation has been critical to the development of Latin America's scientific infrastructure in this century. Although emphasis, goals, and approaches have varied over time and with the country and institutional groups concerned, three distinct stages can be identified.

The first stage, covering the period from 1900 until World War II, was characterized by a strategy on the part of the industrialized countries to divulge science according to national molds. The goals of this strategy were cultural influence and competition, although the need to support science was accepted as an inherently international activity (for a good description of this period, see Schroeder-Gudehus 1977). In the years leading up to World War II, international cooperation agencies were established in Belgium, England, France, Germany, Italy, the Netherlands, Spain, and the United States.

The second stage of international cooperation, organized through the United Nations, lasted from the end of World War II until the 1970s. During this period, the role of science in economic affairs became central to international relations. Scientific and technological hegemony were increasingly used to achieve dominance in the international system. The basic sciences acquired a new economic significance because of their contribution to new process technologies, and scientific knowledge was converted into intellectual capital (OECD 1980). Megaconferences on science and technology for development, the Group of 77, and the Trilateral Commission were all milestones in the evolution of international relations in the scientific field. As a result, science was controlled by private-sector institutions in industrialized nations, and access was only granted to countries willing to play by the rules of the game. These rules were set up to guarantee the economic domination of the centre over the periphery.

The third stage, which spans the 1980s, is characterized by a giant constellation of multilateral alliances involving scientists, government agencies, nongovernmental organizations, and multilateral corporations that have gained prominence in the context of a widening knowledge gap between North and South. It became clear during this decade that systems for financing science and technology through international cooperation were unrealistic. They are now being replaced by a growing interest in various forms of multilateral cooperation. In the meantime, bilateral cooperation is expanding more rapidly than multilateral cooperation, and the giant alliances of institutions scattered around the world are frequently unconnected to the initiatives of intergovernmental organizations (Standke 1989).

Nevertheless, scientific development still seems to have lost urgency on the North–South agenda. Most developing countries are not using their limited funds for long-term scientific development, although some, such as China and Brazil, have received large loans from the World Bank for science and technology projects. The gap continues to widen, not only between North and South but also between developing countries, between regions, and even within regions. Whereas there is a mounting pressure in all industrialized countries to increase spending on research

and development, this is not occurring in Latin America. Although modest success has been achieved in some of the larger Latin American countries (Standke 1989), recent progress has been threatened, or completely halted.

Despite the advances made, one is hard pressed to say that there is much social space for science in Latin America. A clear role for science has yet to be defined, accepted, and institutionalized within society. A brief historical summary of the institutionalization of the basic sciences shows how precarious, fragmented, and isolated achievements have been.

The formative period, from 1890 to 1930, is associated with relatively isolated attempts to build scientific research institutions such as museums, observatories, agronomy research centres, and medical schools. Public universities, set up as independent schools in the French manner, provided an institutional focus for the basic sciences, which continued into later periods. Scientific research in Latin America was mainly carried out in public universities because there have been no real research universities. Research was conducted by small groups centred around certain outstanding scientific figures, but continuity and diversification were jeopardized by political instability and lack of social demand.

Over time, research was integrated into the university system through merit schemes and advancement based on public examinations and theses. The increasingly bureaucratized system created good conditions for individual research in some instances, but, in general, a tradition of professional research was not developed. The lack of well-equipped laboratories and libraries as well as shortage of research monies drove scientists to seek private funding to cover their personal expenses. The lack of funds restricted contact with more developed scientific centres, and university research became the province of a small elite.

Some scientific research institutes allied themselves with the technical laboratories associated with schools of engineering and medicine, particularly the latter. Some medical schools spawned teaching hospitals and high-level research groups during the early part of the century. But because basic research still took second place to the teaching of medicine

and clinical practice, research was unable to expand beyond certain limits.

Argentina was the first country in Latin America to institutionalize the basic sciences. With a highly educated population in 1950 (27.8% of its economically active population fell into this category), the problem was not in finding suitable scientific researchers but in retaining them. Low salaries, continuous economic instability, and political repression were all factors that drove many scientists and engineers out of the country in recent decades. They also deterred many young people from choosing scientific occupations. Two of the most important institutions in the basic sciences at this time were the School of Exact Physical and Natural Sciences of Universidad de Buenos Aires and the Scientific Sciences of Universidad Nacional de La Plata.

The period from 1930 to 1960, or the second stage of development, can be described as one in which there was a search for new institutional models and a rise in private-sector initiatives. Argentina maintained its position as Latin American leader in the basic sciences until the middle of the century when it began a gradual decline. In contrast, this period marked the beginning of institutional consolidation in the basic sciences for many other countries in Latin America. In Brazil, the Universidade de São Paulo was the first institution created with the goal of supporting research and training a new generation using an innovative form of higher education.

The basic sciences in Mexico are closely associated with the Universidad Nacional Autónoma de México (UNAM) and its School of Sciences, which was founded in 1938. In 1941, the university changed its structure and divided its courses of study into two cycles: professional studies (the master's level) and higher studies (the doctoral level). The latter was designed to train scientific researchers by immersing them in scientific culture. Those graduating with doctoral degrees were given preference for research posts in the university's institutes. However, because the research budget was so small, the university provided the buildings but expected scientists to find the means to carry out their work.

During the third stage, from 1958 to 1980, numerous schools of science sprang up in new universities as ambitious attempts were made

to reform traditional structures and to make scientific and technological research more central to socioeconomic planning. Outside the university, independent centres engaged in basic and applied research received strong support from both the public and private sectors. This period was also characterized by organized international cooperation.

Although universities in Latin America created modern systems of knowledge production in the context of rapidly expanding higher education, the schools dealing with the basic sciences did not grow very quickly. They accounted for a relatively low proportion of total university enrolment, rarely exceeding 5%. (The exception was computer science, although even here there was greater interest in the more applied aspects than in the science of computing.)

Paradoxically, scientists played an active and influential role in the transformation of university life during this period, especially during the 1960s. They argued that scientific education should be conducted within the framework of a national strategy for scientific and technological development and that science should play a more central role in the expansion of higher education. They attempted to change the traditional university structure by making scientific research the focus of university life. They also pressed for the institutionalization of the university's internal mechanisms for encouraging research. Their revolutionary proposals called for changes in the power structure, and the imposition of rigorous research requirements on teaching staff and students alike. They also insisted that greater emphasis be placed on research than professional achievement in the evaluation of universities, departments, research groups, and courses within the higher education system. However, university authority figures, who were not inclined to change their thinking quickly, frustrated efforts to renew university life through political action.

In the 1960s, the School of Sciences of the Universidad de Buenos Aires was the focus of an active effort to change the university's system by setting high scientific standards and encouraging intensive participation in politics. The leaders of this movement came into conflict with the military regime in 1966; most resigned and later left the country (Slemenson 1979; Vessuri 1983). The Universidade de Brasília, set up in

the early 1960s as a brave experiment in implementing extensive changes to university life, suffered a similar fate in a series of confrontations with the country's military regime. The experiment failed. In Venezuela, the impetus for a renewal movement came from young teaching staff and students in the School of Sciences at Universidad Central and spread throughout the university. The government responded by temporarily closing the university and setting up experimental public universities. The best known of these is Universidad Simón Bolívar, which emphasizes technical and scientific skills over political commitment.

We can distinguish two distinct phases in institutional development: one before renewal, which saw institutional experiments in the public sector and modern units emerge within more traditional institutions, and one after renewal, which saw attempts made to design new institutions to replace the traditional public universities as centres of science and technology.

The story of the School of Sciences at the Universidad Central de Venezuela is typical of university evolution during the first of these phases. The school was established in 1958 with the express purpose of producing scientists and research, both considered necessary for the country's economic development (Vessuri 1987). However, the school produced little research during its early years. Even now, although the School of Sciences is considered one of the most productive in the university, only a small minority of its academic staff actually conduct research. Nevertheless, the rules defining programs of study were dictated by international structures and legitimized by disciplinary organizations and international educational agencies such as the International Council for Scientific Unions (ICSU) and the United Nations Educational, Scientific and Cultural Organisation (Unesco). The school has made a notable contribution to training scientists and regularly reviewing curricula; assisting in the establishment of other academic and research institutions; as well as helping to develop the scientific disciplines in Venezuela and finding solutions to national problems.

One example of rapid institutional growth is Brazil. In just a few short years, Brazil has succeeded in building the strongest research capacity in Latin America, second only to India among the developing

countries (Schwartzman 1985, pp. 110–111). The expansion in the 1960s was a wide-ranging drive on the part of the Brazilian government to link scientific development more closely with economic development. What was unusual was that the resources for scientific and technological research came from government sectors responsible for economic planning and investment. As a result, research funds were large in comparison to research capacity, and efficiency and productivity were frequently measured by evaluations of research activity.

Brazil's efforts, many of which coincided with comprehensive changes in its higher education system, have not yet been fully evaluated. The North American model — centralized institutes and departmental organization — was enshrined in Brazil's Education Law in 1968. Graduate instruction became a regular component of university programs and full-time employment opportunities for university teaching staff increased. At the same time, requirements for university entry were lowered, and a parallel system of private schools was introduced to compensate for the limited number of places available within public universities. In short, the system of higher education became larger, more differentiated, and more stratified. At the same time, frustration was growing among the student body and teaching staff because the new research programs were not well adapted to the new institutional climate.

There were also interesting institutional developments in the postrenewal period such as the Universidade Estadual de Campinas (UNICAMP) in Brazil, Universidad Simón Bolívar in Venezuela, Universidad de los Andes in Colombia, and Universidad Iberoamericana in Mexico. The goal here was to establish modern scientific and technological institutions that would be less influenced by the politics that had so often paralyzed traditional public universities.

Despite the difficulty transforming the public university, scientific ideology, which had been traditionally restricted to very small circles, was extended to sectors outside the university. This helped to secure government support for incipient scientific communities in many countries in the region, usually through national councils for science and technology. Although these new programs were often set up as university departments of science and technology, they had a high degree of

autonomy and control over their own administration and research funding.

At this time, new and smaller universities designed for research, such as UNICAMP, were springing up beside the traditional universities; and academic research institutes, such as the Venezuelan Institute for Scientific Research (IVIC), were set up outside the university system. In existence for 32 years, IVIC's rigorous approach to international calibre scientific research has made it one of the region's most successful institutions. Although conclusive study of IVIC has yet to be undertaken, Freites (1984) and Vessuri (1984) have made initial assessments.

After the frustration of the renewal movement in the 1970s, the groups emerging to take advantage of increased resources for scientific and technical research tended to be young and apolitical. These salaried researchers generally worked in isolated and protected locations within universities on externally funded projects and had no teaching duties (Schwartzman 1985).

The period from 1980 to 1991 was marked by a crisis in the basic sciences in Latin America and a corresponding crisis in the university institutional model. The institutional development initiatives of this period were characterized by the creation of isolated and protected niches for scientific research.

Rapidly expanding enrolment and rising costs led to a deterioration in the traditional universities, which had historically housed most research institutes. The staff complement grew so quickly in response to increasing enrolment that the quality of teaching was compromised. Recent studies in Brazil point to serious bottlenecks and low productivity in many areas that threaten to undermine the scientific base of research and development.

Low levels of remuneration also encouraged union militancy on the part of university staff, a large group mostly engaged in teaching. Full-time positions once held exclusively by scientific researchers were taken up by individuals with no scientific background (Brunner 1990). In the absence of industry demand, these factors made the universities less attractive as centres for research. Many scientists and engineers started

to organize their work outside the universities or around isolated graduate programs (Lomnitz 1979).

Graduate programs in Latin America have been characterized by high failure rates, diverse objectives, and unreliable quality; therefore, students continue to be sent abroad when funds and opportunities are available. Brazil and Mexico have had the most success developing graduate level education in the region. In Brazil and Chile, the basic sciences and technologies account for roughly half of all enrolment at the graduate level; in Mexico and other countries, however, enrolment tends to be concentrated in social sciences and administration programs. Doctoral programs in the region are still rare and not very productive.

Unfortunately, efforts to modernize the university seem unlikely to be successful. Very few institutions are dedicated to conducting scientific research and to training new research staff. This does not mean, however, that research at public universities should be ignored. In the case of Brazil, Schwartzman (1986) recommends that efforts would be better spent in consolidating and improving university research despite its limitations than in setting up specialized research institutes or state enterprises less conducive to intellectual initiative, imagination, and discipline.

However, despite the many challenges and frustrations of the last 10 years, there has been an attempt to create isolated and protected niches for basic research within and outside the university. This trend has become more pronounced with the recent changes in society's perception of private institutions engaged in higher education and research. Nonetheless, it has been difficult for institutions to remain isolated and protected. As systems of higher education became more differentiated, scientists working in isolation became more obvious targets of attack. The rapid growth of scientific institutions outside academia has produced many research institutions that could not survive in a demanding scientific climate.

Part of the increasing pressure on the scientific establishment has come from a lack of resources to support growth. In Brazil and Mexico for example, the number of scientific groups and institutions multiplied rapidly while funds were available, but the economic crisis of the

mid-1970s brought this expansion to a sudden stop. Other countries suffered a similar fate. Increasing demand and diminishing resources intensified the competition for funds both inside scientific institutions and between science and other sectors. At the same time, the end of many authoritarian regimes helped to improve the political climate. With conditions once again beginning to favour political participation, contradictory pressures were exerted on universities. Given that researchers hold little power within the university structure and budget decisions tend to be influenced by short-term political considerations, the distribution of resources was generally not favourable to them.

The community of scientific researchers faces a difficult dilemma. One the one hand, scientists seek greater freedom to research and less interference from bureaucrats, university officials, and planning authorities. On the other, their survival as a group depends on increasing their visibility and presence within national decision-making bodies. Strangely, and despite claims to the contrary, most scientists have supported a national system for scientific planning, even at the cost of greater bureaucracy, reduced priority given to basic research, and their exclusion from the decision-making process. They may anticipate being asked to head up the planning agencies and believe there is something inherently good in centralized planning and coordination.

The Basic Sciences Today

The relevance of science was increasingly questioned in the face of Latin America's serious problems during the 1980s. Government cutbacks in financial support for science seriously affected graduate and undergraduate education. To counter the serious risk of a massive brain drain, many countries took steps to improve the situation.

In 1984, the Mexican government created an elite program in science and technology called the National Researchers System (SNI). Its three main objectives were to preserve the nucleus of the national stock of researchers, to upgrade their skills and productivity, and to promote participation and self-evaluation in the scientific community. A key decision was made to limit participation in SNI to highly productive

researchers whose work was deemed to be top quality by a peer-review process (Malo and Garza 1987; Malo 1988). The program provides a salary supplement for each category of researcher within the system. The number of researchers in the system grew from 1 395 in 1984 to 3 495 in 1987, at which point the numbers began to level off.

In 1990, Venezuela introduced the Researcher Promotion Program, an official scheme to support scientific research along the lines of the Mexican system. When the first invitations were issued, 744 researchers were accepted into the program. A further 193 were admitted in 1991, bringing total active members up to 937 (González 1991). Up to now, the program has offered a salary supplement that is enough to compensate for low salaries but not enough to pay for research equipment or inputs. The goal of a joint project of the Inter-American Development Bank (IDB) and the Consejo Nacional de Investigaciones Cientificas y Tecnologicas (CONICIT) in Venezuela is to develop strategic areas in new technologies. It is expected to revive research, development, and higher education in Venezuela.

In Argentina, the basic sciences are part of an old scientific tradition. Although they have achieved substantial development in institutional terms, they are currently showing signs of stagnation and imbalance, and there is a marked weakness in human resources in the areas of technology and engineering. In Brazil, certain basic research institutions have stayed independent of potential technological demand. Physics, for example, has launched important projects, such as the Sincroton Light Laboratory in Campinas. By contrast, areas more closely related to technology, such as biotechnology or microelectronics, have found that their projects have not afforded them a solid identity. According to Botelho (1990), scientific development in the 1990s is flexible, decentralized, and asymmetrical between regions and disciplines. Universities have difficulty in becoming the privileged partners of other institutions. Under the Science and Technology Secretariat, government research institutes will have more international contact. Technological development will become more scientific, and associated specialist enterprises will be responsible for technological development.

Almost all small and medium-sized countries are experiencing an

alarming reduction in the number of graduates in the basic sciences. This is all the more worrying given that many new universities do not even offer courses in the basic sciences. Costa Rica is a case in point, with respect to mathematics (Garcia Bondía 1987). The relatively high numbers of graduates registered in the 1970s can be attributed to the expansion of the educational system at a time when great confidence was placed in investing in human capital. This climate of optimism gave way to the disappointment and short-term thinking of the 1980s. Currently, a pragmatic approach seems to prevail with a corresponding emphasis on programs that can be easily applied and profitable.

Although it is clear that more research is being conducted in Latin America today than 50 years ago, science has still not been fully institutionalized; it continues to be held back by an unfavourable climate. Most students express a clear preference for professional careers other than science and technology. In 1970, only 5% of university graduates came from schools of pure and natural sciences, 14% came from engineering schools, 17% came from medical sciences, and 4% came from agricultural sciences. By 1978, these proportions had not changed appreciably (Sagasti and Cook 1983). In fact, the number of students graduating with a degree in the basic sciences had fallen, and this diminished level of interest persists today. The difficulties in encouraging scientific vocations are reflected in Table 1. This situation is worsened by poor conditions for bringing professional scientists into national research and development systems. Therefore, science graduates with an aptitude for research tend to emigrate in search of better career opportunities.

In conclusion, a radical change in the perception of the value of scientific research has taken place recently within scientific communities. Although this change is just beginning in many places, it appears strong enough to herald major changes in the organizational patterns of institutions in the years to come.

An Agenda for Future Studies

Much effort has been expended on building a scientific infrastructure in Latin America over the few last decades. At the same time, attempts to transform universities and to create protected niches for high-quality

Table 1. Undergraduate students (%) by sector in 1980 and 1984.

Country	Year	Natural sciences	Mathematics and informatics
Argentina	1980	3.8	4.1
	1984	5.7	5.7
Bolivia	1980	1.3	0.9
	1984	0.9	2.0
Brazil	1980	3.6	0.9
	1984	8.2	2.6
Colombia	1980	2.1	—
	1984	1.5	—
Costa Rica	1980	3.8	4.0
	1984	2.8	4.5
Cuba	1980	2.5	0.9
	1984	1.3	0.7
Chile	1980	6.2	6.0
	1984	0.5	4.2
Ecuador	1980	2.3	1.7
	1984	3.1	1.8
El Salvador	1980	0.2	—
	1984	1.9	0.4
Mexico	1980	2.3	0.8
	1984	2.3	1.2
Nicaragua	1980	3.5	2.1
	1984	3.7	0.5
Panama	1980	7.2	0.9
	1984	2.5	2.1
Peru	1980	2.7	1.3
	1984	3.2	1.9
Uruguay	1980	0.9	1.3
	1984	3.1	3.9
Venezuela	1980	1.9	2.0
	1984	1.8	3.1

Source: Vessuri (1991).

research have met with mixed success. The purpose of this brief outline is to pose questions rather than answer them. The methodological approach adopted here — that is, looking at the role of basic science research along with other essential institutional activities and comparing the unique combination of activities found in specific institutions — was used to paint a richer and more accurate picture of institutional development in the basic sciences in Latin America.

Scientific institutions in Latin America are quite heterogeneous. Some are devoted to undergraduate education, others to graduate level education, and yet others exclusively to research. Institutional contexts and connections also differ widely: some organizations are government centres, some are university units, and some are private foundations. Still others take the form of corporate divisions or interest groups. Another difference to be considered is the source of external research funding. Institutions can be supported by national governments, philanthropic foundations, private corporations, and international agencies.

This diversity occurs because institutions have different situations, histories, and future aspirations. In particular, the interaction within subsystems will be shaped by the institution's mission along the basic sciences continuum (whether it deals with pure or applied sciences) and within the scientific and technological process. The subset of institutions analyzed here — some of the most important institutions of the basic sciences — may have comparatively similar views of graduate education and research, but differ considerably in other respects. This leads to a wide variety of institutional structures.

The institutionalization of a scientific discipline requires both cognitive identity and professional identity. In Latin America, the universities provide the context for professional identity. The existence of opportunities and rewards linked to a career gave real meaning to the ability to perform intellectual work within a discipline. Prizes, research subsidies, specially equipped units, prestigious appointments, and honorary titles have all been accepted as expressions of professional identity within a field of knowledge. As this system developed, scientific enterprise penetrated to deeper levels, changing the image of the discipline and its social and cultural function. Therefore, although it is analytically

useful to distinguish between the development of cognitive and professional identities, the two are inexplicably linked in the day-to-day work of any area of knowledge that has been fully institutionalized.

The achievement of identity is not inevitable; it is the product of personal struggles and historical accident. The building of a discipline, especially in the early stages, is frequently the outcome of heroic personal effort by one individual or by a small group. Therefore, a discipline's local cognitive identity is profoundly influenced by the personal vision of its pioneers. Through a subtle process, the tools, approaches, and problems that characterize a field in the process of local institutionalization, are shaped by the moral purposes, metaphysical assumptions, and world views held by the pioneers. Therefore, a discipline's central problems and conceptual and analytical techniques are molded by the individual or small group who built it. The growth and ultimate significance of a discipline depends on the clarity of vision that defined the original intellectual agenda.

If these leading personalities, or pioneers, also succeed in creating jobs for their disciples, they have even greater influence on the professional and cognitive identity of the new discipline. A professional identity is not guaranteed by the formation of a scientific society or public propaganda, however needed they may be. It is also necessary to recruit followers and students and to create satisfactory career structures. These requirements depend on structural changes in society as a whole and cannot be invented or improvised by social engineering.

There has been more continuity in the process of institution building in Latin America than advocates of modernization are willing to admit. Given how hard it was to find teaching staff at the beginning, many scientific institutions resorted to hiring European immigrants, mostly from Spain and Italy. Although they were not capable of doing research, some still made an invaluable contribution to the transition toward modern scientific education. At the same time, fellowship programs were developed to train younger graduate students. The ideal of internationally accredited doctoral programs spread rapidly in the postwar period, especially in the new schools of science. The leadership of Latin

American scientists in managing new and complex institutions remains to be seen.

The conditions of teaching staff contracts posed another problem. Two of the most important achievements of scientific research in the university included full-time employment for research staff and the introduction of the promotion thesis as a means of advancement in a university career. However, as these achievements of the researchers became generalized for all teaching staff, they became a collective trend for a new and rapidly growing group, that of the university professor, and did not necessarily respond to the real needs of research.

In practice, there is a definite lack of congruence between the purpose of research — the generation and dissemination of knowledge — and the structure of teaching. Although many may disagree, the two activities have developed without reference to each other, and each obstructs the other both legally and structurally. Following Humboldt's idea of reciprocal enrichment between teaching and research, the modernization program has served as an extraordinary stimulus to scientific advancement in academia for 150 years. However, not all university lecturers today are researchers, nor does all teaching activity involve research. Not all basic research is conducted with a view to publishing the results. Furthermore, undergraduate programs that are not updated quickly enough pose an obstacle to the incorporation of new knowledge generated by the international environment.

However, university research units such as institutes and centres tend not to be involved in undergraduate teaching, which is normally the responsibility of departments, lecturers, and teaching units. Given the critical situation of basic science research, however, it would seem advantageous for research centres to focus their efforts on developing graduate courses and further enhancing their capacity to train doctoral candidates and other teachers or researchers.

We can see from the discussion that the institutionalization of science is not an easy task. It relies on a favourable cultural and intellectual climate. It also requires a material infrastructure as well as a system comprised of journals, evaluation committees, and scholarly societies that helps to maintain the standards of scientific specialties. Basic scien-

tists can become alienated from societies that question the social relevance of their discipline. When scientists have their discipline as their point of reference, they can see that research efforts in their countries are scattered among a few underfunded and underequipped centres or laboratories that produce only second-rate research, whether in the universities or in government institutions. As a result, researchers may shut themselves away in the bunker of their institution, which is alien to the local context, and depend for their survival on distant intellectual centres.

Latin American scientists work on the same subjects as the best university researchers in industrialized countries, but under far more challenging social and economic conditions. The region's dominant ideology holds that basic sciences are superior to the applied sciences and are thus more prestigious and attractive. It is not surprising that the small centres devoted to the basic sciences are surrounded by an aura of mystery and elitism. But institutions are often only a superficial reflection of the models they copy. In reality, researchers in Latin America frequently lack social, economic, or intellectual protection; they also lack libraries and research equipment as well as strict standards and norms. The overall lack of favourable conditions has led to a massive exodus of scientific talent over several decades and low productivity among many remaining scientists.

Scientific institutions also provide the breeding ground for the region's scientific development. Therefore, if we are to define an agenda, we must go beyond particular institutional characteristics to explore the relationship between scientific institutions and overall research and development policy. The sweeping changes now occurring in productive structures and in the international economy will have a direct and indirect impact on the region's scientific institutions.

The challenges are many. In the first place there is a need to rethink the relationship between pure and applied research, a task ignored by most traditional scientific institutions. Scientific institutions in Latin America must develop close links with the productive sector to attain legitimacy. However, the institutional environment tends to perpetuate conduct that does not meet new needs. For example, publishing in

scientific journals is still considered critical to the advancement of scientific careers, while industrialized countries are reducing the number of journals significantly because of new restrictions on the dissemination of ideas.

In areas where research is more developed, publishing is no longer seen as necessary for the legitimation of research results. However, in Latin America, which lacks definitive standards of quality, publication in professional journals is still considered critical to scientific careers. As new opportunities arise for strategic segments where quality exists, Latin American scientists will be able to interact with partners in government and in industry, in technical and economic coalitions, in which the new scientific knowledge will be of crucial importance.

One issue requiring further study is the underestimation of the costs attributed to research and consultancy services provided by scientists and scientific institutions. Another is the management of interface mechanisms between a research centre and its industrial clients. Even if we uncritically accept the current system of research, technology, economics, and management, industry's lack of independence and the weakness of many scientific institutions makes close collaboration between the two sectors an unlikely solution for current production difficulties in Latin America.

It is imperative to identify forms of collaboration that respond to Latin American realities in both the productive and academic sectors. The current inability to mobilize funds and promote their rational and efficient use threatens the survival of the existing research and development system. To face the new challenges, scientific institutions must have a high degree of autonomy in setting goals and in determining how to attain them. In particular, they must develop research strategies based on a continuing analysis of scientific, technological, and industrial trends. Institutions can no longer function if they do not monitor developments in other sectors. They must explore and, if possible, anticipate the intellectual market in search of research and development niches that they can actively turn to their advantage. This in turn requires the maintenance of academic excellence. National centres of excellence play catalytic roles. In Hobday's (1985) study of the Brazilian telecommuni-

cations industry, for example, the research and development department of TELEBRAS seems to have played exactly that role.

As we have seen, basic research in the region is confined to a limited group of universities and public research institutions. In some countries only one or two universities have any kind of research infrastructure. Even in countries such as Argentina, Brazil, and Mexico that have scientific communities, only a few institutions are influential in scientific and technical production. However, the fact that the research and development effort is concentrated in this way makes it easier to mount an aggressive program.

In any case, studies are needed to identify the type of units that, under similar academic conditions, show greater potential for developing their own strategies and those of the society in which they work. It is neither possible nor desirable that all research and development functions be conducted by scientific research institutions, but critical combinations of functions must occur in at least some of them. This will ensure diversification and integration, characteristics needed to maintain adaptability and dynamism.

A review of earlier analyses and their recommendations highlights several positive elements that should be strengthened. For example, progress has been made in the formation of some disciplinary networks. The Latin American Network for Biological Sciences (RELAB), which began in 1975 as a graduate project of the United Nations Development Programme (UNDP), is a good example. Its organizational structure has evolved. Today, it is highly representative of the biological sciences in the region. Other programs, such as the Latin American Centre for Physics, support the strengthening of regional programs for graduate instruction and research in various basic disciplines.

Permanent cooperation between groups from different countries engaged in similar research is taking root with the support of bilateral and multilateral agreements between national science and technology councils and the Spanish program for the 500th Anniversary of the Discovery of the Americas. However, these actions need to be sustained and expanded to have significant impact.

The fragile scientific communities formed in many Latin American

countries in recent years may prove unable to redefine their roles and may fall victim both to diminishing resources and growing pressure for immediate achievements. But a renewed appreciation of the value of research may provide breathing room, at least in some areas and for some countries.

No country in Latin America will be able to face the technological challenges of the future alone. The objectives of scientific development in the region must be reconsidered in light of the last 40 years of progress, new international challenges, changing societal demands, persistent heterogeneity in production, and severe funding shortages. Institutions will need to take on specific functions to bring about the changes required. It is therefore necessary to discuss the university's mission in relation to the basic sciences and the research and development system and find ways to transform it into an efficient instrument for the production of useful talent and knowledge.

CHAPTER 4

INSTITUTIONAL FAILURE OR SUCCESS: VARIABLES AFFECTING AGRICULTURAL RESEARCH

Jorge Ardila

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The need for agricultural technology usually originates in the intermediate stages of a country's development and normally results from a policy decision. Initially, the research infrastructure tends to be a virtual state monopoly. As countries progress, the private sector begins to generate important research that complements state-supported work. This research is usually done in anticipation of economic gain and tends to be concentrated in industries that produce raw materials such as hybrid seeds, fertilizers, pesticides, agricultural machinery, and processing technologies. In later stages of development, the strategic importance of technology to development starts to be recognized, and public policy becomes more coherent.

Agricultural Research in Latin America

The development of agricultural research in Latin America can be divided into three stages. In the first stage, from 1940 to 1949, agricultural research was organized as a public service. Motivated by agricultural developments in Europe, some Latin American governments (notably Colombia and Uruguay) made formal requests to Austria, Belgium, England, France, and Germany for assistance in laying the groundwork for agricultural research.

This first stage of cooperation featured attempts to import and adapt

foreign species. Although some experimentation was done, especially with fertilizers and pesticides, most countries did not have the capacity to innovate. During this period, political decision-makers demonstrated great interest in research as a way to boost agricultural production, but private research remained minimal. At the international level, the organized research system we know today did not exist.

The second stage of development, from 1950 to 1970, was characterized by external support for state research at the national level. In June 1949, inspired by the success of the Marshall Plan for European reconstruction after World War II, the United States established the Point IV program to transfer technology and expertise in an effort to alleviate the food production crisis in many developing countries (Carter and Harold 1985). American universities belonging to the land-grant system provided agricultural extension services and in-house training. During the 1960s, 3 026 Latin American professionals were granted doctorates in agrarian sciences from universities in the United States, enabling most Latin American countries to consolidate the state research structures they have today.

Table 1 shows the importance of this program of technical cooperation and graduate training for Argentina, Peru, and Colombia. A total of 498 researchers were trained at the master's and doctoral levels, at an approximate cost of 34 million United States dollars (USD).

Table 1. Number of graduate-level (MSc and PhD) researchers from 1960 to 1978 in the National Institute of Farming Technology (INTA), the Colombian Agricultural and Livestock Institute (ICA), and the Universidad Agraria La Molina (UAM).

	Personnel trained			Cost (million USD)		
Institution and country	MSc	PhD	Total	Country	USA	Total
INTA, Argentina	84	27	111	3.7	3.6	7.3
ICA, Colombia	175	93	268	11.6	7.1	18.7
UAM, Peru	89	30	119	—	—	—
Total	348	150	498	15.3	10.7	26.0

Note: If costs for Peru averaged the same as for Colombia, the total investment would have been 8.2 million United States dollars (USD), of which the Peruvian government contributed 6.3%. Note that contributions vary greatly from one country to another.

Source: Ardila et al. (1980).

During this golden age of the system, research made a major contribution to the region's economic and agricultural development. Research institutions flourished and enjoyed strong government support. Investment in research yielded positive returns, with high rates of social profitability, as measured by the economic surplus generated, and its distribution among customers and producers. Regional investment in agricultural research rose 9.5% in constant terms during the 1960s, compared with a world average of 9.1% (Boyce and Evenson 1975).

During this phase, the private sector made some interesting ventures into the field of research. The establishment of the Centre for Coffee Research (CENICAFE) by Colombia's coffee-growers in 1938 is one example (Samper Genecco 1992). However, large-scale efforts in the private sector were rare, probably because public-sector research programs satisfied the needs of the productive sector. Also in many countries, the agricultural sector was simply not large enough to support long-term research.

The third stage, from 1970 to 1990, witnessed the decline of the state model and a crisis in agricultural research brought about by institutional, economic, social, and political changes, both domestically and internationally. There was an urgent need to transform the research model to meet new demands, to face a new economic order, and to adjust to the reduced level of resources available.

A system of international research centres emerged during the late 1960s. It grew out of the experiences of England and France with tropical crops in their colonies as well as those of the Rockefeller Foundation in Mexico in the 1950s and 1960s. The system was composed of bilateral and multilateral assistance agencies and private foundations in developed countries, under the umbrella of the Consultative Group for International Agricultural Research (CGIAR) and its Technical Assistance Committee (Samper Genecco 1992).

This new research system was part of a strategy to channel international cooperation more efficiently. Efforts at institution-building had failed in many countries, and early successes were losing their effectiveness. Although the international centres were intended to complement the national systems, they were initially seen as competitors or replace-

ments. This led to a reduction in resources for important national research programs.

At the same time, the private sector, represented by interest groups, associations, and federations of producers, became more actively engaged in research. It did so partly to compensate for the weakened state of public institutions and partly to meet the demand for new technologies in which the public sector had no direct interest because they were felt to be designed primarily for private benefit.

These two main groupings — the international centres and the private sector — although contributing to the enrichment of research, also served to lessen and even displace state involvement in the production of technology. This effectively reduced the state's potential to socialize the benefits of technological change in the interests of greater equity.

Furthermore, the international agencies and the private sector offered more professional opportunities for researchers trained by the public sector, normally at much higher salaries than those paid by the state. Consequently, researchers left the public sector in droves. In addition, much of the international technical cooperation of the 1960s relied on resident American researchers. The end of this practice further complicated the staffing of state research institutes and threatened a specialist shortage.

The threat was temporarily averted by the establishment of graduate programs in agriculture in countries such as Argentina, Brazil, Chile, Colombia, and Mexico. When these programs were subsequently dropped, specialists were sent abroad to be trained once again. This time fewer funds were available, and most of the training opportunities under previous technical cooperation agreements had disappeared. The new programs arranged with foreign governments or with foreign loans never matched the former level of training activity. In some countries, the new graduate programs in public research institutes barely managed to replace the specialists who had left for other organizations.

This led to a drastic reduction in graduate specialists working in most public institutions. Brazil was the exception because it had never stopped training specialists through the Brazilian Agricultural Research Organization (EMBRAPA). Other consequences included a slowdown in

the production of innovations and increased training costs, which exerted even greater pressure on already tight budgets. With the lowering of public-sector salaries, research institutes were forced to replace outgoing researchers with nonspecialist staff, which reduced their chances of producing high-quality innovations and further contributed to their loss of social recognition.

In addition to this human resource crisis in the public sector, budgets were drastically cut by government in an effort to reduce fiscal deficits. For example, in Colombia in 1990, research staff of the Colombian Agricultural and Livestock Institute (ICA) received only half the amount for equipment and materials that they had received in 1970. If, in 1970, operating costs comprised 30% of expenses, in real terms, then a 15% budget reduction amounted to a 50% reduction in operating capacity (ICA 1990).

The state research infrastructure is suffering seriously from underinvestment. As a result, the national expenditure needed to restore the system to its former level of functioning is likely to be substantially less than the economic benefit lost because of the lack of technological change in agriculture.

In addition to these institutional factors, several economic considerations deserve mention. The energy crisis of the 1970s raised the cost of producing goods that required imported inputs derived from oil and rendered much technology obsolete. The national research institutes (NRIs) in Latin America continued to develop technological systems based on modern inputs and to produce costly capital-intensive technology to improve physical yields.

These economic variables accompanied major changes in worldwide patterns of consumption. Increased urbanization and personal incomes generated a demand for new and improved products and for research to develop them. The demand for research was further intensified by the liberalization of Latin American economies and the need to boost the international competitiveness of local production. Economic liberalization put pressure on the NRIs to expand their range of research subjects and regions; it also focused research on raising the export-earning

potential of products. This expansion has further reduced the operating capacity of the national institutes.

Fundamental quantitative and qualitative changes are currently taking place in the demand for agricultural technology. The new trend has serious implications for the entire research system, affecting the topics selected for study, as well as the equipment and specialists required. The research system faces the new demand that agricultural development be sustainable over the long term. Bottlenecks created by earlier research and the occupation of new land must be removed. Problems such as soil erosion, compaction, and salinity as well as the pressing need to replace pesticides rendered ineffective by resistance must be solved. Because the private sector has no direct interest in financing this basic research, it must be supported by weakened public institutions.

Latin America is currently engaged in the political process of decentralization and democratization designed to achieve greater efficiency in the use of public resources and a more equitable distribution of services. This will require moving resources from research to support technical assistance and technology transfer at the farm level.

Although renewed private-sector interest has resulted in some notable successes, it is still the public-sector NRIs that have made the most significant contribution to agricultural research. Their deterioration may result in slower economic growth and a restricted contribution to increased agricultural productivity. The scarcity of research resources, the decline in quality, and the new demand for technology have combined to reduce technology's contribution to regional growth in the last 10 years, and threaten to lead to technological stagnation.

These factors have had a negative impact on the region's capacity to produce needed technological change in the field of agriculture. With the institutional model in decline, Latin America has an additional disadvantage in that recent progress in biotechnology and genetic engineering may be widening the technology gap between the region and the industrialized countries.

Characteristics of Agricultural Research Institutes in Latin America

This section offers a preliminary review of the diversity of institutions in agricultural research in Latin America, with some comments on their interaction from three points of view: the economic nature of technology; the level of participation of technology in stages and processes of agricultural research; and the level of coverage of the organization's objectives and user satisfaction.

Institutions have many kinds of relationships with each other. Sometimes the decline of one institution is accompanied by the rise of another (substitution), and sometimes the success of one depends on the success of the other (complementarity). Institutions may also compete with each other for resources, or over research products.

Institutional transformation in agricultural research may be attributed to such factors as the benefits to users; political changes, normally associated with an attempt to improve bureaucratic efficiency; and major changes in the availability and price of resources required for production (Ruttan 1982). Several economic and political reasons explain the creation, development, and transformation of research institutions, always making the distinction between institutional variance (reasons for creation, transformation, or disappearance) and institutional failure or success.

Economic nature of technology

Both the state and the private sector have an interest in obtaining part of the economic surplus generated by technology. The goal of the state is to make technology more widely available to its citizens, and the goal of the private sector is to use technology for profit-making production.

Technology may be in the public domain or it may be associated with the appropriation of economic benefit. Examples of the former include varieties of plants developed to ensure successive identical generations, usually by propagation, as in potatoes and sugarcane. Examples of the latter include hybrid seeds that cannot be used to grow successive generations because of falling yields, forcing the grower to buy from the

hybrid breeder who retains the genes for crossing. Here, it is obviously in the private sector's interest to promote hybrids and in the state's interest to promote varieties. Some biological techniques, such as improved varieties resistant to pests or diseases, substitute for the use of chemical inputs. Here, the state has a central interest in research; private industry, in production.

The introduction of biotechnology and genetic engineering has enabled major chemical manufacturers to control the producers of improved varieties and hybrids and to create seeds that respond only to certain inputs, which they produce. This forces the buyers of hybrids to also buy the inputs. As a result, the seed producers of Latin America are in danger of losing their market.

Technology is also built into equipment, processes, and raw materials that are sold at prices set to recoup research costs and generate profits. Private enterprise is particularly interested in this type of technology, and it is often the only sector capable of making the large financial investment required. The four main models of research institutions are described here.

Institutions that liberate technology — Public-sector agricultural research institutes, regional research centres, and international institutes are typical of this organizational model in Latin America (Tables 2, 3, and 4). These institutions are complementary, although most NRIs do

Table 2. National agricultural research institutes in Latin America.

Country	Institute	Year created
Argentina	National Institute of Farming Technology (INTA)	1957
Ecuador	National Institute of Agricultural Research (INIAP)	1959
Mexico	National Institute of Agricultural Research (INIA)	1960
Venezuela	Fondo Nacional de Investigaciones Agropecuarias (FONAIAP)	1961
Colombia	Colombian Agricultural and Livestock Institute (ICA)	1963
Peru	Servicio de Extensión y Promoción Agraria (SIPA)	1963
Chile	National Institute of Agricultural Research (INIA)	1964
Brazil	Brazilian Agricultural Research Organization (EMBRAPA)	1973

Source: Piñeiro and Trigo (1983).

Table 3. The international agricultural research centers.

Year created	Name	Location	Programs
	The Consultative Group for International Agricultural Research (CGIAR)		
1960	International Rice Research Institute (IRRI)	Los Baños, Philippines	Rice and rice-based systems
1966	International Centre for Maize and Wheat Improvement (CIMMYT)	Mexico, Mexico	Maize, wheat, barley, triticale
1967	International Center for Tropical Agriculture (CIAT)	Cali, Colombia	Beans, rice, yucca, tropical grasses
1967	International Institute of Tropical Agriculture (IITA)	Ibadan, Nigeria	Maize, rice, yam, yucca farming systems, potato, soya, caupi, lima bean
1970	International Potato Center (CIP)	Lima, Peru	Potatoes
1970	West Africa Rice Development Association (WARDA)	Bouaké, Côte d'Ivoire	Rice
1972	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	Hyderabad, India	Bean, pigeonpea, soya, millo, groundnuts, production systems
1973	International Laboratory for Research on Animal Diseases (ILRAD)	Nairobi, Kenya	Trypanosomiasis, theilerosis
1974	International Board for Plant Genetic Resources (IBPGR)	Rome, Italy	Genetic resources
1974	International Livestock Centre for Africa (ILCA)	Addis Ababa, Ethiopia	Animal production systems
1975	International Center for Agricultural Research in the Dry Areas (ICARDA)	Aleppo, Syria	Farming systems, wheat, barley, lentils, beans, triticale, forage
1975	International Food Policy Research Institute (IFPRI)	Washington, DC, USA	Food policy
1977	International Center for Living Aquatic Resources Management (ICLARM)	Manila, Philippines	Fish, aquatic organisims
1977	International Centre for Research on Agroforestry (ICRAF)	Nairobi, Kenya	Agroforestry
1980	International Service for National Agricultural Research (ISNAR)	The Hague, Netherlands	National agricultural research systems

(continued)

Table 3 concluded.

Year created	Name	Location	Programs
1984	International Irrigation Management Institute (IIMI)	Colombo, Sri Lanka	Irrigation management
1984	International Network for the Improvement of Banana and Plantain (INIBAP)	Montpellier, France	Improvement of banana and plantain
1992	Center for International Forest Research (CIFOR)	Bogor, Indonesia	Tropical forests
	Non-CGIAR Centres		
1970	International Centre of Insect Physiology and Ecology (ICIPE)	Nairobi, Kenya	Physiology and ecology of insects
1972	Asian Vegetable Research and Development Center (AVRDC)	Taipei, Taiwan	Tropical vegetables
1974	International Fertilizer Development Center (IFDC)	Muscle Shoals, AL, USA	Fertilizers
1983	International Board for Soil Research and Management (IBSRAM)	Bangkok, Thailand	Soil science

Source: AUCC and IDRC (1992).

Table 4. Regional research centres with links in Latin America.

Name	Location	Programs
Caribbean Agricultural Research and Development Institute (CARDI)	St Augustine, Trinidad	1. Production of vegetation 2. Animal production 3. Technology adaptation and transfer
Tropical Agricultural Research and Training Centre (CATIE)	Turrialba, Costa Rica	1. Improvement of tropical crops 2. Sustained agricultural production 3. Integrated management of natural resources 4. Graduate program

Source: CATIE (1990).

not possess the infrastructure needed to reproduce the products of the international research system.

In terms of investment, it is estimated that the system of international centres spends approximately two and a half times more than national institutes. The investment of the CGIAR-affiliated centres is

estimated to be about 200 million USD plus a similar amount for the other institutions listed in Table 3. Latin American NRIs probably spend another 200 million USD between them. The economic surplus generated for the region runs into billions, which explains the interest in agricultural research.

International centres help countries keep up with developments in basic food production, a task that is especially critical in light of the current technological revolution in biotechnology and genetic engineering.

Institutions that appropriate technology — These models are generated by local or international private industry or agroindustry and are frequently linked to the research and marketing efforts of large transnational corporations. These companies are likely to be involved in breeding improved seeds and manufacturing fungicides, pesticides, fertilizers, other forms of soil treatment, or animal feed and concentrates (Pray and Echeverría 1989).

Included here are firms that manufacture and distribute machinery and implements, companies that produce the active ingredients and raw materials later assembled in satellite countries, as well as firms that provide support services (such as software for agricultural applications) and technical assistance for the pseudotransfer of process technology. (Pseudotransfer of technology occurs when research is conducted abroad, but development and promotion are carried out at home. This happens when inputs and machinery are imported and assembled with their technology built in and then sold locally. In vitro growing techniques for certain species are an example.)

Some NRIs work on technology that can be appropriated by the private sector. This includes farm machinery and irrigation systems, plants for research, and inputs such as nitrogen-fixing bacteria. Recently, NRIs and agroindustrial interests in Latin America have undertaken joint ventures to produce and market certain types of improved genetic material, machinery, and implements. The government contributes to the development of the technology and shares the profits with the private-sector partner.

Institutional models of restricted release — Here, technology is either copied, created, or adapted and then used by the group funding the research. Private institutes dedicated to applied research financed by producer associations are typical of this model. Examples include the Executive Commission of the Plan for the Economic Recuperation of Cacao (CEPLAC) in Brazil and the Centre for Coffee Research (CENICAFE) in Colombia.

In another version of this model, firms engaged in the processing of farm products support research to improve their raw materials. In Colombia, CENICAÑA, the Research Centre for Sugarcane, is an institute for research on sugarcane, and other countries have similar institutes funded by the manufacturers of cigarettes, chocolates, beer, and wine (Pray and Echeverría 1989). National and international consultants such as Chemonics and Winrock International, which release their knowledge to a restricted public and make cross-border transfers of technology, also fit this model.

Institutions liberating technologies between countries — These integrative institutions promote the dissemination of knowledge through the exchange of research as well as germplasm and other materials. Work often goes on concurrently and in a coordinated fashion in a number of countries (for more information, see Trigo 1988; IICA 1990; Plucknett et al. 1990). This category includes the following research networks (Ardila 1990):

International system networks, performing work that originates in the international research centres and is coordinated at the national level by an NRI;

- Cooperation networks among countries, such as the Central American Cooperation Program for Crop Improvement;
- Networks related with specific work under development by regional centres such as the Tropical Agricultural Research and Training Centre (CATIE) in Turrialba, Costa Rica, the Caribbean Agricultural Research and Development Institute (CARDI), in St Augustine, Trinidad and Tobago, or the Agricultural Research Foundation of Honduras (FHIA);

- Cooperation programs involving two or more countries, such as the Inter-American Institute for Cooperation on Agriculture (IICA), also linked to the work of international centres. Examples are the programs for the Southern Cone (PROCISUR) and for the Andean Region (PROCIANDINO).

The development and transfer of technology

This section describes institutions composed of small groups working separately to contribute to the development and transfer of technology. The process includes the following stages (Ardila 1987, 1989):

- Acquiring and copying technology that requires no adaptation;
- Developing basic research to expand knowledge and production opportunities;
- Adapting, validating, and adjusting technology for specific applications;
- Developing technology to make it commercially available to a large market;
- Promoting technology; and
- Maintaining technology already on the market.

Argentina, Brazil, and Mexico are the only Latin American countries to participate in all these stages. They are the only ones to distinguish between different research functions and to set up specialized scientific units with substantial budgets and first-rate staff and equipment. In contrast, the international centres focus almost entirely on basic research in defined areas. They do little applied work and international promotion, and their work requires completion by the countries to which it is delivered.

Most research institutions in Latin America are not actively involved in the first two stages (copying and developing technology). They tend to be engaged more in adapting, validating, and promoting technology as well as in protecting national inventions by restricting the import of new technologies. They may also take on ambitious projects to extend, transfer, and promote technology.

There is a serious lack of coordination in the region between research

(adaptation, validation, and applied research) and efforts connected with the extension, promotion, and massive development of technology. Frequently, innovations go no farther than interesting research results. Although both research and development functions can be carried out successfully by one organization, they can also be divided between different bodies (as with EMBRAPA and EMBRATER, the Brazilian Technical Assistance and Rural Extension Corporation). These functions can take place under one roof and one management authority (as with the National Institute of Farming Technology (INTA) in Argentina) or under one roof and two management authorities (as with ICA in Colombia). In general, the more the functions are separated, the more difficult it is to make a positive impact on development because of the additional coordination required.

Institutional objectives and users

An institution is characterized by clearly defined objectives that can be associated with identifiable groups of users. In agricultural research, the users are farmers and the objective is technological development. Some institutions, however, have more than one objective and more than one kind of user. This multiplicity can lead to an overload of functions and complex operational structures that reduce effectiveness. The NRIs in Colombia, Mexico, and Peru are examples of this; in addition to research, they perform control and supervision functions, provide technical assistance, and run sanitation campaigns.

Institutional users can be broken down by region, product group, type of research problem, and type of user. Some institutions are designed to serve the research needs of a specific region. For example, IAP (the Research Institute on Peruvian Amazon) serves the Peruvian Amazon and COA (Araracuara Corporation) covers the Colombian Amazon. Institutions also differ widely with respect to the type of products and problems they deal with. The NRIs tend to work on a wide variety of products, regions, and problems; other institutions restrict themselves to a single product and a few research problems. The work of the International Laboratory for Research on Animal Diseases (ILRAD) in Kenya on trypanosomiasis and theilerosis in animals is an example of the

latter. In general, an institution's chance of success is increased when its objectives and coverage are well defined and somewhat limited.

In addition to those mentioned so far, other organizational models also support the system's viability. The most important is the foundation model promoted by USAID (Sarles 1988). Foundations allow producers to exercise real influence in directing resources and activities to meet the sector's needs. This model ensures the creation of bonds and articulations in research because boards of directors include representatives of different research institutions. This promotes collaboration among them and strengthens their research, promotional, and educational activities.

Foundations have a more flexible and less bureaucratic management structure, and they are not as influenced by politics. Their role is not to undertake research, but to support institutions that do. In recent years, USAID has supported foundations in the Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, and Peru. Initial evaluations of the foundation model point to difficulties in ensuring stable, long-term domestic funding, a factor that may jeopardize its future.

An Agenda for the Future

We now have improved methodologies for evaluating the contribution of research results to economic growth. They have been refined to take equity into account — the distribution of benefits to different social sectors. Methodologies have been developed to evaluate impact at the product and regional level, and the work of Robert M. Solow has provided methodologies for evaluating research from the aggregate economic point of view (Romano 1987). Less work has been done on methodologies to evaluate equity, although the subject is now receiving closer attention. These three levels of methodological development are illustrated in the work of Solow (1957), Griliches (1958), and Schmitz and Seckler (1970).

The decline of the institutional research model has been advanced as a key reason for the failure of technological management to contribute to economic growth. Therefore, it is useful to identify the variables linked to institutional success. Institutional success occurs within a framework

of efficiency — technologies that help to attain global objectives — and effectiveness — the achievement of results through good management of the organization and its resources.

This section outlines factors that may help to explain the success of agricultural research institutions. The variables thought to influence success are: the way in which the institution complements other institutions, the type of technology it produces, and its internal organization (Table 5). Each is analyzed in detail.

Although the international centres have focused on basic technology, the NRIs have concentrated on applied technologies for public use, and the private sector has concerned itself with profit-making technology, there is a complementary relationship between all three. This affects the success of the system as a whole and each institution separately.

Table 5. Variables hypothetically associated with institutional success and failure.

Level	Description
1	Interinstitutional; horizontal, complementary relationships
2	Nature and effects of technology delivered
3	Institutional factors
3.1	The institution's context ✦ Policy sustaining or destabilizing the entity ✦ Sponsor resources ✦ Ability to develop technological links ✦ Ability to develop policies to make alliances and partners ✦ Social control ✦ Relationships with institutional complexes ✦ Size of country and of economy
3.2	The organization itself ✦ Ability to retain qualified staff ✦ Quality of staff ✦ Ability to adapt to changing circumstances ✦ Ability to overcome internal resistance to change ✦ Complexity and coverage of objectives and users ✦ Limits to vertical and horizontal growth ✦ Balance of effort between generation and transfer ✦ Ability to form and maintain critical mass ✦ Stability of objectives, management, and specialist staff

The system of international centres is constantly expanding the frontiers of knowledge through basic research and connections with specialist centres in developed countries. Because the NRIs are unable to perform this function in Latin America, their work is assisted in great measure by the international system. If that interaction ceases, the efficiency of the whole system will suffer and so will food production.

Improved biological material usually comes out of the international system. Very few countries in the region have the capacity to improve their gene banks. Private enterprise has worked with applied technology, but only after obtaining improved germplasm from the international system and the NRIs. Therefore, private interests rely on the international system to provide improved material so that the yields of key crops such as rice, maize, wheat, potatoes, soybean, sorghum, and grasses can be maintained or increased.

Private enterprise in developed countries is different because it has the capacity to develop technology very rapidly for both machinery and inputs as well as genetic material. In this case, the NRIs import and adapt technology that perpetuates their dependency. Because the NRIs are mainly occupied with improving plants, this complementary relationship has a decisive influence on success. The same is true of private enterprises associated with producer groups, although they are more interested in direct participation in research that goes further than producing improved varieties, responds to real needs and interests, and matures in the short term. Research institutes working on machinery and inputs face a different situation. But they barely exist in Latin America, except for some that are satellites of companies in industrialized countries.

Besides the complementarity between countries and the international system, countries in the region also complement each other. Important efforts are beginning in this respect, to some extent compensating for some of the defects and omissions of the international system, especially in fields different from basic foods (such as in the development of tropical products for export). It is clear that there is no such thing as technological independence and that interaction between the system's components is essential to institutional success.

Institutional success is closely linked to the practicality of a technology's new application. Technological change that does not meet real needs can result in institutional failure. A technology can, therefore, be measured by its contribution to economic growth, equity, and the conservation of natural resources. Contribution to economic growth refers to the overall aggregate impact of technological change on the allocation and use of a nation's resources. If the change does not produce a substantial surplus for the country and uses more of its scarce and more expensive resources, it represents a failure.

We may see a continuation of the institutional failures of the 1980s and 1990s if the NRIs cannot match the level of institutional activity of international centres and private enterprise in Latin America; that is, if they can no longer complement the other two elements in the system.

It is generally agreed that technology produces favourable results if it helps to improve the situation of a country's poor. Equity means that the benefits of technological change should be distributed fairly throughout society. Thus, the measure of institutional success or failure at this level will be largely determined by how equity is defined. Technology is considered a failure if it adversely affects sustainability and conservation of natural resources. Evidence seems to suggest that failure is more common than success.

Sixteen variables can be linked to an institution's success. The first seven are related to the context of the institution and the last nine to its internal management, organization, and policy.

1. **Policy** — Government policy, although not expressly formulated for research institutions, does in fact affect them, particularly with respect to funding for research and technology transfer and to organizational characteristics, functions, and objectives. For example, evidence shows that policies promoting an export-oriented economy also tend to support research and resource allocation for exportable goods.
2. **Funding** — Regardless of the legal nature of the institution, if the source of funds is limited, so is the institution's research capacity. Recently, the debt crisis and economic adjustment policies in Latin

America have exacerbated the financial difficulties of the publicly funded NRIs.

3. **Communications** — All technologies require some degree of massive replication to reach producers. Latin American seed producers accomplish this task very efficiently. For other kinds of technology, particularly those not in the public domain, research institutions must develop communication links to ensure that technology reaches the producer.

4. **Strategic alliances** — In avoiding initiatives designed to broaden their funding base, publicly funded research institutions jeopardize their capacity to survive government cutbacks. Institutions need partners to perform complementary functions. Joint ventures always contribute to success.

   When funds are scarce, partnerships within and between countries can be valuable. If operating costs comprise 30% of research costs, an institution can look to partners to cover the smaller budget items, or contract out its research capacity to other institutions. Depending on the type of institution receiving the contract, this arrangement can greatly expand an institution's capacity to achieve results. International cooperation on research is an example of using scarce resources wisely and simultaneously promoting equity among nations.

5. **User participation** — Institutions structured to allow the direct participation of users in research efforts tend to be more successful because they are more responsive to user needs. Several research institutions have created producer councils with the power to approve research plans and allocate funds. Governing councils can also be made up of government representatives rather than producers and serve as bureaucratic coordinating mechanisms.

6. **External affiliation** — Research institutions connected with larger institutional complexes have better chances for success. In Colombia, for example, coffee and sugarcane research institutes are part of a more complex system of production and distribution.

7. **Country size** — The larger a country and its economy, the better its chance of institutional success in research. Studies have shown that

even the smallest crop research team in Central America costs far more that the crop's financing capacity, assuming that producers contribute 1% of the harvest toward research. This is one of the reasons that foundations and associations of regional centres are so vital to research.

8. **Staff turnover** — High staff turnover tends to delay research and raise its costs. An institution's ability to achieve significant results and use its resources efficiently depends on its capacity to retain qualified staff.
9. **Staff quality** — There is some evidence to suggest that high-quality technology requires highly qualified staff but this relationship must be investigated further.
10. **Adaptability** — An institution that can adapt easily to changes in its environment is more likely to be successful. Changes in research needs do not happen abruptly; they tend to evolve over time. Also, quick reactions to policy changes may lessen an institution's efficiency.
11. **Capacity to change** — Sometimes an institution's internal mechanisms act as obstacles to desired change and reduce its capacity to adapt to the environment. Changes in direction that are not backed by coherent internal decisions rarely produce good results.
12. **Complexity and coverage** — Institutions with a wide variety of objectives and clients may be more inclined to experience operational difficulties, internal competition for resources, and a greater likelihood of conflict, all of which lessen their chances of success.
13. **Growth limits** — Institutions that place clear limits on their growth are more successful than those that constantly expand their programs and coverage. The NRIs are a case in point. The fact that their programs and geographical coverage have grown far more quickly than their funding has created bottlenecks and hurt their performance.
14. **Balance** — A fair division of institutional resources between the development and transfer of research normally brings good results. In many cases, however, the balance of the two functions is not

clearly defined, and resources for research exceed those devoted to transferring technological innovation.

15. **Critical mass** — Institutions must develop a critical mass of resources to achieve reasonable levels of success. If resources fall below a certain critical mass, an institution may be advised to reallocate funds and eliminate some of its activities.
16. **Stability** — Because research is a long-term activity, it needs stability to achieve its objectives. Frequent changes in objectives, organization, management, and staff can lead to institutional failure. Stability is therefore a prerequisite for success.

CHAPTER 5

INSTITUTIONAL DEVELOPMENT OF RESEARCH IN ECONOMICS

Miguel Urrutia

✦

This chapter outlines factors affecting the development of economic research within Latin American institutions. It begins by looking at the supply and demand for economic research and exploring factors affecting the performance of economic research institutions. It concludes by offering proposals for institutional development.

Economic Research: Supply and Demand

Although research is always influenced by both supply and demand, in the field of economic research the supply often determines the demand. Highly qualified economists can create a demand for research by promoting the need for it within various social sectors. The demand for economic research is affected by the technical development of the government sector, the development of the university, the degree of democracy in a society, and the competitiveness of its economy.

Much of the demand for economic research is generated by the state, particularly the central bank, because the success of a country's monetary policy requires an understanding of money markets and monetary demand. Although central banks normally conduct most of their research internally, they may also tap external sources for research, such as associations of bankers and manufacturers, as well as universities and independent centres.

Economic research is also undertaken by unions, private banks, universities, and independent institutes and is shaped both by a society's decision-making processes and the openness of its public discussion. Democratic societies may exhibit a greater demand for research; in more authoritarian societies, research may be carried on in secret.

Levels of public-sector spending have a major impact on independent economic research. Central banks usually have sufficient resources and salary flexibility to perform research in-house. However, the intellectual freedom of researchers may be limited by the confidential nature of the research, as well as by the inability of these institutions to publish research critical of their own policies. Also, research topics are generally restricted to monetary and exchange policy. Much of the demand for economic research comes from government ministries, especially those concerned with finance and planning, although ministries of education, health, energy, and trade also need this type of research.

The nature of the demand for research is shaped by a country's decision-making process and the degree to which its decisions are democratically controlled. When a country's decision-making processes require methods to measure economic efficiency — for example, when the feasibility of projects must be assessed — the demand for applied economic research rises. The need for the technical justification of projects by international organizations or by the technocratic budget allocation process also increases the demand for research. Furthermore, the support for those technocratic processes is political and depends on the outcome of a conflict between those who base legitimacy on efficiency and economic growth and those who favour the clientelistic benefits of less rigorous selection criteria for public spending.

The state's research needs are shaped by the ideology of the body requesting the research, as well as by the flexibility of its salary structure and hiring regulations. In general, there is more demand for applied research than theoretical research. Most public-sector research is designed to find practical short-term solutions to urgent problems, although the state may occasionally contract for research of a more theoretical nature.

Another factor that affects public-sector demand for research is the

professional training of senior government bureaucrats. If, for example, most of the top officials in a ministry of health are doctors, then less demand would be expected from that sector for economic research. On the other hand, in a country such as Colombia, where most senior government officials have graduate degrees, there is greater appreciation of the need for economic research and, therefore, a greater demand for it. Also, if it is well known that senior officials have a propensity to base their decisions on technical criteria, then unions and private firms may be more inclined to use economic studies to back their demands to government.

An economy's competitiveness also bears directly on the demand for research. In closed economies with a high degree of state intervention, there may be a tendency to use inside information to lessen business uncertainty. In open, competitive economies, economic research proves to be a better method of reducing uncertainty.

Because issues related to university development are so critical to understanding the demand for economic research, especially theoretical research, they must be a focus of our investigation. Top-quality schools of economics create a demand for teachers with research ability because these institutions rely on research to expand. Unfortunately, owing to low salaries and controls on tuition fees, many schools in the region cannot attract full-time professors or support much professional research. The lack of doctoral programs further affects the demand for academic research.

The crisis of the Latin American university has had a particularly adverse impact on theoretical research. Factors such as the financing of higher education and the structure and objectives of the university all shape the demand for theoretical research. For example, if a university's main objective is professional training, then its administrative systems will promote teaching rather than research. When funds are tight, teaching costs are cut by employing part-time and chair professors, who do not usually undertake research. Controlled tuition fees and constraints on public spending have led to such low faculty salaries that it is virtually impossible to retain highly qualified economists within the university.

In the future, all evaluations of institutional development in economic research organizations must consider the characteristics of research demand, the factors affecting the success of research, as well as the capacity of institutions to respond to changes and take advantage of demand niches.

The institutional development of research organizations is determined largely by the supply of qualified personnel. A limited supply makes it difficult to establish research centres with the necessary critical mass to make research feasible. The supply of researchers is determined by the number of economists with postgraduate training. Research skills are acquired through postgraduate programs and good undergraduate programs. The supply of qualified personnel has been shaped to a significant degree by the availability of scholarships for overseas study because the region did not have its own doctoral programs until very recently.

The characteristics of these scholarships have affected the supply of economists. Many scholarships were awarded on condition that a recipient spent time working at the sponsoring institution. This type of scholarship ties students to institutions that are not capable of sponsoring research and, therefore, contributes to increasing the pool of independent researchers only over the long term. It has been the scholarships that have been awarded without conditions that have been largely responsible for expanding the supply of independent researchers in Latin America.

Many Latin American countries have a limited supply of research economists. The overall number of postgraduate economists is small, and many are absorbed by government or international institutions. It is difficult for institutions to maintain more than five researchers on a permanent basis. It is also difficult to create productive research environments with small groups.

Historically, expatriates were the first economists in many Latin American countries. The first economic research was done by external organizations such as USAID, the Economic Commission for Latin America and the Caribbean (ECLAC), the Food and Agriculture Organization of the United Nations (FAO), the Organization of American States

(OAS), and the World Bank. Many foreign economists then became attached to schools of economics where they trained the first nationals as researchers. In the 1960s, foundations such as Ford and Rockefeller, as well as USAID, also financed visiting scholars' programs. So, in the beginning, part of the supply of economists was made up of foreign experts, and a large portion of postgraduate scholarships were of foreign origin. When the foundations and USAID reduced their support, the resulting cutback in scholarships and visiting professors significantly reduced the supply of economists. In the future, those concerned with the development of economic research should examine the relationship between institutional performance and the qualifications of research personnel.

Factors Affecting the Success of Research Institutions

Factors determining the success of economic research institutions include the motivation of economists, the research environment, research funding, the use of research, and the reliability of government statistical data.

The principal challenge of any research organization is to keep its research staff motivated. High levels of motivation are more likely to occur when research receives the approval of the community, particularly the academic and scientific community. It is vital to researchers that the results of research be seen as contributing to the formulation of economic and social policy, the efficiency of public spending, or the performance of private enterprise. It is generally easier to sustain motivation for research that accepts the dominant economic paradigm of the society. Economists working within other paradigms are more likely to be motivated by ideological commitment. The danger here is that if research results are not applied in a timely fashion they may lose their practicality.

The international scientific community is another source of motivation, as well as a source of research funding. It was the support and encouragement of the international community that enabled Chilean economists to continue their work under the dictatorship, despite its

total lack of support. The motivation and productivity of economists also depend on the working environment and the existence of a critical number of researchers. There are important synergies that make research very difficult to carry out in isolation. Research is much enriched by discussions between peers.

Economic incentives also play a decisive role in research. It is relatively easy for a researcher to find employment in the productive sector or with the government; therefore, income from research cannot be too much less what could be earned in alternative employment. Rigid salary structures make it difficult for universities to retain experienced economists and benefit from their increased productivity. Research on institutional development must address this issue.

The single most important determinant of institutional success is access to research funding. In the early stages of development, there were few local funding sources for economic research in Latin America. The region relied heavily on external sources such as the Ford and Rockefeller foundations, some smaller foundations such as the Tinker Foundation, as well as international assistance from Canada, the Netherlands, and Sweden. Later on, the World Bank and the Inter-American Development Bank began to sponsor a limited amount of external research, although these agencies still preferred to do their own research. But because external financing is usually tied to specific projects, the flow of funding is rather unstable.

As the region developed, local sources of funding increased. They included foundations, state research funds, government contracts, as well as private sector and union funds. Because most local sources provided funding through projects, institutions were forced to develop the capacity to design and execute complex research projects. This had an impact on institutional structures. Because it is hard for centralized institutions to coordinate large quantities of funds and research staff, institutions were required to either shrink in size or decentralize project administration and hand it over to the researchers. The latter option necessitated a sophisticated system of cost-control accounting and precise rules for allocating administrative expenses.

Future research on institutional development should explore issues

related to administration, research staff size, centralization versus decentralization, and quality control mechanisms such as peer review.

With externally financed research, the market may apply a certain degree of quality control. Because poor quality research affects a centre's output, the market can exert pressures for peer review. A few centres in the region have benefited from stable funding from sources such as government or academia, but these centres do not appear to have survived well, and the quantity and quality of their research has been somewhat inferior. Often, these centres have been unable to complete the long-term and complex projects they have begun. These cases require further study.

Funding is more likely to be available if sponsors can derive profit from the research. The private sector often makes this a prerequisite for its support, but it is also becoming a more common condition of contracts given out by the public sector. Many of the determinants of institutional success described here do not apply to theoretical research, which tends to be linked to teaching. However, the current difficulties experienced by Latin American universities have led to a shortage of theoretical research in the region.

Research on institutional development must prove this hypothesis to be valid. If it is, systems should be designed to overcome this imperfection of the market. A system to overcome this shortcoming is proposed.

A Proposal for Institutional Development

The design of methodologies to assess research activity must be central to all efforts to develop economic research institutions. A survey of international journals would reveal a great deal about the production of Latin American research centres; it would establish the relative distribution between applied and theoretical research and analyze the success of research in the regional centres. Case studies could be conducted to investigate the influence of research on economic policy and decision-making. It is also important to find out how much local research is used in the region's economics courses. What books or papers resulting from

local research are used in economics courses in relation to the international reference bibliography?

Most economic research in Latin America has been carried out outside the university, sometimes in research centres related to schools of economics but more often in completely autonomous research centres. One exception is the theoretical Marxist-oriented research conducted in some universities. Because there is little demand for this kind of research from either the private or public sector, it tends to be conducted in the spare time of faculty. In contrast, there is a great demand for applied economic research. Both the public and private sectors have a direct interest in studies that assess the impact of economic policy. Journals that publish studies in applied economics are in so much demand that they do not need to be subsidized.

Because university salaries have declined markedly throughout the last decade, many professors have taken on other research projects to supplement their incomes. In some universities, faculties have set up connected research centres. It is here that staff find research projects to enhance their basic salaries. However, these research centres lack the administrative flexibility of the university.

It is fair to conclude that the current structure of the university in Latin America does not promote research. Research activities do not furnish the promotions or rewards needed to advance teaching careers. Funds for research are scarce because the bulk of the university's budget goes toward salaries, and more emphasis is placed on the number of courses taught than on the quantity of research completed. Also, the salaries of academic staff have deteriorated to such an extent that university careers hold little allure.

The independent research centre has emerged as a viable institutional model in many Latin American countries; today, a large proportion of economic research in the region is conducted in these centres. These centres have many advantages. They have an administrative flexibility similar to small business and can pay competitive salaries. They can supplement teaching salaries until they become competitive with salaries in the private and public sectors. Their research may be more relevant to the community because it must please funders. Economists endeavour

to produce work of a high enough academic standard to attract international funding. Competition for funds between centres tends to increase the quality and relevance of research projects. The relevance of research can be both a strength and a weakness: a strength because research has influence and applicability; a weakness because important research topics may be ignored because they are of little interest to funders.

The development of independent centres has deepened the crisis of the university. Many researchers have left teaching to dedicate all their efforts to projects in the centres. With the loss of researchers from university schools of economics, the quality of teaching has diminished. One result is that university professors who lose contact with research may transmit more obsolete knowledge. This type of teaching cannot make much of a contribution toward helping to apply theory to concrete national problems. Another problem is that independent research centres have few resources available for theoretical research. The result is a certain lack of theoretical economic research in the region. As with other sciences, economics requires theoretical development to advance. Applied economics is important, but the scientific community requires a minimum of people dedicated to the development of theory.

The two main strengths of independent research centres are flexibility and responsiveness. The fact that they are more likely to be influenced by market pressures means that the research topics chosen will generally tend to coincide with the interests of some organization or societal group. There is also a greater chance that research will stay within reasonable time frames and budgets. The weaknesses of the independent centres lie in the separation of the researcher from the teaching environment and the difficulty of financing theoretical research. These problems are not insurmountable; the best economists are generally involved in consultancies, teaching, and theoretical research. The challenge for the profession is to develop the funding mechanisms to allow economists the time to engage in all these activities.

One possible solution is to set up an endowment in each research centre to allow researchers to devote part of their time to university teaching. This scheme would enable researchers to return to teaching and conduct theoretical research related to their specialty. At the same

time, they could finance the rest of their time with contracts and consultancies from the private sector, which would let them maintain contact with the real world through their professional work in the field of applied economics. The capacity to obtain some income from the market could also be used as a test to select those professionals who should remain in research centres.

This scheme differs from those of industrialized countries where endowments are created within universities for professors. Here, it is recommended that partial endowments be established for professors at institutions other than universities. The North American or English system would not work in Latin America because of problems related to the extremely bureaucratic nature of the university as well as the system of salaries and economic incentives. Research institutions introduce the required element of competitive pressure.

In conclusion, the ideal solution is to establish endowments for research centres in economics that would enable researchers to devote part of their time to university teaching and part of their time to theoretical research. To further justify this strategy, it would be critical to identify the institutional environments that currently promote the best economic research in Latin America. The Inter-American Development Bank has clearly shown that excellent research is carried out in independent research centres. However, it would also be useful to study specific cases to discover which institutional arrangements best promote theoretical research and closer links with the university without destroying the flexibility and responsiveness of the independent research centres.

CHAPTER 6

INSTITUTIONAL DEVELOPMENT OF EDUCATIONAL RESEARCH

Patricio Cariola

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The purpose of this chapter is to outline factors that influence the development of educational research institutions in Latin America. Although the discussion is mostly confined to factors that only affect institutions, it is somewhat difficult to separate these from factors that influence the overall development of educational research.

This chapter looks at both the internal and external factors affecting institutional development. The main internal factors are type of institution, product specificity, research staff, management, and commitment to action programs and teaching. It begins by examining the types of institutions conducting educational research because this factor is so important that other factors can only be understood in relation to it.

The chapter then addresses the sensitive issue of product specificity. Although the quality of educational research in Latin America has been surprisingly good, it is still poor in comparison with other fields of knowledge and inadequate to meet the needs of the educational system. It then goes on to examine the training and working conditions of research staff, a factor that takes on unique characteristics in education. It also looks at the academic and financial management of educational research. Lastly, the chapter considers the commitment of research centres to action programs and teaching activities. The former applies mostly to nongovernmental research centres; there is little data on the latter.

The external factors considered include financing, the social and

political environment, and communications networks. In conclusion, the discussion identifies the most influential factors in the development of educational research in the region and presents suggestions for further research.

Internal Factors Affecting Institutional Development

Type of institution

Four types of institutions carry out educational research in Latin America: universities, government education ministries, nongovernmental centres, and international organizations. The characteristics of each type shapes its development and interacts with other internal and external factors.

Universities — In Latin America, educational research originated in high schools and pedagogical institutes attached to universities. After World War II, educators attempted to give their profession a more scientific basis by establishing schools of education. At the curriculum level, these schools train specialists and future education professors. At the post-graduate level, an increasing number of universities have succeeded in attracting qualified department heads to conduct research; however, no new knowledge has been produced. Even in the best universities, research has been limited to graduate theses; only an exceptional few have achieved a sustained output. University centres are characterized by their relative autonomy as academic units, and working conditions do not seem to favour other alternatives.

The emergence of the social sciences in the 1950s changed the landscape of educational research in Latin America. The social, economic, and political dimensions of education were recognized, and most importantly, new theoretical and methodological perspectives were introduced. Professionals with training in areas other than education began to investigate educational problems, teach in schools of education, and take jobs in public-sector technical organizations. When sociologists started to influence educational theory at the academic level, the psy-

chopedagogical perspective, formerly the leading school of thought, gave way to a socioeducational perspective.

The field of educational policy and planning was left to the economists in charge of ministries of finance and international agencies. Educators and schools of education began to lose control over the field as new disciplines and professional groups began to shape political and technical decisions on education. This shift was supported by international organizations that believed that as the key to development, education was too important to be left solely in the hands of educators.

A clear distinction must be drawn between the approaches of educators and those of interdisciplinary groups and NGOs. The former are linked to the attempt to create an autonomous field of knowledge called "educational science." The latter are linked to groups outside education concerned about the growing demands placed on the political structure by the educational system and society. These two approaches have very different outcomes.

Ministries of education — The growth of the educational system in the 1950s and 1960s coincided with the rise of planning offices within ministries of education. These technical bodies produced quantitative and operational studies on the administration of the educational system. They tended to advocate a socioeducational approach — which concerns itself with the impact of the educational system on the country's social and economic goals — over a psychopedagogical or curriculum-based approach.

At the same time, some governments were setting up research and curriculum-development centres to support educational reform. This is how the Centro de Perfeccionamiento, Experimentación e Investigaciones Pedagógicas in Chile, the Instituto Colombiano de Pedagogía in Colombia, and the Oficina de Planificación Educativa in Venezuela were born. These centres only produced research for a short time then they either declined in importance or disappeared completely (Chiappe and Myers 1983).

Some ministries of education contract out research to other institutions; this is the case in Mexico (Quintero et al. 1983), Colombia (Calvo

1991), and Chile. Most of the funds for such studies come from international sources in the form of loans or donations.

Nongovernmental centres — Nongovernmental educational research centres are characteristic of Latin America. They emerged out of severe social and political problems; the challenges of the Cuban revolution; the new social awareness of the Catholic Church; the development of the social sciences in the universities; the financing for community development projects available from international cooperation agencies set up by European and North American churches; and the rise of a generation of young professionals in church movements dedicated to social change. Neither the university nor ministries of education provided environments conducive to change-oriented research and action.

Nongovernmental centres have their origins in philanthropic, professional, and scientific interests. Over time, their approach has shifted from a socioeconomic orientation to a sociocultural orientation. Within a varied array of centres, there are many whose primary activity is educational research.

These centres have chosen to use "popular education" methods to address social problems engendered by poverty and marginality (Gajardo 1989). The first experiences of grassroots social and political change, as expressed in the writings of Paulo Freire, stirred an interest in popular education on the part of social scientists, educators, and community-development workers. Because popular education has both research and action components, it is not surprising that most of the activities undertaken by the educational research centres employ a popular education approach to adult education. This approach is based in a group's own culture and promotes their active participation in the solution of everyday problems, within a social change perspective.

This new thinking has also awakened academic interest in industrialized countries and generated new models for social development. It is also having an interesting impact on the school system (Program de las 900 Escuelas 1991). Although these centres have a hard time obtaining funding for research on the school system, they are still generally the leaders in educational research in their countries. The largest ones are

now beginning to communicate with universities and to cooperate with international development agencies, at both national and regional levels.

Because nongovernmental centres tend toward greater academic and administrative efficiency, ministries of education expect more from them than from universities in terms of policy design, implementation, and evaluation. It has been observed that the work rhythms of university institutions do not meet ministry requirements (Calvo 1991).

Perhaps the greatest achievement of the nongovernmental centres has been to support teams of interdisciplinary researchers who publish research studies and train other researchers. Neither governments, universities, nor international organizations have been able to match this accomplishment. Despite the precarious situation faced by most institutions in Latin America, these centres have shown remarkable operational stability, although they depend almost exclusively on international funding for educational research and innovation.

International organizations — International organizations such as OAS, Unesco, the International Labour Office (ILO), and the United Nations Children's Fund (UNICEF) produce and disseminate educational research through projects, technical meetings, and specialized centres. Outstanding specialized centres include the Centro Regional de Educación de Adultos y Alfabetización Nacional in Mexico (adult education); the Centro Regional para la Educación Superior en América Latina y el Caribe in Venezuela (higher education); Instituto Latinoamericano y del Caribe de Planificación Económica y Social in Chile and Centro Interamericano de Estudios de Investigación para el Planeamiento de la Educación in Venezuala (planning); Centro Interamericano de Enseñanza de Estadística (statistics); Centro Interamericano de Investigación y Documentación sobre Formación Profesional in Uruguay (professional education); and the Programa Regional del Empleo para América Latina y el Caribe (education and employment).

A recent study (Garcia-Huidobra and Ochoa 1989) on the contribution of research to educational policy-making in Latin America underscores the importance of institutional type to the development of

educational research centres and explores its impact on research outputs. The study shows the following:

- Government agencies generally undertake research to help improve the operation of educational systems. In the poorest countries, this type of research is conducted exclusively by government; in more developed countries, it is done by universities and nongovernmental centres. Government research is purely pragmatic and has no academic pretensions.

- The university's focus on disciplinary studies with precise methodologies allows it to excel at dealing with well-defined subjects. However, its deficiencies include studies on conventional subjects and with narrow objectives. Because universities are highly influenced by professional interests they tend to favour studies related to university specialties.

- Nongovernmental centres are particularly relevant to the production of educational research in Latin America because they account for more than one third of the region's total research output — half, if international organizations are excluded. These centres have three special features: their contribution to new subjects and methodologies, their social vision on educational issue, and their willingness to deal with issues relevant to the popular sectors. The latter include nonformal education (popular education), literacy, preschool education, and the links between education and poverty — more than one third of research is on this last subject. In general, critical research on the education of the poor is increasing (Garcia-Huidobro et al. 1989).

- International organizations play an interesting role in educational research in Latin America. Although they share many of the characteristics of government centres (as well as institutional and systemic interests), they are more like independent research centres in their capacity to innovate and introduce critical new concerns to the research agenda.

Although educational research has made great strides, it has not as yet made much headway in improving the efficiency of the educational

system and helping it to meet the requirements of socioeconomic development in the region (ECLAC 1991; Unesco 1991). The main contribution of research has been to help identify and provide a rich socioeducational framework for understanding and solving key educational problems.

Product specificity

Product specificity is characteristic of scientific and technological activities. Here, "specificity" refers to the capacity of research — in this case on education — to contribute to the design of precise policies and the formulation of solid explanatory theories. Most educational research in Latin America is not sufficiently specific. All research groups, regardless of their institutional situation, should strive for more specificity in their work on education.

One analysis of the products of educational research in Latin American drew the following conclusions (Garcia-Huidobro and Ochoa 1989):

- Educational research is increasingly concerned with issues related to learning, knowledge taught in schools, and the social usefulness of education. This major shift came in response to the severe problems facing educational systems, which have achieved wide coverage while suffering from poor quality. However, the approaches used in this research are far too general to make a real contribution to improving the operation of policies and educational quality; this is especially true in poorer countries. For example, research tends to concentrate more on the education system in general than on specific issues and more on Latin America as a whole than on specific countries or groups (such as farmers or the indigenous population). There are few research studies that take a case-study approach.
- Research attention has centred on the macrostructural relationship between education and the community or on strictly pedagogical issues unrelated to the social framework. Issues related to teaching and learning and the main actors in the educational system — parents, teachers, and students — as well as knowledge generated by the process have only begun to be studied. Variables related to

professors, alumni, and the communication process have always been considered more important.

- Educational research in Latin America is largely confined to the educational arena — paying little attention to the media — and to major technological, scientific, and economic developments affecting education today.

Whereas the quality of learning is determined by the pedagogical relationship, the efficiency of education depends on the way the educational system obtains and administers resources. Therefore, the lack of research on the administration and financing of education has potentially serious consequences. There is also a dearth of research on the relationship between administrative changes (such as decentralization) and the quality of teaching.

In our opinion, specificity and pertinence are not unattainable goals for research because Latin America already has a language of education. The basic assumptions of research have shifted from a naive belief in development theories and central planning to a radical critique of social structures and the educational system. Today, efforts centre on designing specific policies to improve educational quality (García Guadilla 1987). These efforts have been heroic because the new language is located in a context of "theoretical poverty," "methodological inconsistency," and nascent research traditions (Favero et al. 1990, quoting Guiomar Ramos de Mello).

Research staff

Perhaps the most important aspect of an institution is its research staff. An institution needs competent, imaginative, and committed researchers to earn a good reputation, attract funding and produce quality research. The competence of the research staff, the time available to devote to research, and the opportunity to establish permanent working groups are key factors in the production and accumulation of knowledge. Behind every good piece of research is a group of researchers who have worked together for a long time.

The institution's capacity to recruit and retain top-notch research staff is a function of academic and financial factors as well as of the

institution's capacity to offer structured research careers, and all of these vary according to institutional type. Each type of institution has its own disadvantages: for the ministries of education, it is low rents; for the universities, shortage of time; and for the nongovernmental centres, lack of stability.

Studying the relationship between training and productivity may help to identify that young people should be recruited into educational research. It is widely believed that educators do not make good researchers because they prefer to teach than to observe, read, or write. Their main concerns are methodological, and they learn from their experience.

The existence of another group raises key questions for the training of researchers. These are specialists in the human sciences and philosophy who have dedicated their professional careers to education without losing touch with their specialties. These individuals often express an interest in education right from the beginning of their studies; they also know how to work with educators. They produce interesting and relevant research that has excellent potential to influence policy and educational practice. Because the educational system relies on educators, it is necessary to understand their language. The development of educational research institutions requires both first rate researchers and interdisciplinary research teams.

The training of young researchers, whether at home or overseas, must be oriented beyond the opportunity market. Ideally, the managers of institutions employing researchers should follow their training activities and provide attractive working conditions on their return.

We should also take a closer look at the relationship between the aims of research and the needs of the educational system. There is no question that research outputs should be useful to the educational system (the users of knowledge); however, researchers (the generators of knowledge) should also feel free to tackle the issues that they consider important, regardless of what the rest of society thinks. The development of research centres and the overall legitimacy of educational research depend on the ability of research staff to do both. However, usefulness

should be the engine driving educational research, not knowledge for its own sake.

The issue of research careers is linked to the way different types of institutions are organized. It is not only a matter of economics; it is also a matter of how knowledge is conceived, produced, transmitted, and used. It is also a question of the connection between educational research and teacher training as well as the academic and power relations between teachers and researchers. Another key factor is the links between bodies dedicated to education, psychology, economics, social sciences, and philosophy because they all affect education.

Institutional management

It is our hypothesis that management skills will prove to be increasingly important to the development of educational research institutions in the future. Here, "management" means the ability to establish and promote all facets of an institution — academic, financial, and administrative. In practical terms, management can be thought of as a group's capacity to undertake an intellectual project to which it is committed. The following three points support this hypothesis:

- The bulk of funding for educational research has been channelled through projects, even at the university level. Because this funding has come primarily from international sources, institutions need to establish and maintain an international reputation. They must also produce high-quality research and be able to justify the funding received.
- The most dynamic institutions are able to deal with funding that is delivered through projects, especially external funding. This discussion refers to institutions that have a certain independence of thought along with an organizational structure that can handle projects; examples are the nongovernmental centres, the more independent of the university centres, and some international organizations. Project financing requires a certain management ability to guarantee continuity. In the more successful institutions, the principal researchers are integrally involved in designing and marketing projects as well as carrying them out; their salaries depend on it.

Dedicated effort is required to ensure that the supply meets the demand and vice versa. An institution must be familiar with the policies of funding agencies, local educational policies, as well as the nature of the academic discussion that influences them. It must also be able to grasp the workings of research contracts and educational research subsidy mechanisms. This constitutes the public relations and marketing aspect of educational research.

- Strong academic leadership is needed to safeguard the intellectual and economic independence of institutions because of the interdisciplinary nature of the field and the weakness of knowledge within it.

The preceding points confirm the importance of management skills to the survival of educational research institutions in today's small, segmented market. However, the real challenge for educational research — and society in general — is to recognize that educational systems constitute an enormous potential market for research. Researchers should not be perceived merely as the supply — as those who generate the knowledge needed to increase the productivity of educational activities — they should also be actively involved in helping to create the demand for research by convincing those in authority of the urgent need for it. Not only must the product be good, but consumers must be persuaded they need it. It is not enough for more resources to be allocated to educational research; research results must also be published and widely disseminated to those who might find them useful. This would help to increase the demand for research.

Action programs

We have previously mentioned the contribution made by the nongovernmental centres to adult popular education and to addressing the problems of poverty. Research–action programs have been central to the development of these centres; their survival would have been jeopardized had they devoted their efforts exclusively to research.

Although many international agencies are reluctant to provide funding to the formal educational system and to educational research, they

are often willing to finance projects that design, streamline, and communicate approaches to educate and improve the situation of the poor.

Scientists and practitioners in the field of education rarely work together or communicate well. However, the evaluation of adult education programs — which emphasize action over knowledge acquisition — has provided such an opportunity. Combining research and promotion has enabled social scientists and adult educators to work together in such a way that research and action can influence one another. Popular education has provided a vehicle for the merging of scientific research and the development and dissemination of new technologies. Cooperation in this area has stimulated the development of more effective technologies. Interestingly, it has been in these areas, so far from the productive world, that the most interesting educational innovations in Latin America have occurred.

The phenomenon of popular education illustrates the importance of the "development" factor to the educational research centres. If these centres were also able to operate in the formal education system, perhaps the synergy (in terms of change) that has taken place in the productive world and in popular education programs, could also happen in the school system.

Teaching

When it comes to teaching, there are more questions than answers. How does teaching affect the development of educational research? Is it a help or a hindrance? Is it the university's responsibility to link research and teaching? What is the potential for a productive relationship between research and teaching today and in the future? What conditions should be placed on educational research? Do the theses of doctoral students contribute to the productivity of educational research? Is it possible to create links between the needs of educational systems and the output of the universities? Should the nongovernmental centres be involved in teaching? Would this affect their productivity? Would it reduce their contribution to policy formulation? Would they be able to maintain the action programs that influence their theories? Can scientific research, technological development, the diffusion of research, and teaching all be

done in one institution in the case of education? If they could, would this have strategic or tactical importance?

Experience does not provide any answers. It is disturbing that the knowledge on education generated by teachers' training centres is not meeting the real needs for education and training. It is also of concern that these centres are not linked to organizations generating new ideas on education. In the same way that it is necessary to take a serious look at the way educational research is organized — perhaps more so than any other sector — the same is true of teaching, technological development, and dissemination. These must respond to — and, indeed, anticipate — social needs; at the same time, they must foster the scientific disciplines needed for the growth of knowledge.

There is a new dynamic in education characterized by the introduction of the interests of private firms; deregulated and privatized educational systems; and informatics and the mass media in the transmission of knowledge and values. In a new institutionalization of knowledge production and dissemination in education, there are three challenges: combining conflicting trends, making schools more effective, and having an impact on the ethical dimension of human development.

External Factors Affecting Institutional Development

Three external factors affecting educational research are worthy of analysis: financing, the sociopolitical and cultural environment, and communication networks between centres and researchers.

Financing

International financing — International financing has been critical to institutional development. To understand how critical, we only have to recall the serious decline in quality research during the economic crisis of the 1980s. During this period, there was also a significant reduction in opportunities for postgraduate study overseas. This lack of external support completely wiped out a whole generation of researchers.

International assistance from bilateral agencies, international organizations, and NGOs should be directed to independent centres so that they can work with government ministries to generate research and innovation. Ministry staff are preoccupied with running the educational system and have little time to develop ways to improve its quality through research and experimentation. They may not even be capable of doing so. The universities are more concerned with academic and instructional issues than with innovation. Because the independent centres have shown such creativity and efficiency with respect to nonformal education, perhaps they could also be an effective vehicle for reforming the formal education system. If we do not use them to advantage, we are wasting a wonderful opportunity to reach the poor through the formal education system.

National financing — Governments support educational research by providing funds to universities and national educational research bodies. Of the latter, the National Council for Scientific and Technological Development (CNPQ) in Brazil has been one of the most active. Others include the Consejo Nacional de Ciencia y Tecnologia (CONACYT) in Mexico (Quintero Hernandez et al. 1983), the Fondo Colombiano de Investigaciones Cientificas y Proyectos Especiales Francisco José de Caldas (COLCIENCIAS) in Colombia (Chiappe and Myers 1983), and the Comisión Nacional de Investigación Cientifica y Tecnologica (CONICYT) in Chile. These funds are designated to cover research expenses and not salaries. Despite the large amount of resources spent on educational systems, it seems that few countries other than Mexico allocate significant amounts to educational research and to the development of innovation. The only exception is when funds come from external sources. Chile, for example, has recently invited bids for eleven projects that will lead to the eventual redesign of secondary education in that country.

We are unable to say much about the contribution of the universities to the financing of educational research. Except for those with special funds for research, the contribution of universities is limited to financing faculty salaries.

Private foundations have furnished significant support to the development of educational research in countries such as Argentina, Brazil, Colombia, and Venezuela and, more recently, Chile and Peru. One example is the Carlos Chagas Foundation of São Paulo, an institution that supports research with the funds it obtains from evaluating and selecting students and personnel for universities and companies. In Argentina, Brazil, and Chile, the Lampadia Foundations have initiated important educational research activities. Some governments are beginning to offer tax exemptions to firms that provide donations for educational or scientific ends.

This review of financing mechanisms exposes the overall weakness of educational research in Latin America. Educational research does not yet have a solid economic base in Latin America; neither the public nor the private sector has taken charge of its overall development at the national level. The production of new knowledge depends largely on external support, which is delivered through a wide range of vehicles.

A more thorough study of the role of funding in institutional development should take the following variables into account: the origin of the funds (external, internal, or both and the proportions of each), mode of delivery (by institution, by program, by project, or by service), funding agency priorities (for research or action programs), socioeconomic level of the recipient (poorer countries are more likely to attract external financing), and the type of institution requesting the funds. Regardless of how these variables are combined, the main factor is the overall availability of funds, both external and internal.

The social and political environment

External financing is influenced both by current ideas on development and the relationship of developed countries to the less developed ones. These determine development assistance policies and priorities. This also applies to the field of education and, therefore, to educational research.

It was not accidental that the momentum of educational research picked up after the Regional Conference on Education and Economic and Social Development, organized by Unesco in Santiago in 1962. This conference highlighted the relationship between education and develop-

ment and the need for planning and educational research. The Jomtien Conference, sponsored by UNDP, Unesco, UNICEF, and the World Bank, raised these issues once again (WCEA 1990).

At the regional level, a significant impetus to educational research was provided by the new growth strategy proposed by ECLAC (1991), the recent meeting of ministers of education in Quito (recommendations of PROMEDLAC IV; Unesco 1991), and especially the document on education and knowledge prepared jointly by ECLAC and Unesco. These documents and meetings have helped to shift the heavy gears of national and international financing.

At the national level, the programs of governments and political parties have an impact on research. So does modernization; a country in the process of modernization generally strives to improve the research on which policies are based. Countries that modernized early and have an older educational tradition tend to accord greater importance to research in general and educational research in particular. Faith in the potential of science and progress bears more heavily on the culture of the community and its institutions.

From a cultural point of view, key factors in educational research include the state of social science development and the recognition of scientific work as a social asset. Without these, no serious educational research can be accomplished; only the formal requirements will be met. Most researchers are not subjected to peer criticism or to measurement against a set of standards. It would appear that the setting of standards is one sign of institutional development. When standards are socialized, they are easier to achieve.

Communication networks

Communications networks have acquired a new importance to research. A network allows for coordination, accumulation, criticism, and communication between researchers over geographic distances. It is worthwhile to study how networks can contribute to the development of educational research. They have great potential; without them, it is more difficult for knowledge to be used.

Regional networks — There are a wide variety of educational research networks in Latin America (Schiefelbein 1982). The main one is the Latin American Network on Information and Documentation (REDUC), which is made up of a network of institutions and a comprehensive data base on educational research.

Since its inception in 1972, REDUC has collected, analyzed, and disseminated documents related to educational research through a cooperative network of 27 centres located in almost all Spanish- and Portuguese-speaking countries in Latin America. The data base currently processes about 2 000 new documents a year. In addition to circulating print materials and magnetic disks, each national centre publishes a magazine and exchanges it with other centres, thereby making the production of the entire network available to the public (Braham et al. 1983).

Recently, a need has emerged for intermediaries or brokers to link available knowledge to the policy development process. These brokers may play an important role in increasing the demand for educational research and in encouraging new funding for it.

The following have influenced the achievements of REDUC:

- The cooperative nature of the network. Each institution customizes its work according to its possibilities and interests through its own publications. Consistency is ensured through technical rules and the survival of national networks.
- The network links research institutions interested in documents, rather than specialized documentation centres, which means it can facilitate access to the results of research and its subsequent use.
- These organizations belong to all the categories discussed in this chapter: governments, universities, private centres, and international organizations.
- The wide variety of tasks performed by the centres: from analytical summaries to state-of-the-art work; from publications on paper to magnetic disks; from meetings of researchers to national networks.
- The leadership and coordination, in terms of methodology develop-

ment, personnel training, and the search for and administration of funding.

- The emphasis on the use of products and the continuous education of users.
- The recognition by centres that belonging to REDUC provides important institutional benefits, and the willingness of these centres to invest substantial resources in its operation.
- Its status as a regional institution, which qualifies it for regional funding from bilateral aid organizations. These funds are often easier to obtain than funds allocated to specific countries by the same organizations.
- The provision of cumulative indexes, by author and key word, for all the material collected and processed by REDUC, creating an indispensable foundation for a regional community of researchers.
- REDUC is both a data base and a network of institutions; therefore, it is a living organization at the regional level. The national networks just starting should copy this example at the local level.

REDUC's constraints include a lack of connection between demand and supply, the difficulty marketing its products, and an insecure financial arrangement with governments and international organizations.

International networks — In the discussion of management, the importance of academic and financial connections with the outside world was stressed. The wider and more active an institution's networks, the greater the likelihood of institutional development, especially if it aims to provide services outside the country. The academic and financial networks are closely linked in this case.

Latin American institutions must stay abreast of the knowledge produced in industrialized countries so that the region's products can command respect in the rest of the world. It is especially important to establish direct contact with researchers in industrialized countries, especially those working in the area of education and development. They are looking at problems that directly affect people in Latin America and generally have more access to resources to investigate them. Because

these countries are richer in resources and are normally at the forefront of world knowledge production, our relationship with them is not equal. Educational research in Latin America will have achieved maturity when it is as capable as the North of generating the knowledge and innovation needed to solve common problems.

Conclusion

Experience has shown all the factors previously described to be critical to the development of educational research; however, it can be argued that the most important is management capacity, especially as it affects an institution's ability to stimulate and meet the demand for educational research. The more that management capacity is shared throughout the institution the better; without it research cannot be improved.

The second most important factor is the quality of research staff. This disparate group of professionals must continue to work together in a coordinated fashion to investigate the key problems facing education today. Only in this way will Latin America be able to meet its main challenge: the production of useful and specific educational research.

CHAPTER 7

INDUSTRIAL RESEARCH AND DEVELOPMENT INSTITUTIONS IN BRAZIL

Jacques Marcovitch and José Adelino Medeiros

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This chapter looks at the origins, development, and performance of technological and industrial research institutes in Brazil. Although the discussion here is based on the Brazilian experience, some of the conclusions may apply to other Latin American countries as well.

Technological research institutes and technological centres within corporations and universities bring scientific and technological knowledge to industry and play a key role in the acquisition and transfer of technology. These centres facilitate technological innovations involving products, processes, and services. These bodies are able to act as intermediaries between academia and industry and to connect scientific and empirical knowledge with the production process because they understand and function in both worlds. They generate technology by transforming scientific and technological research into technological innovations.

These institutes fall into four main categories:

- Public institutes for technological and industrial research (federal and state institutes),
- Private institutes for technological and industrial research,
- Technological research centres connected to universities, and
- Technological research centres run by industry.

Despite the crisis that currently threatens their survival, these institutes have played and will continue to play a crucial role in Brazil's technological development. They have emerged to bridge the gap between industry and academia that exists in most developing countries. Universities often find it difficult to establish links with industry. They may fear that efforts to apply research to production would divert the university from its main goal, which is to train human resources and contribute to the development of knowledge. Technological research centres take advantage of the efforts, human resources, and equipment of universities to connect industry to the sources of knowledge.

The excitement that greeted the development of these institutions in the 1970s was soon overshadowed by the crisis of the 1980s. So far, there are no signs that the scientific–technological sector will be revitalized; a radical reorientation is needed. The economic instability in Latin America has impeded many attempts to produce long-term results; the biggest casualty has been scientific and technological development projects.

With few exceptions, the scientific and technological apparatus has become outdated and stagnant, owing in part to the lack of enthusiasm shown by individuals involved in it. As a result, Latin America has fallen even further behind countries that lead the way in science and technology. However, this situation has laid the groundwork for the adoption of realistic and consistent measures that can stimulate technological and industrial research.

Trends in Science and Technology in Brazil

Brazil's significant scientific and technological progress has been fragmented and dispersed throughout certain areas of knowledge and economic sectors. In the 1980s, Latin America experienced an economic and fiscal crisis that contributed to the deterioration of higher education in Brazil. At the same time as the frontiers of scientific and technological knowledge were being pushed back on the international level, science and technology in Brazil was suffering a severe setback.

Scientific and technological development was the subject of much discussion during the 1989 presidential election campaign in Brazil. The authors of this chapter were given access to questionnaires completed by presidential candidates as part of a survey conducted by the Brazilian Technology Magazine for CNPQ. This material was published in the interviews of Mascarenhas (1989) and provides the basis for the following discussion.

According to the CNPQ survey, defining a medium- and long-term strategy for developing science and technology and giving the sector top priority would require that

> Brazil must increase its investment in science and technology, carry out a more strict coordination and articulation of activities and choose priorities and routes for research and training of human resources in a careful and steady way.

Decisive action on the part of the state and a comprehensive reformulation of the actions and strategies of technological research institutions, as well as of national productive and economic sectors, are essential. These subjects are of particular interest for the analysis under consideration.

As Brazil enters the 21st century, its technological development and links to the industrial sector still do not occupy a well-defined and durable space. Brazil does not compare favourably with other nations. Currently, Brazil invests about 0.6% of its gross domestic product (GDP) in science and technology; Italy invests 1.5%; Korea, 2%; Japan, 3%. Brazil has 400 researchers per million inhabitants; Italy has 200; Korea, 2 000; Japan, 6 000. In Brazil, the private sector's proportion of total investment in science and technology is 8% (in Italy it is 30%; in Japan, 72%).

Although some progress has been made in scientific and technological development in Brazil, there have also been countless setbacks and a lack of firm and consistent policy guidelines. Some scientific and technological developments must be stimulated selectively, and stagnation must be identified along with human resources involved in education.

According to Marcovitch (1990, p. 28) the scars of recent economic failures still affect science and technology in Brazil today. The govern-

ment has dealt with urgent problems through confrontation or "clashes": turbulence, crises, and collapses are all part of the country's socioeconomic context. Unrest turns into a crisis, a crisis into a collapse, and, before a collapse turns into chaos, a "clash" approach is adopted, leading once again to unrest.

In recent years, industrial and technological policies have suffered from such an approach. The former government took many years to develop such a policy, which was finally announced in May 1989 in an atmosphere of great anticipation. The plan included concrete projects and seemed to have both internal and external consistency. Unfortunately, its regulation was distorted by the guidelines followed. A year later, the productive sector was no longer a priority, and technological development programs had not been strengthened.

In 1990, the current government introduced two documents vital to the country's industrial and technological policy: *General Guidelines for the Industrial and Foreign Trade Policy*, in June, and *Support to Technological Training in Industry*, in September. These documents advocated a more efficient use of the market, a substantial reduction in incentives, tariff protection, and the competitive reconfiguration of industry through an increase in productivity and the adoption of international quality standards. The Brazilian Quality and Productivity Program supports these activities.

The impact of the new policy should be carefully monitored. Enhancing the competitiveness of Brazilian firms abroad will require strengthening the domestic market through better income distribution. A company's export capacity depends on economies of scale, which can be adversely affected by a consumer market weakened by inappropriate income distribution.

The sectors generating technological progress were given special attention in Brazil's industrial and technological policy in light of their overall contribution to modernization and economic development. The proposals anticipated such activities as identifying selective markets, products, and services capable of maximizing the impact of new technology. According to the plan, Brazil's technological infrastructure was also to be updated. Efforts were to be concentrated on modernizing research

institutes, laboratories, and university research centres and, in the future, creating new institutes in emerging areas.

Technological and Industrial Institutions in Brazil

Industrialization in Brazil reached its peak after World War II. There was a decline in the foreign demand for primary products and a reduction in import capacity. Brazil's industrial machinery overcame these problems by adopting a model of import substitution, emphasizing the production of consumer goods with technology from abroad. This marked the beginning of a technologically dependent industrial structure. This hurt the capital goods industry, which favoured the production of consumer or intermediate goods.

According to Kataoka (1987, p. 29), it was later recognized that the import substitution policy could not accelerate industrial growth. Since 1967, different measures have been taken. These new measures were geared toward encouraging the export of manufactured goods as well as expanding the domestic market for durable consumer and capital goods.

The period between 1968 and 1973 was characterized by serious stagnation in Brazil's development and the beginning of explicit technological policy. A study by Gusmao (1987) shows a noticeable increase in exports and significant public investment during this period, which led to a major expansion of the productive segment of the state apparatus. Industrial research institutes proliferated; approximately 60% of these centres were created between 1966 and 1980. There was also a more profitable use of existing capacity, especially in projects that provided technical support to infrastructure activities.

This chapter provides a profile of these institutions and exposes the thinking behind the scientific–technological base that existed in the country up to the late 1970s. It also discusses the problems that emerged in the 1980s and persist today.

Tables 1, 2, and 3 classify industrial technology institutions and centres in Brazil by type, date of establishment, regional distribution, and size (number of employees). Research institutions run by federal and

Table 1. Distribution of industrial–technological research institutions in Brazil (1985) according to founding date and institutional category.

Founding date	Federal and state institution	Private institution	University-related centres	Industry-supported institutions	Total
Up to 1955	7	1	2	1	11
1956–1965	3	1	2	1	7
1966–1975	12	—	15	3	30
1976–1985	3	3	9	2	17
Total	25	5	28	7	65

Source: Gusmao (1987, p. 29).

Table 2. Distribution of industrial–technological research institutions in Brazil (1985) according to region and institutional category.

Region	Federal and state institution	Private institution	University-related centres	Industry-supported institutions	Total
North	—	—	—	1	1
Northeast	4	—	1	1	6
Centre-west	—	—	—	1	1
South	3	1	12	3	19
Southeast	18	4	15	1	38
Total	25	5	28	7	65

Source: Gusamo (1987, p. 30).

state governments are worth considering given their number and size. Although the number of university centres appears to be higher (28 against 25), it is obvious that they have fewer employees than government institutions. Other factors that must be taken into account are the concentration of institutions in the southeastern and southern region and the low participation of the private sector in technological research activities.

In assessing the current situation of technological research institutions in Brazil, it is clear that the relationship between government research institutions and the industrial sector is precarious and interrupted. Although there are some successful cases, the activities of most research centres do not meet industrial needs.

Table 3. Distribution of industrial–technological research institutions (% in parentheses) in Brazil (1985) according to number of employees and institutional category.

No. employees	Federal and state institution	Private institution	University-related centres	Industry-supported institutions	Total
<20	—	—	13 (46)	3 (44)	16 (25)
20–99	3 (12)	2 (40)	10 (36)	2 (28)	17 (26)
100–299	3 (12)	2 (40)	3 (11)	2 (28)	10 (16)
300–499	11 (44)	1 (20)	2 (7)	—	14 (21)
500–999	2 (8)	—	—	—	2 (3)
>1 000	6 (24)	—	—	—	6 (9)
Total	25 (100)	5 (100)	28 (100)	7 (100)	65 (100)

Source: Gusmao (1987, p. 33).

The problem lies mainly with public-sector technological research institutions. Other types of centres have less conflictual situations in spite of current problems. These are the captive centres of industries such as auto parts, for example; sectoral institutions for technological research in state-supported monopolies such as oil, telecommunications, and electricity; and, finally, university foundations with links to the productive sector, such as the one at the Universidade de São Paulo.

A common problem of research institutions is that they deviate from their original objectives. It is true that some so-called pure research can be carried out at technological research institutes, and it is also possible for research institutions to complement the training of human resources according to the needs of specific fields. However, these activities should be seen as secondary to the primary objectives of technological research institutions. The costs associated with additional activities should not consume more than 20% of institutional budgets under normal conditions.

The anomalies were verified in several Brazilian research institutes that duplicated the role of the university. The constant changes in government programs imposed on those institutions and the obsolete laboratories made the situation worse. Researchers and politicians tend

to be more concerned with the success or failure of research projects than with analyzing the performance of research institutions. Gómez (in Chapter 2) reminds us how important it is to study the performance of research institutes and the variables associated with their creation, development, and performance. In any analysis one must bear in mind the objectives of the institution (specialized versus diffused); the kind of technological information generated (routine versus creative); the type of penalties (individual versus collective); and, finally, the environment surrounding the institution (calm atmosphere or competitiveness).

The majority of institutions mentioned have not become instruments to support the technological development of Brazilian industry. As Souza Neto (1986, p. 92) has pointed out:

> Industries have used other means to obtain technology.... Acknowledging the heterogeneity among institutes, there were few successful examples of development and technological transfer for the national industry and, even less so, cases of contracts for joint development action.

Data from Souza Neto shows that state research institutions most frequently relate to industry through analysis, essays, consultancies, and technical assistance. These institutions are not sufficiently structured or instrumental to provide leadership in the generation or transfer of technology. Even successful cases have not resulted in awards for the researchers involved. These institutions must increase efforts to strengthen relations with industry and develop new technologies. The strategy adopted must give them autonomy and flexibility; it must also function to diversify and strengthen the financial participation of government.

These institutes were conceived as government instruments to support the technological development of national enterprise. However, this objective has not been achieved. The researchers' fees and the configuration of the institutions have precluded attainment of their goals. They have ended up reproducing parameters of many Brazilian universities that do not favour relationships with the productive sector.

Brazil's National Space Research Institute (INPE) was created by the federal government in 1961. Today, with 1 500 employees, INPE is in

charge of carrying out civilian research and development activities related to space and its applications.

A study by Kataoka et al. (1987) suggests that researchers are the main source of project ideas used by institutions. These ideas may be inspired by technical publications and exchanges with other organizations, or based on previous training and experience. This immediately leads to the "science-push" position. To benefit from research efforts, the community of users must ensure that institutional activities are transferred. This has in fact occurred with two important products from INPE, meteorology and remote sensors.

In Brazil, activities related to space technology do not have a high enough volume of production to motivate major industry participation. Other countries developing space technology, such as France and the United States, have adopted better interaction mechanisms between research centres and industry.

In Brazil, a split occurred between INPE and industry when INPE adopted, in its technological segment, mechanisms similar to those used in space science and in applications (meteorology and remote sensors). Government hesitation and changes in the state structure also helped to discourage interaction with industry.

The position of Brazilian industry on research institutions has been highlighted in a study by the National Confederation of Industry (CNI 1988, p. 19). It states that there is little integration between universities, research institutes, and productive enterprise. It also argues that

> in spite of the existence of some centres of excellence with a highly reasonable level of integration with industrial enterprises, there is still a rather high lack of communication between the research activities conducted in universities or research institutes and industrial enterprises; 65% of the entrepreneurs participating in the Brazilian Industry Competitiveness Evaluation Group consider that the state of such integration is inadequate.

Several factors inhibit a productive relationship between research institutions and industry:

- Industry's lack of preparation to receive development, in terms of technical training;

- Lack of integration between industry and the research institution from a project's inception (teams should work together, using the facilities of the research institute);
- Problems with adequate technical documents;
- Uncertainty about the nature of the enterprise to receive technologies or processes developed by research institutes;
- Difficulties in contractual negotiations surrounding the transfer of the technology between the institute and the entity receiving it; and
- Limited institutional effort expended in stimulating and strengthening technology transfer and the link to industry.

From the standpoint of industry, the consequences of the separation between research institutions and enterprises are

- The existence of techniques developed by research institutions that have not been commercially explored;
- The presence of an interaction that allows the research system to explore matters with the capacity of economic application; and
- The presence of a rigid entrepreneurial attitude that is not inclined to look for technological solutions outside company walls.

Kataoka et al. (1987) also looked at the other side of the coin by analyzing a sample of three technological research institutions. The most serious problems and consequences identified were

- The departure of qualified personnel due to low salaries reduces the level of technical experience;
- The lack of formal technical documents during project implementation makes technological transfer more difficult for the client;
- Bureaucratic obstacles to importing equipment needed for projects discourages the adoption of new research and development lines and inhibits the technological innovation process;
- Cumbersome management practices and limited use of consistent criteria and techniques for evaluation, planning, and project control result in poorly conceived projects and cost overruns;
- A lack of specificity in allocating project funds means that allocation is done without a plan and only when needs arise. This can result in

the use of resources not included in the timetable and delays in the execution of project activities;

- A lack of sufficient financial resources for developing new lines of research and development means accommodation to already established lines and a loss of innovation capacity; and
- An unsatisfactory level of communication between programs and departments can duplicate efforts. A lack of critical information for undertaking different tasks can decrease the productivity of research institutions.

The Weakening of Technological Research Institutions

The deviations of industrial technological research centres and institutions have harmful effects on "industrial competitiveness poles," a concept used by Stoffaes (1990, p. 37). He argues that a nation's competitiveness is based on the capacity of all of its companies. But because these companies are part of a national environment, competitiveness is not limited only to companies; it also brings along collective elements that result in a competitive industrial mesh. According to Stoffaes, the competitiveness poles

> are formed by a group of enterprises linked together by inertia relations; they stimulate one another at all levels (computers offer markets for integrated circuits), laterally (aeronautics and electronics).... Competitiveness is based on work, research, innovation and product quality.

Understanding this concept implies a recognition that Brazil's scientific–technological–industrial base formed during the late 1960s and 1970s needs strengthening. The symptoms of a collapse have already been felt by some sectors, and urgent steps must be taken. The technological backwardness of Brazilian industry was discussed in a study summarized by Suzigan (1990). The study noted a substantial reduction in investment during the 1980s. There was also a delay in the growth pattern of industry in terms of modernizing installations, implementing research and development activities, and using contemporary technology

for the manufacturing processes, quality control, and managerial approaches.

The impact was seen in a slowing of the development of industries and activities representing new paradigms, with the partial exception of informatics. According to Suzigan (1990):

> In general, the Brazilian industrial companies, in contrast with the international pattern, still present low levels of productivity, deficient quality of products, high costs, low inventory turnover, slow response to demand and low level of flexibility in production — as indicated by the low use of "just-in-time," little training of versatile workers and high average time for the preparation of the equipment. Thus, one can say that the international competitiveness of the Brazilian industry is still based on the intensive use of natural resources and energy and in factors such as low salaries and subsidies.

Concluding the analysis, Suzigan mentions some important special cases. The auto parts and aeronautics sectors are two examples. In the former, research centres were created in the industries themselves (the so-called captive research and development centres); in the latter, government research institutions brought up the rear.

Turning to exports may be a possible way out for Brazilian industry. Nevertheless, Suzigan warns that the generalization of the export model is "simplistic and naive," due to the features of a technologically heterogeneous industrial machinery that is part of a socially unbalanced country. The low cost of labour discourages the modernization of facilities and productive routines.

The industrial base that requires transformation is extremely heterogeneous. In Brazil, high-technology sectors coexist with traditional sectors whose rustic production techniques are seemingly immune to change. Even when considering just one sector, it is possible to observe a revealing asymmetry that brings about the clash between technologically advanced enterprises with companies of reduced efficiency.

The problem of scale production still precludes the generalization of the export industrial model. An important manufacturer from the auto parts sector has pointed out that in almost all countries — including Brazil — there is a vast array of situations. Auto parts companies range

from the very small, which work empirically, to the very large, which produce highly sophisticated goods. All of them use some technology, but obviously to different degrees.

In analyzing the captive research and development centres and the role of technology from abroad or from national sources, namely government research institutions, Suzigan (1990) concludes that

> The decision to include in a company a research and development sector is not an easy one. It requires a certain degree of advancement and a certain industrial capacity that really justifies the expense and the risks involved, for burning stages is full of financial and organizational dangers. As long as the company doesn't reach a degree of development to justify that innovation, it is preferable that it resorts to external technology, even if it comes from abroad or from national sources but without creating a structure that is incompatible with its own growth phase.

The preceding arguments justify a reassessment of the role of technological research centres in Brazil and other Latin American countries.

Strategies to Link Research Institutions and Private Enterprise

Industrial and technological research centres must behave according to the parameters of industrial enterprises and conform to guidelines set out in a country's scientific–technological–industrial policy. Because it is necessary to understand the behaviour of industrial enterprises, strategies need to be specified to point to the actions of an industry, especially its research and development centres.

During times of unrest and crisis, expenditures are often reduced, and research and development activities are seen as wasteful. In fact, in terms of the uncertainty of the results, they undergo a strong slowdown. However, a country's investment in science and technology can guarantee an innovative competitiveness, which is of vital importance in helping industry survive critical periods.

Some industrial sectors justify the importance of this innovative position and participate extensively in research and development. Data from the National Association of Research and Development Centres of

Industrial Enterprises reveal that the chemical and petrochemical sector is responsible for 29% of total investment in research and development, the metallurgical–mining–iron sector is responsible for 19%, the electric–electronic–communications sector for 11%, the machines–equipment–instruments sector for 11%, the foodstuffs–beverages–tobacco sector for 7%, and the paper–cellulose sector for 3%. These sectors can facilitate the insertion of the country in the international productive system.

Industry's technological leap must take into account sectoral efforts and combine them to achieve the common objective of development and social progress. This requires more than merely increasing resources invested in science and technology from 0.6 to 2% of GDP, it demands an adequate articulation and evaluation of the components of the entire science and technology system.

Objectives must be expressed, priorities chosen, and programs and projects outlined. Management must be competent, and the evaluation system must be transparent. The industrial enterprise must have a technological plan and act in an environment that stimulates industrial development and innovation. It must determine an acceptable level of technological dependence on technology suppliers.

A technological strategy starts with an analysis of a company's current situation. Its internal profile is assessed, along with its business units, its comparative advantage, its strengths, and its limitations. Then, changes in the external environment are identified in political, economic, and technological areas. Analyzing the external environment involves describing the evolution of technologies dominated by the enterprise as well as those emerging technologies capable of revolutionizing its own productive processes. The invention of the transistor and the future potential of super-conductibility are examples of new parameters in technological evolution. They are breakthroughs that mark the dawn of a new cycle in technological change; they should be foreseen by the industrial enterprise.

The main components of a technological strategy for an industrial enterprise are

- Routine measures that seek to enhance productivity and quality;

- Innovation projects that guarantee the necessary technology for modernization and expansion; and
- Entrepreneurial action to face unforeseen technological disconnections, the promotion of strategic alliances, or investment in new business units.

In dual economies such as Brazil, development occurs in a succession of rapid cycles of growth and recession. Most industrial enterprises tend to follow these cycles by investing and expanding production during times of growth and hibernating during recessions. During a recession these enterprises maintain their efficiency in the productive process, protect their existing markets, and reduce investment in all innovative activities.

The innovative entrepreneur anticipates rather than follows the economic cycles, promotes innovation by anticipating market needs, and adopts the decisive technologies of technological research institutions. Therefore, it is recommended that the management of enterprises and research institutions play a more active role to accompany emerging technologies.

Finally, it should be noted that new technologies such as informatics, automation, genetic bioengineering, and new combinations impose an explicit technological strategy for industrial enterprises and research institutes, one that must be inserted in long-term planning processes.

An Agenda for the Future

An agenda for future research specifies topics that could promote the building, strengthening, and upgrading of industrial–technological research institutions in Latin America.

Heading the agenda is the need to identify the factors contributing to the slow growth and weakening of these institutions. Because this concern underlies all other topics on the agenda, it should be the main focus of research. The following are signs of obvious weakness: the almost vegetative survival of many research centres, the splitting up or loss of motivation on the part of research teams, and the lack of

communication between technological research institutions and industrial enterprises.

The agenda's overall goal is to delineate the research subjects that contribute to the establishment and consolidation of highly skilled industrial–technological research institutions attached to industry. Research should identify and analyze the causes of growth retardation and the weakening of industrial–technological research institutions in Latin America and propose policy guidelines for strengthening these institutions.

The following topics permit the assessment of the research institution: national, regional, and international contexts; sectoral contexts; organizational components; human components; and microregional or local components. Presented here is a summary of the policies, strategies, and actions that would facilitate the recovery and consolidation of industrial–technological research institutions.

1. Policies affecting the institution
   - ✦ Government industrial–technological policies
   - ✦ Industrial competitiveness poles
   - ✦ Technological plans of industrial firms
2. Design of policies, projects, and plans
   - ✦ Continuity and concentration in the allocation of resources
   - ✦ Technological "mix" and mobilization programs
   - ✦ Stable and "tuned in" government policies
   - ✦ Association with the private sector
   - ✦ Study of the impact of technological poles and packages
3. Institutional strategies
   - ✦ Improve and motivate human resources
   - ✦ Increase the trustworthiness of products and services
   - ✦ Promote market orientation
   - ✦ Anticipate new technology
   - ✦ Stimulate the surge of "project champions"

4. Immediate institutional actions deriving from the strategies
   - ✦ Re-equip and update the laboratories
   - ✦ Recycle human resources
   - ✦ Integrate the institution's activities
   - ✦ Improve the institution's organizational structure
   - ✦ Create forums for assessment and orientation
   - ✦ Rediscuss the creation and analysis of projects
   - ✦ Rediscuss the planning and evaluation of projects
   - ✦ Increase the support for technology transfer
   - ✦ Stimulate research and development projects in collaboration with industries
   - ✦ Disseminate a competitive, efficient, and trustworthy image.

CHAPTER 8

HEALTH RESEARCH INSTITUTIONS

José Gabriel Carrasquilla

✦

Research makes an important contribution to development. In light of the fact that support to research should encourage self-sustaining development, strengthening institutions is much more effective than financing individual projects.

Before a working hypothesis can be developed on the factors that affect health research in Latin America, the term health research must be defined and the health situation in Latin America must be described. Health should be understood in a comprehensive context, not merely as something to be recovered after an illness. The Commission on Health Research for Development (CHRD 1990) defined health research as "the generation of new knowledge, using the scientific method, to identify and face health problems."

Research must be directed toward improving health. The final result will be measured in terms of the morbidity or mortality of a given population. Bearing this in mind, the health situation in Latin America is complex: the epidemiological situation varies from country to country, region to region, and even among social groups.

The health situation in Latin America has undergone a transition, which contrasts with countries in the developed world and with countries in Africa and Asia. On the one hand, there are marginal areas in big cities and scattered rural areas with persistently high rates of mortality, especially among infants and children 5 years of age. Here, the most common diseases are diarrhea, acute respiratory infection, intestinal multiparasitosis, malaria, and tuberculosis — the so-called "diseases of underdevelopment."

In urban areas, on the other hand, there are chronic diseases such as hypertension, diabetes, and cancer occurring with greater frequency — diseases that have already become the leading causes of death in many countries. Finally, the large urban areas of Latin America are facing the same problems as urban centres in the North: violence, accidents, drug abuse, mental illness, and depression. This makes it difficult to establish priorities for allocating health resources and difficult to allocate funds for health research.

If health research is to answer the most important health questions and solve real health problems, clear national policies are needed, as well as mechanisms to endorse and promote scientific activity. There are numerous complex health problems, and many are related to sectors such as food production, public service infrastructure, and the actual delivery of health services.

Health, especially individual and community health, is often seen as something that can be divided into mutually exclusive compartments rather than viewed along a "multidimensional continuum." The former view is commonly held in the field of health research and, as will be discussed, it is also common to health research institutions, as they have concentrated on specific problems throughout their development.

To be truly useful, research must take into account all aspects — biological, social, and cultural — of the health–disease process. Individual and community health is influenced by many factors. The more that is known about a disease and the more that social, cultural, behavioural, economic, and ecological factors are recognized as affecting health, the more complex is health research.

The determinants of disease are changing. Important demographic factors must be taken into account. For instance, the population of children under 5 years old will increase by 2% between 1985 and 2015, while in Asian and African countries, the same population will increase by much larger quantities (Jamilson and Mosley 1991). Health research must shift its priorities from a maternal–infant orientation to issues affecting societies with a different age structure.

The approach to health service delivery also provides guidelines for research. Research provides the tools to solve patients' problems in terms

of diagnosis, treatment, and rehabilitation. Health indicators reflect the approach to providing services. The way institutions view the concept of health and health-care delivery influences the orientation of research.

Overview of Health Research in Latin America

Research on health has changed along with socioeconomic conditions and shifts in thinking about health. García (1981) points out that changes in health institutions reflect changes in the social structure; the same is true for scientific research on health. There are three stages in the development of health research in Latin America.

In the first stage, from 1880 to 1930, research focused on bacteriological and parasitological problems linked to the agro-exporting industry and was characterized by state-sponsored research in the field of hygiene. The first health research institutions were set up by governments during this period. They were established mainly to conduct research on bacteriology and parasitology and to produce vaccines and serums for the most common diseases affecting humans and cattle (Table 1).

An analysis of early health research highlights some factors associated with institutional success in Latin America. The conditions creating the potential for scientific development were the development of the agroexporting industry and the growing control of state power by agro-exporting producers, which tended to result in research conducive to their economic interests. Hence, it is no surprise that the first Latin American countries to establish health research institutions were also the first in which agroexporting producers were able to gain control of state power: Argentina, Brazil, Chile, and Uruguay.

It is interesting to note that only two institutions were set up to study fields other than microbiology and parasitology during this stage: the Institute of Physiology and the Cancer Institute in Argentina. In Central America, health institutions did not emerge until the late 1930s, when the Rockefeller Foundation made an important contribution to the

Table 1. The origin of health research institutions in Latin America.

Country	Institution (year established)	Nature	Orientation
Argentina	Instituto Nacional de Higiene (1892)	State	Bacteriology and parasitology
	Instituto de Fisiología (1919)	University	Physiology
	Instituto de Cáncer (1923)	University	Cancer
Bolivia	Instituto Médico Sucre (1895)	Private	Bacteriology
Brazil	Institutos de bacteriologia, vacunació y química (1892)	State	Microbiology and bacteriology
Chile	Instituto de Higiene (1892)	State	Hygiene, statistics, chemistry, microscopy, bacteriology
Colombia	Laboratorio Central de Lepra (1907)	State	Leprosy
	Laboratorio Samper-Martinez (1917)	Private	Bacteriology
	Laboratorio Oficial de Higiene (1919)	State	Bacteriology
Costa Rica	Laboratorio Hospital San Juan de Dios (1914)	Hospital	Medical care
Ecuador	Laboratorio Químico (1905)	Academic	Pest study
El Salvador	Laboratorio de Bacteriología (1922)	State	Bacteriology
Guatemala	Laboratorio Bacteriológico (1927)	State	Bacteriology and parasitology
Honduras	Instituto de Vacuna Jenner (1911)	State	Vaccines
Mexico	Instituto Médico Nacional (1880)	State	Flora, Fauna, geography, medical, national climatology
	Instituto Nacional de Bacteriología (1905)	State	Bacteriology
Nicaragua	División de Laboratorios e Investigaciones (1925)	State	Bacteriology
Panama	Instituto Gorgas (1930)	International	Tropical diseases
Paraguay	Laboratorio Bacteriología (1899)	State	Bacteriology, cattle diseases, preparation of antipest serum
Peru	Instituto Vacinal (1896)	State	Vaccines, serotherapy
Uruguay	Instituto de Higiene Experimental (1895)	University	Yello fever serum and vaccines
Venezuela	Instituto Pasteur de Caracas (1896)	Private	Vaccine preparation

Source: García (1981).

development of institutions involved in research, production, and diagnostic services.

The second stage, from 1930 to 1950, saw the emergence of basic clinical research. This emanated from the growth of hospitals that was part of the industrialization process. From 1940 on, research was conducted mainly in large hospitals, where studies could be carried out on patients. Many professionals went abroad for training, especially to Europe, and returned to Latin America to do their hospital practice. Hospital research adopted a clinical and therapeutic orientation during this period.

The third stage in the development of research corresponds to the second half of the 20th century. Starting in the 1960s and picking up in the 1970s, there was a renewed interest in tropical medicine. This was prompted by an interest in cattle production and concern about outbreaks of tropical diseases, such as malaria, as a result of the failure of global programs designed to eradicate them.

Research also began to take a more comprehensive approach to health during this stage and started to take into account the social, cultural, and economic factors linked to health. This coincided with the emergence of a more multicausal understanding of disease advocated by American epidemiologists such as Lilienfield, MacMahon, Rothman, and Miettenen in the second half of the 20th century.

The advent of the Special Training and Research Program on Tropical Diseases (TDR), sponsored by the World Health Organization (WHO), the United Nations Development Programme (UNDP), and the World Bank began a new era in research on tropical diseases for developing countries. Established in 1978, TDR had two objectives. The first was to develop preventive, diagnostic, therapeutic, and vector- control methods to prevent, treat, and control the most important tropical diseases. The second was to strengthen the institutional capacity of countries affected by tropical diseases. By 1988, 50 research institutions in developing countries had received support from the program.

The Rockefeller Foundation and TDR have recently joined forces to launch an important North–South cooperation program. The former provides support to tropical disease research institutions in Africa, Asia,

and Latin America, and the latter funds institutions in Europe and the United States so that North–South relationships can be established and joint research activities undertaken. These partnerships place Latin American institutions on an equal footing with the research institutions in more economically advanced countries, enabling the former to participate in technologically advanced research and the latter to apply technology in areas where problems are located.

In this last phase, interest in infectious diseases common to the developing world has returned. The dimensions of the problem have been expanded to consider not only the micro-organisms causing disease but also the factors that contribute to the prevalence of the disease in communities.

Health Research Institutions in Latin America

Research institutions in the health sector in Latin America can be classified into different categories; categories that are not mutually exclusive (Table 2). The nature of a health research institution largely

Table 2. Classification of health research institutions in Latin America.

Criteria	Classification
Nature of the institution	Official research institution
	Official university
	Private university
	Private institute, foundation
	Service-rendering institution
Nature of research conducted	Basic biomedical research, based in laboratory
	Clinical research
	Applied research, adapting knowledge to specific cases
	Social science and health research
	Health service research
	Epidemiological research
Objectives	Identify and establish priorities in different health problems
	Guide and accelerate the application of knowledge to solve health problems
	Develop new tools and strategies to deal with health problems
	Advance basic knowledge

determines the type of research that is conducted. It is possible to identify the leading interest behind the development of certain lines of research in an institution. Whereas official institutions can usually determine their lines of research autonomously, private institutions that receive foreign funding may have to follow lines of research prescribed by international organizations.

According to the classification in Table 2, subgroups such as official or private-sector institutions, health care institutions, or universities can be identified. The nature of an institution also determines the extent of its dedication to research. Some institutions, such as private research institutions or foundations, are dedicated exclusively to research. Others, such as public-sector research institutes, may provide diagnostic services or serve as reference centres in addition to conducting scientific work.

Universities, which should in principle produce important scientific work, actually devote much of their time to academic chores. Universities are able to take more initiative in determining lines of research. Because of their multidisciplinary character, universities can conduct studies describing the characteristics of common health problems in a comprehensive context, taking into account social, cultural, and geographic factors as well as biological ones. Multilateral organizations such as WHO and government sources are more likely to provide support to universities for research purposes.

Public-sector research institutions were the first health research institutions to be established in Latin America. These institutions account for a large proportion of qualified researchers. They are able to send their professionals to train in developed countries through scholarships provided by international agreements between countries and multilateral aid organizations. The full-time dedication of researchers in these institutions enhances the quality of research and the productivity of researchers. These institutions generally develop their own personnel and help to train researchers for other institutions. Being national in scope, these institutions also function as reference centres for diagnostic services, vaccines, serums, and diagnostic methods. They count on available technology to carry out research.

Dependence on government budgets often facilitates the purchase

of technology and equipment, but makes lines of research less stable. Included in this group are national institutes of health, reference laboratories of health ministries, and other government organizations. These institutions receive much of the funding available to research in Latin America (Table 3). In Colombia for example, 31.1% of funding for health research goes to these public-sector institutions. These institutions often lack the flexible administrative mechanisms that contribute to good management.

The largest proportion of health researchers in Latin America are employed by public universities. For example, in Columbia 75% of all researchers work here. Although the universities also send their faculty abroad to study, they are less likely than public-sector institutes to retain qualified personnel. Very few researchers are able to work full-time on scientific activities. In general, university faculty are required to dedicate most of their time to academic activities, leaving less time available for research.

Because universities are often associated with hospitals where training in medicine and health takes place, an important component of their research is clinical. Public universities tend to do more research in the social areas of medicine and ethnomedicine than the official institutes.

A small group of health researchers in Latin America are associated with private universities. Here, the teacher to graduate ratio is lower, as is the number of full-time researchers. These universities provide training

Table 3. Distribution (%) of projects, financial resources, and number of researchers acording to institutional character in Colombia, 1989.

Institution	Projects	Financial resources	No. researchers
Public university	69.8	38.3	64.8
Private university	8.4	7.6	10.2
Official institutes	7.5	31.1	9.5
Others (government)	7.3	17.0	9.2
Private institutions	7.0	6.0	6.3

in the health field and offer postgraduate programs on a smaller scale than public universities.

Because of the new orientation of medical education in the 1980s, which includes less specialized training and visits by students to the first and second levels of health care, the private universities have become more interested in the sociocultural aspects of health research such as basic sanitation. They also frequently conduct research in service delivery, the efficiency of hospital administration, and other management issues related to the health sector.

Although private institutes and foundations employ fewer research staff than public institutions, they have a greater capacity to retain them. Employing research staff on a full-time basis also improves the quality of research in these institutions. These organizations have access to advanced technology for research purposes as a result of their close links with international institutions, which they sometimes represent, and their external sources of financing. They frequently establish cooperation agreements with international organizations.

These institutions are generally well managed and their administrative efficiency results in a good use of resources. They tend to search for self-sustaining mechanisms that provide greater administrative stability. They have created councils, where both managers and directors are represented, that contribute to good administrative practice. Members of these councils are also in contact with the external environment, which helps the institution to secure financial resources.

Service-delivery institutions have few resources, human or financial, to devote to research. Research is usually oriented toward clinical and treatment areas and meeting the needs of patients. These institutions tend not to be concerned with improving their management capacity. With budgets devoted to the provision of services, they have limited financial resources for research.

Service-delivery organizations offer little stimulation to researchers. In these institutions, the development of research depends almost exclusively on the interest and personal motivation of the researcher. These institutions do not have a research culture that recognizes scientific work, provides incentives, or motivates new researchers.

Research institutions in general, and health institutions in particular, can be divided in two groups, taking into account the aspects of research they seek to develop, the types of questions they address, and the kind of knowledge they generate. The first group is geared toward solving fundamental technological or methodological problems. This is the type of research that, with sufficient resources, can be conducted anywhere in the world. The second group includes institutions that conduct research on ecological, epidemiological, and social aspects of health and disease, the application of new knowledge, and the implementation and assessment of potentially beneficial interventions. This type of research must be done in the countries or geographic areas where a particular problem exists.

A brief review of research conducted in Latin America will help locate institutions by the type of problem studied and methodology used. A study of 1 725 researchers from 11 Latin American countries by Duarte (1986) found that 38% were dedicated to the basic sciences, 36% to clinical specialties, and only 16% to public health. The latter includes epidemiology and the administration of health services. It can be inferred from this data that most Latin American researchers are not engaged in describing common health problems, nor are they seeking alternatives that will improve health-service delivery. These two areas of health research must be conducted in the countries experiencing the problems.

Data from Asian countries and Mexico show that most research is of the biomedical, clinical, and laboratory type. Very little research has been done in the areas of information systems, epidemiology, or behavioural sciences.

Many health problems in Latin America are not being researched at all. Only in isolated instances have institutions chosen to study health problems in a comprehensive fashion, taking biomedical, sociocultural, and epidemiological factors into consideration. Many common diseases in Latin America, such as tuberculosis, must be studied in the region, because they are no longer as prevalent in developed countries.

It is evident that the global resources allocated to health research are not in line with the priorities of developing countries. Although 34% of deaths worldwide are caused by infectious and parasitic diseases, the

same proportion of health budgets is not spent on these diseases. For example, 600 USD is spent for each death caused by AIDS (acquired immune deficiency syndrome), but only 20 USD is spent for each death caused by a tropical disease.

Institutions can be classified according to the type of research conducted: basic research, clinical research, applied research, research in social sciences and health, health services research, and epidemiological research. This takes into account important characteristics such as human resources, available technology, and sources of financing.

In general, basic research is conducted at public or private research institutes and in universities. It requires carefully trained researchers, most of whom have been trained in the laboratories of developed countries. These institutes do not generally provide training themselves. A large proportion of researchers are able to devote attention to their scientific work on a full-time basis. They have good access to scientific information through subscriptions to periodicals and often have the opportunity to attend international meetings and congresses. These institutions publish the most scientific documents. Technology, usually contributed by foreign donors (such as TDR), is available to advance the institution's technological development. Although there are some national financing opportunities, most funding comes from external sources.

In general, clinical research is performed at service institutions where research takes a backseat to other activities. Professionals dedicate most of their time to providing health services and very little time to knowledge production. Recently, the preparation of clinicians for research has increased, through clinical trials, for example. Although some university hospitals with clinical residencies require research as part of postgraduate medical training, this seems to be the exception rather than the rule. Financing is frequently provided by private firms and pharmaceutical laboratories to conduct therapeutic trials and test new diagnostic methods.

Universities take the leading role in applied research. Although researchers in this field do not need to be highly trained, they do require a high degree of motivation. They must also have access to current

information. The scientific productivity (in terms of papers published) of universities involved in applied research tends to be lower than in institutions dedicated to basic research. Less complex technology is required for applied research than for basic research. Efforts are usually made to adapt technologies to the needs of the country or area where an investigation is being carried out. It is relatively easy to obtain financing from both national and foreign sources because of interest in adapting technologies and new discoveries to local conditions. This type of funding is more often directed to project support than to institutional strengthening.

Research in the social sciences and health has advanced considerably over the last 15 years. Health researchers in the universities are often situated in departments outside the health sciences. The disciplines of sociology and anthropology have been quite involved in analyzing and researching health problems; more so than economics or administration. This research does not require complex technology for diagnosing diseases; it does require good training in the relevant disciplines. Organizations supporting this type of research include multilateral aid organizations such as WHO, which has funded professional training in this area. Other sources of funds are international organizations such as foundations, as well as government and private funding sources in the countries themselves.

Research on health services is mostly carried out in the university. Since the establishment of the strategy of primary health care and the objective of health for all by the year 2000, research interest in the health services field has been increasing. Questions of how to increase coverage, improve quality, and boost efficiency are all current challenges in health services. The growing costs of health care faced by other countries must also be addressed. There are few researchers trained to work in this area and few financial resources for research. Delivery institutions use their limited resources to provide services; research is not considered a priority.

Epidemiological research is concentrated primarily in universities and institutes such as the Institute of Public Health of Mexico. Postgraduate courses designed to train epidemiologists have been established in the region. Many epidemiologists trained in excellent universities in the

United Kingdom and the United States have returned to Latin America in recent years to conduct research and help train others. Institutions and researchers in this field do not require sophisticated technology, except for good systems to analyze data.

Health research can also be analyzed according to the objectives of the institution. Identifying and prioritizing health problems is the first step in the complex pattern of health research. This is a descriptive task that involves identifying the most common health problems in a region, country, or specific geographical area. Information from this type of research is used to plan health services and allocate health resources.

This task, which is the responsibility of government organizations, is not performed very well. Unfortunately, information is not collected with enough scientific rigour to obtain valid data about health problems. Health-care institutions, starting with the ministries of public health themselves, do not have the capacity for recording the information needed. Information systems are technologically obsolete, and the resources and political will needed to update them do not exist.

Applying knowledge to solve health problems is the second stage in health research. Health research institutions in Latin America, as in most other developing countries, tend to concentrate their activities in this area. They use knowledge generated by institutions in other parts of the world to solve health problems. This type of research involves applying technological advances for diagnosing and treating common diseases in the region and identifying the risk factors linked to disease prevention. Institutions such as public universities and research institutes have the capacity to adapt and apply new technologies. Economic resources for this purpose may be available from commercial firms. Firms that sell equipment have an interest in adapting new technology, which guarantees the future use of their products.

Health research also results in the identification of risk factors associated with morbidity and mortality. Once these factors are identified, the application of new knowledge calls for intervention and decisions about resource allocation. Health services in charge of this process are sometimes faced with bureaucratic delays, hesitation, and reluctance to change. Sometimes decisions may result in high costs that fall to the

users of health services. Government is the main source of funding for this type of applied research.

Developing new instruments and strategies to deal with health problems is the next stage in health research. Here again there is a distinction between technology and public health. New technological tools for diagnosis and treatment are usually developed in the research centres of industrialized countries. However, the health-research capacity of developing countries will no doubt be strengthened through the North–South linkages between research institutions encouraged by the joint program of WHO and the Rockefeller Foundation.

Public-health research has greater potential for Latin American health institutions. Considering that social and cultural factors interact with biological factors to affect the health of individuals and communities, research can produce new strategies to deal with health problems. Universities tend to be best equipped to undertake this kind research, one of the main reasons being their capacity for establishing interdisciplinary research teams. Funding for this type of research comes from international and national sources. Because emphasis on public health research has increased over the last decade, some institutions have been strengthened enough to embark on research in epidemiology, social sciences, and health.

The most advanced level of scientific research involves generating new knowledge. Not only does this research require highly qualified personnel but it also demands a critical mass of researchers to permit ongoing exchanges about new scientific discoveries. It requires cooperation between institutions as well as technology and sufficient resources. Conditions in Latin America generally do not favour this form of health research. The joint WHO–Rockefeller Foundation program will help to link more closely the research institutions in developed and developing nations.

Factors Affecting Institutional Success

Institutional success is a complex concept to define. It is difficult to determine the characteristics of the process and the factors involved in an institution reaching "maturity" and "stability." One could say that

successful institutions are those that have financial independence, the autonomy to define their own research objectives, recognized scientific production, and the capacity to modify their environment (such as the capacity to help control diseases that affect the population). This success is confirmed by the recognition given by national and international scientific communities.

Factors affecting institutional success and failure (independent variables) can be classified according to their relationship to the institution: extrainstitutional, institutional, and interinstitutional.

Extrainstitutional factors

Extrainstitutional factors have to do with the environment outside research institutions. They refer to health and research macro policies, health problems in need of solution, scientific culture, and the need for research. Because these are macro factors, they can serve as a useful means to compare the success of health research institutions between countries.

The first stage in the development of health and research macro policies consisted mostly of biological research aimed at identifying microorganisms causing infection. This was defined by the most important problems facing agroeconomic expansion at the time. A second stage corresponded to research on hospital development that came out of the industrialization process. The third stage returned to disease-causing factors in an effort to generate a more complete understanding of factors that are social and cultural as well as biological.

Special emphasis in research is being placed on tropical diseases and human reproduction. Both are related to important macropolicy issues such as the resurgence of tropical diseases stemming from the failure of eradication measures taken during the 1950s and 1960s and to the demographic growth of the region. Research on health-service systems is also being undertaken because of its importance as a factor in reducing the cost of such services.

Every country should have social and economic processes that direct scientific research according to its resources, culture, institutional system, and social values. A country's health-research policy must be

consistent with its training of human resources, delivery of health services, and health requirements. In addition to policies that stimulate research, countries need to define structures, organizations, and mechanisms to finance research. Priorities should also be set in accordance with major national health issues.

The factors that integrate this independent variable are related to

- The existence of a national research policy backed by legal instruments and operationalized by special procedures to define priorities, allocate resources, and train researchers;
- The relationship of research undertaken by different institutions; and
- National and internationally defined priorities.

Institutional factors

Institutional factors refer to an institution's capacity to

- Attract highly qualified researchers;
- Train new scientists and maintain their motivation;
- Possess technological resources appropriate to the complexity of the research undertaken;
- Establish contact with the environment and respond to (or influence) external changes;
- Develop good scientific, adminstrative, and financial management skills; and
- Obtain the financial resources needed for research.

Institutional factors explain the viability of organizations. They refer to the institution's capacity to compete (or complement and interact) with other research institutions within the same political, economic, or scientific context.

Education and training — Successful research institutions need researchers with adequate training. Researchers with solid academic training are required to produce high-quality research. In most Latin American countries, the proportion of researchers with postgraduate

training is still very low. Exceptions are Argentina, Brazil, and Mexico. According to a survey conducted in Colombia by COLCIENCIAS in 1982, only 3.7% of health researchers held a doctorate and 17% held a master's degree.

Another reason research institutions with substantial numbers of doctoral level researchers are more likely to attain institutional success is that trained researchers are more capable of clearly defining areas for investigation and determining projects they want to pursue. This increases the institution's ability to initiate its own lines of research. Important variables to consider are the number of researchers holding doctorates or master's degrees and where researchers receive their training.

Time devoted to research — Institutes, mainly private ones, that can devote staff resources to research on a full-time basis can be more successful than those that cannot. Full-time university professionals have scholarly and adminstrative commitments that prevent them from devoting their time exlusively to research. In Colombia, the COLCIENCIAS survey showed that 89% of researchers dedicated only part of their time to research activities.

The most important variables here are the time dedicated by researchers to scientific activities and the time dedicated to activities such as teaching and management.

In-house training and development — The professional development of researchers contributes to institutional success in research. The Instituto Venezolano de Investigaciones Cientificas (IVIC) is an interesting example of an institution that, although not associated with a university, has made a commitment to train its own researchers. IVIC publishes a large body of scientific work in international magazines and books and has developed postgraduate programs in many different areas. Instead of sending students overseas, they prefer to bring in professors to the Institute.

With respect to training and professional development, the variables to be considered are

- The institution's contribution to the training of researchers;
- The characteristics of the postgraduate programs in health sciences; and
- The curriculum during training (like research and thesis requirements).

Incentives — An institution is more likely to be successful in its scientific work if it can retain its researchers. First, such an institution is more likely to have a defined and sustained line of research; second, it will tend to produce more scientific work. Clear incentive policies must be established so that scientific success generates rewards for scientists. Because researchers in Latin America do not receive the same compensation as their counterparts in developed countries, they frequently emigrate in search of incentives. Economic incentives are not enough; career development plans must be offered to researchers as well. These can include opportunities to work under the guidance of more experienced researchers.

Mexico is an example of a country with a clear policy aimed at providing incentives and promoting researchers. Under the National Researchers' System created in 1984, scientists evaluate themselves. There are four categories within the system. A tax-free salary overhead can be as much as 50% of the salary received in an official organization. The system has resulted in a dramatic increase in the number of publications produced annually by researchers.

An institution's capacity to retain researchers is closely linked to its capacity to

- Offer competitive salaries and other economic benefits;
- Provide a favourable research environment with a critical mass of researchers that can facilitate professional development;
- Gain access to technology;
- Provide administrative flexibility;

- Provide easy access to publications, bibliographies, and other current information sources;
- Furnish opportunities for participation in congresses and institutional exchanges; and
- Offer opportunities for research work to be recognized.

Technological resources — An adequate infrastructure supports quality research. The availability of physical facilities and equipment makes for better quality research. Different technology is required for clinical research and research in the basic sciences than for public health research. The former require highly specialized advanced technology. Less complex technology is needed for public-health research that is oriented toward the prevention of disease and the promotion of health. High levels of technology are not needed for research in disciplines such as social sciences and epidemiology or for applied research.

Capacity to interact with the environment — Research institutions must be flexible and dynamic to adapt to environmental changes. These changes could be new policies, new laws, or new demands on the part of the community. The International Centre of Cooperative Medical Research (CIDEIM) in Colombia is an interesting example of an institution, once part of an American university, that transformed itself into a totally Colombian institution. It now owns a substantial proportion of its administrative resources. Both the state and the private sector have provided CIDEIM with significant support and the institution's governing council is made up of members from both sectors. With excellent administrative development and financial direction, CIDEIM produces high-quality research, and can be considered a model of success in Latin American research.

Research management — An institution's administrative capacity is an important factor in its success. This variable will affect some of the components of the dependent variable, institutional success. Good management facilitates scientific production by researchers, contributes to the consolidation of the organization, and influences the environment.

Administrative processes concerned with planning, organizing, direction, and control must be carried out in research institutions. These processes strengthen an institution's capacity to define its own lines of research, acquire independence for its basic functions, and influence its environment. Flexible and decentralized administrative mechanisms are most suited to supporting the research process. Highly bureaucratic and centralized institutions create obstacles to research and discourage researchers, lowering their productivity.

Universities and official institutions engaged in health research often face the same problems as other government institutions in the region. Independent institutes tend to possess a greater management capacity through administrative flexibility, a decentralized decision-making process, and simpler, less bureaucratized organizational structures that contribute to a more efficient research-management process. The factors that should be taken into account with respect to this independent variable are

- Long-term planning for institutional development;
- Decision-making processes (delegation versus concentration);
- Definition of priorities and research lines (defined by the institution or funding agencies); and
- Administration of the research process (bureaucratic versus flexible).

Financial resources — International financing for health research is primarily oriented toward solving the problems of industrialized countries. Fully 95% of all expenditures on health research goes to the North; only 5% is used to investigate the health problems of the South. This is in stark contrast to the fact that 93% of potential years lost as a result of early death are in developing countries; only 7% are in developed countries.

Furthermore, the support provided by the North for research on health in developing countries often does not reach these countries. Instead, it is given to institutions in industrialized countries to conduct

research on Third World countries. Out of 950 million USD for health research from the North, 800 million USD, or 84%, stays in the North, supporting researchers working in Northern institutions.

These facts suggest that Latin American research institutions that obtain access to international financing are ones that carry out scientific activities similar to those in economically advanced countries. Therefore, the development of local financing sources is critical to supporting research on health problems in developing countries.

Forty-two percent of all financing for health research comes from developing countries, with governments in these countries providing 95% of these funds. The remaining 58% comes from developed countries. Within this, governments provide 37% of these funds, industry provides 32%, official assistance for bilateral development accounts for 13.5%, multilateral development assistance accounts for 11.5%, and foundations and NGOs account for 6%.

Health research often fails to be coordinated with health needs because it responds to the interests of individual researchers and external financing agencies. Institutions that consolidate financially and have access to resources that free them from anxiety-ridden dependence on new project financing are more likely to be successful in the scientific field.

Institutions may obtain financial support from international organizations dedicated exclusively to institutional strengthening. Providing funds for this purpose is one of the key contributions of the TDR program, however, the amount of funds dedicated to institutional strengthening is still small compared with the amount devoted to project financing. In 1990–1991, for example, funds directed toward institutional strengthening constituted 25.9% of the program's total budget; 63.1% of the budget went to support research projects. Institutions can also generate their own income by selling their diagnostic or consultancy services. They may also have access to other financial mechanisms that enable them to consolidate and count on a permanent source of income for their basic needs. The following factors, related to financing sources

and alternatives for financial consolidation, should be considered as independent variables of institutional success:

- Financial resources of international organizations versus national organization resources;
- Project support resources versus institutional consolidation resources;
- Sale of services and percentage of this income in the basic budget of the institution; and
- Existence of other mechanisms and the use made of them.

Interinstitutional factors

Institutions in the health sector form a triangle. The three angles are represented by institutions that train human resources, institutions that provide health services, and institutions that conduct health research.

Interinstitutional factors refer to an institution's ability to establish relationships for the exchange of information, experience, and resources with similar institutions in the same country and region, with research institutions in developed countries, as well as with institutions at the other two angles of the triangle.

Relationships with other research institutions and membership in health research networks — In the international context, the joint WHO–Rockefeller Foundation program should help to end the isolation of scientific institutions in the developing world and give researchers in developed countries an opportunity to investigate health problems in the areas they occur. This is an important example of an interinstitutional mechanism that promotes institutional success.

In Latin America, a Regional Network of Researcher Exchange for the Development of Latin America and the Caribbean (RIDALC) has been formed by scientific organizations from Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico, Uruguay, and Venezuela. This network has a unit in each of the member countries for research in the health sciences. RELAB, another network, is composed of 12 member countries

that seek to integrate the biological sciences in the region through cooperation in the training of young scientists.

Institutions may choose to start their own publications as a vehicle for exchanging information and research results. Institutions with their own publications tend to last longer. These publications can also provide an important source of financial support through subscription income.

Within a country, it may be difficult to establish networks; fear or incompatibility between research institutions may create obstacles. It is often difficult to establish relationships between public- and private-sector institutions. The same is true for institutions with similar research objectives.

The intellectual isolation of scientists in developing countries reduces the quality of the research and the success of health research institutions in Latin America. Institutions must offer scientists the opportunity for contacts and exchanges with colleagues. Institutional factors to be taken into account include

- Membership in international research networks;
- Scientific publication;
- Resource, experience, and information exchanges between institutions in the same country;
- Coordination with other local institutions on the development of different research lines; and
- Opportunities for researchers to attend congresses, meeting, and exchanges.

Relationship with human-resource training institutions — The importance of a research institution being involved in training its own human resources has been demonstrated. Universities are the main operators of health research. There is often no coordination between institutions engaged in research and those that train human resources.

Relationship with health services — Health research was mainly concentrated in hospitals during the second third of the century. A large part of biomedical research, especially clinical and therapeutic research, is conducted by health services. Coordination, mutual support, informa-

tion, and resource exchange must exist between institutions providing health services and those engaged in research. Colombia offers a good example. The Universidad del Valle in Cali, a leader in health-research medical training in Latin America, cooperates closely with the health service of the Department of "El Valle" and the municipality of Cali.

Recently, a group of Colombian foundations supported a descriptive research project on the current state of social security in the country. The findings have led the Ministry of Labour to propose changes in some important aspects of Colombia's social security system. Important factors must include

- Use of research results by the service-providing institutions;
- Applied or operational research conducted by institutions providing health services;
- Type of relationship established between institutions, and the exchange of resources and information between them; and
- Participation of research institutions in health-sector decisions.

PART III

INSTITUTIONAL PERFORMANCE: WHAT CAN BE SAID, WHAT SHOULD BE LEARNED

CHAPTER 9

FACTORS AFFECTING INSTITUTIONAL SUCCESS

Benjamin Alvarez

✦

Certain themes and hypotheses have recurred in the case studies in Part II of this book. These case studies analyzed how science became institutionalized in organizations devoted to research on the basic sciences, agriculture, health, economics, industrial technology, and education in Latin America. Other chapters presented and systematized recurrent themes and hypotheses from different perspectives.

The purpose of this chapter is to synthesize the key factors in institutional success and to illustrate their validity with case studies of research institutions in Africa and Latin America. Also, in addition to confirming the findings of the case studies presented in Part II, this chapter also attempts to extend the arguments to two more institutions of knowledge: the university and the private firm. Although these institutions may not be engaged in scientific–technological research, they do confront related challenges in their performance.

Much of the analysis in this chapter is based on the following studies: *The Consortium Graduate School of Social Sciences: the process of building an institution* (Bernard 1993); *La formación de recursos humanos en la fundación para la educación superior y el desarrollo de Colombia* (Lora, E., unpublished, 1991); *Estudio de caso: el Centro Rosarino de Estudios Perinatales, Rosario, Argentina* (Rigoli, F., unpublished, 1991); *Estudio de caso de la maestria centroamericana en sociologia de la Universidad de Costa Rica* (Campo, R., unpublished, 1991); and *Appui institutionnel en matière de formation et de recherche* (Amoussou, J., unpublished, 1991), which

analyzes three cases in West Africa. All of the institutions in these studies have received support from IDRC and have programs for training researchers.

Factors in Institutional Success

The case studies exposed five crucial factors for success in research institutions:

- Human competence and motivation;
- Clarity of objectives and capacity to adapt (the supply perspective);
- External pressure (the demand perspective);
- The culture of knowledge; and
- Management strategies.

Three of these factors overlap with the literature on complex organizations and more specifically, with factors identified by Israel (1987) in his work on institutions of knowledge. Clarity of objective is similar to Israel's notion of specificity; external pressure is similar to his notion of competition; and the concept of management strategies seems to be almost identical. The other two factors — human competence and motivation and the culture of knowledge — pertain more to institutions whose primary activity is intellectual creation.

Human competence and motivation

As might be expected, experience managing institutions and empirical evidence seem to agree that the human factor is the most important aspect of scientific production, as it has been throughout the history of science. Because the heart of a research centre's work is the development of thought, the quality and professionalism of its research staff is critical to its success. Ardila (in Chapter 4) observed that "An institution's ability to achieve significant results and use its resources efficiently depends on its capacity to retain qualified staff...high-quality technology requires highly qualified staff...."

However, the training and experience of researchers, although necessary, is not sufficient to sustain scientific research. Individuals and

groups must be motivated to persist with the work. According to Urrutia (Chapter 5), "The principal challenge of any research organization is to keep its research staff motivated." Motivation brings personal commitment. There must be a reward that matches the effort made, but productivity seems to be motivated more by ethical or ideological commitment, the commitments to the institution, and personal professional development (see Chapter 6). Lack of motivation on the part of researchers was cited as one of the main obstacles to institutional development in research on rural economics, health, and social management in Benin, Côte d'Ivoire, and Senegal (Amoussou, J., unpublished, 1991).

The competence and motivation of the research staff must be matched by academic or scientific leadership that is accepted by members of the organization. Leadership directly affects all institutional development activities and is even more important in environments where ideas are constantly under review, where rationality is emphasized, and where formal authority is not readily accepted.

The characteristics of the leadership required changes as the organization evolves. As pointed out by Bernard (1993):

> It seems reasonable to hypothesize that, over the course of an institutional development process, the characteristics constituting an "appropriate leader" would change; moving from an initial emphasis on charismatic professional competence with some managerial capacity, through more of a balance as a wider band of staff and community come to accept the idea of innovation and to expect effective and efficient application, to an essentially management focus with professional expertise useful for enabling expression of an overall coherent framework but no longer necessary to stimulate interest or commitment.

Besides the individual characteristics of staff and leaders, the most efficient research centres can boast a critical mass of researchers with a sense of collegial identity.

Just as the success of an institution of knowledge depends on the competence of the people who work in it, the professional and scientific success of a researcher and the application of research results is closely linked to the overall capacity of the institution. A recent study of a group

of researchers in several countries in Asia, Africa, and Latin America found institutional capacity to be one of the most consistent variables explaining individual success.

The study, conducted by Benjamín Alvarez with the support of IDRC, attempted to identify the variables associated with professional and scientific success and with the impact of research on development. The analytical model was based on the following independent variables:

- Personal characteristics of the researchers such as age, gender, previous education, and work experience before winning a fellowship;
- The general environment (the country and perception of the labour market);
- The institutional context of the work done (type of institution, type of work, position in the institution, and capacity of the institution); and
- The characteristics of the researcher's postgraduate training (country of specialization, discipline, level, duration, and participation in research during training).

The study found that the capacity of the institution most consistently explained the personal success of researchers; as well, other important factors included the labour market, the place where training was received, and the level of previous education. These results suggest that training is not enough to strengthen a country's scientific capacity in support of social, economic, or human development; there must also be a solid institutional infrastructure and an environment favouring scientific activity.

It can be concluded that four variables comprise the human competence factor in institutions of knowledge:

- Individual capability;
- Critical mass or collegiality;
- Academic leadership; and
- Personal motivation and commitment.

The supply perspective

The nature of the research supplied by institutions of knowledge is critical to their legitimation and potential impact on society. In Chapter 5, Urrutia noted that "the supply often determines the demand. Highly qualified economists can create a demand for research by promoting the need for it within various social sectors." The same seems to be true of other disciplines (see Chapter 6).

The main requirement for a viable supply of scientific research seems to be clear objectives (Bernard 1993):

> Goal analysis is an important component in understanding institutional development. It serves to provide an idea of the magnitude of the task being undertaken: its scope and complexity, the potential for mismatch between goals and methods, the potential conflict among different goals or perceptions of the same goal.... They provide guides to managers, designers, clients and founders as to the appropriateness of methods and mechanisms, because these are variables which can only be assessed on the basis of their effect.

On the other hand (Bernard 1993):

> In this context, goals need not, and should not, be seen as immutable or unidimensional, however. In thinking about the validity or value of procedures for achieving a goal, it may be determined that the importance or definition of the goal itself needs to be reconsidered. In this sense, the process of congruence testing or negotiating between goals and means in the institution becomes itself an indication of the quality of that institution's design and implementation.

The capacity to review and rethink objectives and to consider the philosophical basis of research in light of changing environments is characteristic of the most dynamic research institutions.

The analogy of intellectual development, as well as Piaget's concepts of assimilation and adaptation, may help to explain how institutions of knowledge change in relation to their environments, structure institutional awareness, and pursue strategies for acquiring knowledge.

Extrapolating on the theory of human development, it can be hypothesized that institutions simultaneously resist change and need change. Resistance promotes stability, change produces growth. Human

beings resist change through the mechanism of assimilation, which incorporates new perceptions of experience into our current frame of reference. If this mechanism is dominant, the mind creates stable categories to manage the information it receives. The mechanism of adaptation and accommodation allows humans to modify their frame of reference. If it prevails, the mind creates so many categories to handle new information that generalization becomes difficult. The status of equilibrium and disequilibrium between stability and change results in high levels of understanding. An institution's capacity to adapt to contextual changes within a clear institutional awareness allows it to go beyond its own understanding, thereby enriching its cognitive strategy.

The research supplied by a given institution naturally depends on the size and quality of its research staff. Institutions must also find their own market niche, in terms of content or focus, and be able to differentiate themselves from other institutions to meet unsatisfied needs. As Rígoli (unpublished) proposes:

> The identification of a field of knowledge which will help to legitimize the institution may be guided by two criteria: the knowledge must be of use to other members of the scientific community, as a permanent and practical resource; and it must be sufficiently esoteric (that is, not too widely known and able to accept new methods) for the institution's members to want it.

Clear objectives help an institution to define an approach that differentiates it from its peers or competitors. The more the members of an institution share a common understanding of its goals, the clearer will be the institutional profile and supply of knowledge to users.

An institution that does not conduct its own theoretical research has more difficulty developing its thinking, interpreting its context, and responding to social demands for knowledge. An ongoing assessment of an institution's relationship to its social and theoretical context creates a balance between assimilation and accommodation, stability and change. This requires ready access to information.

The variables related to supply that seem to affect institutional success are

- A clarity of mission and objectives;

- A niche in a specific, differentiated area of knowledge;
- An institutionally shared level of congruence;
- An articulation of research and instruction, and a social need for knowledge;
- In-house theoretical research;
- Capacity to assimilate and adapt; and
- Access to information.

The demand perspective

The success of an institution of knowledge is shaped by many external forces. Its interlocutors, or significant others, comprise a wide range of groups, such as peers, sponsors, users, and competitors. All of these help to form the pole of demand.

The scientific community is an important point of reference for research, but not the only one. Funding organizations also exert a strong influence on management, choice of research topics, and purpose of scientific research. The decisive role played by North American foundations in the development of Latin American social sciences is a case in point.

Governments contribute to the development of scientific and academic institutions through policies and direct sponsorship — they are also clients of institutions. In economics, for example, "The demand for economic research is affected by the technical development of the government sector, the development of the university, the degree of democracy in a society...." (Urrutia, Chapter 5).

Industry, trade, social services, and public opinion are all potential users of science. Research institutions must establish a niche and position themselves in the complex environment of specialized and constantly changing organizations. The capacity of an institution to form relationships can be depicted as a series of "Venn circles," each representing a different environment, with the lines that separate them changing position depending on the degree to which the circles overlap.

Institutional development requires that an institution define, accept, analyze, and manage changing relationships with its surroundings. An

institution that does not take into account the goals and capacities of external organizations cannot be assured of receiving the resources or cooperation it needs, or of attaining a legitimate status in the community (Bernard 1993). This ongoing evaluation is as important to organizations engaged in basic research as to those engaged in social research and training. Vessuri (in Chapter 3) argues that institutions must

> develop research strategies based on a continuing analysis of scientific, technological, and industrial trends. Institutions can no longer function if they do not monitor developments in other sectors. They must explore and, if possible, anticipate the intellectual market in search of research and development niches that they can actively turn to their advantage.

An institution can increase its legitimacy and longevity by interacting continuously with its context. Competition often greatly improves the quality of research. An overconcentration of researchers in a single institution may increase its risk of becoming rigid and conservative and reduce its potential for innovation and relevance. An institution that participates actively in the local and international scientific community becomes more truly a part of it, turning competition into a positive element. In some fields, such as agricultural research, there has been a division of labour (Ardila, Chapter 4):

> Although the international centres have focused on basic technology, the NRIs have concentrated on applied technologies for public use, and the private sector has concerned itself with profit-making technology, there is a complementary relationship between all three.

Although there is no formally organized scientific community, there are informal networks of researchers or what can be called invisible colleges. Their role in the evaluation of scientific activity is not yet clear.

Vessuri (in Chapter 3) contends that "Scientific institutions in Latin America must develop close links with the productive sector to attain legitimacy." This suggests that an institution should know its clients and understand how they want to access its knowledge. The logic and rhythm of scientific knowledge do not always correspond with the needs of users.

The competition between research centres has helped to differentiate scientific production as well as stimulate high-quality research, the

formation of specialized scientific communities, and the expansion of opportunities for researchers. Competition provides funding bodies with a broader spectrum of alternatives and encourages research institutions to improve their negotiation skills.

A capacity to negotiate is vital to the relationship between donor agencies and recipient institutions. An institution that is not capable of promoting a mutually enriching relationship with donor agencies, contractors, local governments, or private sources of support, may experience inappropriate interference. The potential support of different social sectors tends to increase in democratic environments. This is particularly true with respect to the social sciences. Variables related to external pressures include

- The identification of significant others;
- Mechanisms for ongoing interaction with the environment;
- The presence of competition;
- Participation in the scientific community;
- Capacity to negotiate with donors;
- Local sustainability (government, private policy);
- Identification of clients and an understanding of how they acquire knowledge; and
- A democratic environment (in the social sciences).

The culture of knowledge

The quality that best defines an institution is less its physical presence than a shared understanding among members that it is one and the same across a set of dimensions that can be only partially defined (Douglas 1986). Two features that distinguish an institution of knowledge are a climate of learning and the existence of intellectual values.

An institution that clearly expresses its standards, attitudes, values, and expectations finds it easier to change and learn. The learning process also calls for evaluating goals achieved and modifying the objectives and assumptions that govern the behaviour of members.

Whatever emphasis an institution places on the application of its

scientific work, one of the most attractive incentives for researchers is the opportunity to lead an active academic and intellectual life. The director of one well-known research centre in the region put it succinctly: "The salaries are not good, but we offer intellectual adventure" (Lora, E., unpublished, 1991).

According to the same case study, even if researchers carry on with their intellectual work:

> After a few years they find they have stopped applying their advanced knowledge and have lost track of theoretical development in their subject. The basic reason for this situation is that most research projects are totally for application; there is pressure of time, little connection with the international academic world, little teaching activity, and an absence of academic environment in national terms.

The learning environment is present in formal and informal training programs for young researchers, as well as in vehicles for publishing studies and disseminating innovations. The socialization of future generations of researchers occurs in the context of this work. As explained by Rígoli (unpublished), common interests, values, and expectations

> produce a sense of belonging to the institution which is seen as a most welcome place to be...a sort of home which they are prepared to support beyond the call of their conditions of contract.

Researchers frequently develop a sense of ownership of the results of their efforts and reap rewards only in the long term. As a result, symbolic incentives are important to research careers and to an appreciation of institutional success. They also play an important role in the creation of a learning climate and the nurturing of a culture of knowledge.

Institutions that give their members opportunities to expand beyond organizational boundaries through participation in scientific events, academic exchanges, publications, and direct contact with international and national agencies help to maintain a culture of knowledge and a climate of learning, which, in turn, lays the groundwork for the training of new researchers. Values such as creativity, innovativeness, and an acceptance of delayed rewards are inculcated through this process of on-the-job socialization.

The culture of knowledge in an institution is composed of

- A climate of learning;
- Intellectual values;
- A sense of belonging;
- A sense of ownership for work done; and
- An acceptance of delayed rewards.

Management strategies

According to Israel (1987), management joins specificity of purpose and competition as a key incentive to institutional performance. Management includes both organizational structure and management per se (staffing policy, management techniques, and training). Management may, in fact, be the main incentive in institutions with unclear goals and little competition.

Institutions of knowledge vary significantly in the type of research they undertake. For example, social science research tends to be less specific than research on industrial technology or agriculture. Regardless of these differences, management strategies play a decisive role in creating an environment that breeds success.

Bureaucratic red tape is a major impediment to the innovation essential to scientific discovery and experimentation. As detailed in Chapter 6, we need the right combination of autonomy in the pursuit of our individual academic interests and practical work in interdisciplinary teams. This autonomy demands a flexible management style.

The decentralization of decision-making gives researchers a twofold responsibility, both inside and outside the organization. As Lora (unpublished) explains:

> It would seem desirable that internal and external academic responsibility should be decentralized. Internally, this means that project management and project orientation are decentralized. Externally, it means that each researcher is responsible for the dissemination, publication and discussion of his or her research and opinions.

This responsibility for the research product and process, whether individual or collective, requires internal mechanisms for adaptation and

evaluation as well as a system of incentives. The incentives must include appropriate remuneration, a fact too often overlooked by universities and government research centres. Urrutia (in Chapter 5) argues that

> Economic incentives also play a decisive role in research. It is relatively easy for a researcher to find employment in the productive sector or with the government; therefore, income from research cannot be too much less what could be earned in alternative employment.

Although a degree of uncertainty may serve to stimulate new ideas and proposals, long-term scientific efforts and social impact depends on financial stability. Private research centres, whose financial support depends almost entirely on specific projects, need to develop and implement long-term financial strategies. The most stable centres in the region have done this. Just as theoretical research helps to clarify an institution's research supply, internal evaluation systems and administrative assessments allow it to adapt its managerial style to continuous internal and external changes. A consideration of management strategies includes

- Flexibility and adaptability;
- Economic stimulus;
- Reduction of red tape;
- Mechanisms for self-correction;
- Long-term financial strategies; and
- Decentralization of decision-making.

Success Factors and Dilemmas

Institutions of knowledge face a series of dilemmas within each group of success factors. Solving these dilemmas is the main focus of institution building and development. Some tensions between opposing trends show up more clearly at different stages in an institution's development. They become more or less critical depending on the nature, the environment, and the loyalties of the organization. For example, personal commitment is critical early in the development of a private research centre; later on the division of labour becomes a more important factor.

Tensions and dilemmas manifest themselves differently in various

types of institutions. Research in health institutions offers a good example. Health research tends to be done in state institutions, public universities, private universities, private institutes, or health-service centres. Government centres can offer stability, but find it difficult to introduce innovations or maintain scientific independence. The health-service centres provide a setting for the immediate application of research, but they "do not have a research culture that recognizes scientific work, provides incentives, or motivates new researchers" (Carrasquilla, Chapter 8).

The first success factor mentioned — human competence and motivation — requires that stability, commitment, and cooperation be balanced with innovation, external influences, competition, and regulation. The tensions between stability and change can show up on several different levels: the individual (the professional career versus institutional commitment), the labour force (the stability of research staff versus the need for innovation and change), scientific cooperation (team commitment versus internal competition and division of labour), and education (dedication to research versus dedication to complementary activities such as training researchers). To summarize this discussion, the following are dilemmas for research institutions:

- Stability of employment versus innovation;
- Personal advancement versus commitment to the institution;
- Personal commitment versus division of labour;
- Stability of employment versus new social influences;
- Cooperation versus internal competition; and
- The relative size of the senior versus junior group of researchers.

Specific research supply is based on clear research objectives. An institution that cannot negotiate or adapt runs the risk of obsolescence. Objectives are the reflection of ideals that must be constantly scrutinized against reality. A clear awareness of the ideas that underlie a research enterprise is perhaps as important as the capacity to reformulate them. This seems to be valid for priority themes, research methods, and the use of research results. The most frequent dilemmas here are

- Stability versus change;

- Convergence versus divergence in issues and methods;
- Emphasis on content versus emphasis on method or approach;
- Priority on research versus teaching;
- Practical versus theoretical research;
- Stability versus academic stagnation; and
- Utopian versus realistic approaches.

With respect to the definition of significant others, an institution may prefer the international community to local users, may choose to look after the interests of the funding agencies rather than follow a set work program, and may prefer the market to the dynamics of scientific development. Obviously, these are not mutually exclusive choices but they represent competitive pressures. They are typified by the following:

- A focus on local versus international significant others;
- Autonomy versus influence in a wider context;
- Independence from government versus closeness to policy;
- Autonomy versus dependence on donors; and
- Individual interest versus market interest in research.

A culture of knowledge requires accepting some characteristics inherent in the scientific process, such as uncertainty, rigour, criticism, the value of dedication, free discussion and prestige, and the capacity for constant re-evaluation. The typical dilemmas here are

- Individual motivation versus impersonal bureaucracy;
- Organizational rules versus new priorities;
- Personal prestige versus teamwork;
- Utopia versus reality in the organization; and
- A competitive approach versus institutional identity.

In addition to the dilemmas encountered by all organizations with respect to management strategy, the institutions of knowledge have to compensate for a dearth of incentives caused by lack of specific products, the long-term nature of results, uncertainty, and internal specialization. This can lead to dilemmas around

- Symbolic versus financial incentives;

- Size and power of administrative versus academic–research groups;
- Continuity versus adjustment to new circumstances;
- Systematic planning versus inductive planning; and
- Safety versus risk.

Institutional Appreciation of Success

Because success does not mean the same thing to any two people or any two institutions, it is difficult to appreciate and evaluate systematically. To some, a successful institution is one that achieves its objectives. For others, a successful institution is one that has achieved a level of development or strength that allows it to stand on its own feet. Nonetheless, it is not easy to define "strengthening," a complex process of updating or building infrastructure for research, defining research objectives, preparing projects, and having the capacity to relate to other institutions (see Chapter 8). Those who work in institutions of knowledge tend to define institutional success in terms of three broad concepts: scientific, organizational, and social.

Scientific success is the same as the production of knowledge: the development of theory, analytical tools, technologies, and global insights. This production takes the form of publications, presentations, demonstrations, and, occasionally, objects that have been developed or transformed. Success is measured by the products' quality and characteristics and the institution's capacity to innovate.

Organizational success is evidenced by an institution's strength and evolution and by an overall learning process that engenders collective commitment and continuous self-improvement. The questions here centre around the profit taken from comparative advantages, competitiveness, stability, and growth.

Social success is more varied. It may take the form of shaping public opinion, creating a critical mass of researchers or users, gaining acceptance of policy recommendations, achieving the use of new technologies or products, or modifying social services or practices. Institutional development is not enough to measure success, because it relates more

to answers to environmental needs, practical knowledge, and the potential of society to make use of the products of research.

There is often tension between these three kinds of success. Scientific success does not always go hand and hand with organizational or social success. This topic deserves special consideration in assessing strategies to build and develop institutions.

The University and the Enterprise as Institutions of Knowledge

The changing world economy and the leading role played by science, technology, and information systems place the subject of relationships between educational institutions, the productive sector, and the government in the context of growing interdependence. Knowledge, the area where the three intersect, is our most important tool for progress and social equity.

The university and industry, representing speculative and practical knowledge, are both in the throes of changes taking place at the dawn of the 21st century. Both need to rethink their identities in light of the close relationship they will be required to form in the future.

Traditionally, the university's role in relation to production was quite simple: the universities trained the professionals needed by the labour market and the development process. A surplus of unemployed university graduates was considered the fault of the education system. What has happened is that the dynamics of the educational system and the labour market have not been running in parallel (Vivas and Rojas 1991); each is changing and increasing in complexity. Also, the aims of a university are different from those of an enterprise — the university trains professionals for a professional life, one of its traditional missions, as well as something more. The university needs to be aware of what is happening in other areas of society to feed its flow of knowledge and improve its capacity to satisfy external demands. At the same time, it must accommodate other forces pushing to create knowledge whose purpose goes beyond solving specific or immediate problems.

The relationship between the university and productive enterprise

is circumscribed by the university's appreciation of the balance needed between the purpose of knowledge and the exercise of power, between basic research and technology, between general and specialized instruction, and between benefits and services and research. The balance of all these factors determines the curriculum, the nature of scientific production, and the budget.

According to formal statements, universities have three missions: teaching, research, and providing services to the community. Yet most universities in the developing world focus almost exlusively on teaching. The research option demands decisions that have a major impact on the university: its purpose and value system, the type of human resources needed, as well as its structure. Several universities have tried to solve the problem of hosting research activities in an environment developed for other purposes by adding postgraduate programs to support research. They have not all been successful.

Universities have a choice in the way they relate to knowledge. They can house it and pass it on; create it and develop it; or encourage its practical application. If the primary objective is to house knowledge, the curriculum will follow the logic of specific disciplines, and research will be largely descriptive. If the goal is to create knowledge, basic research will be a part of teaching activity, and lecturers will divide their time between teaching and research. If applying knowledge is the priority, technology will be a laser beam pointing inward and outward to energize activity.

Similarly, an institution of higher education must establish its views on political power, and these will affect its extension and service activities. Although most universities have paid little attention to this mission in the past, there is a definite trend toward opening up relations with other educational institutions, research bodies, and society in general. As a result, their organization needs review. Table 1 shows the choices a university might make in relating itself to knowledge and power.

The theory of complex organizations has never provided a coherent explanation of university life. Many theorists call the university an "anarchic environment" in which there are no specific objectives or incentives. The fresh emphasis now being given to research and practical

Table 1. Knowledge and power: the university perspective.

(A) The knowledge continuum.

Conception of a research activity	Appropriation of knowledge	Creation of knowledge	Application of knowledge
Educational purpose	Dissemination of information	Development of intellectual research skills	Development of application and evaluation skills
Some curriculum patterns	Structure of knowledge	Structure of knowledge and thinking	The technological process
Some curricula resources	Resources addressed to "personal culture"	Resources addressed to solving problems	Resources addressed to the needs of the immediate community

(B) The power continuum.

Conception of an "extension" activity	Promotion of graduates	Student practices	Uses of research in policy	Use of research in everyday life
Purpose	Increasing social power of the university	Serving community training	Social change	Social and human development
Some operation patterns	Aspirations of graduates	Low-cost services	Studies and evaluation	Development of technologies and practical knowledge
Some resources	Resources addressed to "lobbying" power	Resources addressed to the community as a laboratory	Resources addressed to social equity and service efficiency	Resources addressed to the productive sector and information

knowledge and the alliances being formed with other institutions will allow universities to become more efficient and to develop the capacity to manage new nontraditional activities.

From university to productive enterprise

Universities have started, albeit timidly, to build bridges to business. They have taken various approaches:

- Changing the direction of research in the schools most closely related to industry so that the research is more innovative and more closely linked to production or services;
- Searching systematically for opportunities to use research results obtained in the university, including creating special units to search;
- Offering training programs to businesspeople and specialists;
- Offering academic accreditation for corporate activities;
- Providing consultancy services to private companies;
- Integrating material on the content and processes derived from innovations made in the business world into university curricula;
- Providing specialist conferences and seminars for company employees;
- Offering leave for students to do practical work on their degrees;
- Organizing visits of university teaching staff to industry;
- Using the laboratories of private industry for teaching and scientific purposes; and
- Giving university administration the opportunity and capacity to make research contracts with private enterprise.

This kind of activity carries risks for the university. These risks include placing excessive importance on one area of activity at the expense of others, overemphasizing technological research, losing teaching staff time to business-related activities, and facing the increased potential of conflicts of interest.

Enterprise and knowledge

The objectives and methods of business are usually more specific than those of research centres and universities; they tend to be defined more by competition and economic motives. Evaluation systems pay special attention to efficiency and good judgment among senior staff. Structures are more inflexible and predictable.

Postmodern business is rapidly becoming aware of the advantages of research and information. As the line between action and knowledge becomes more and more blurred, education requirements change along with factors related to productivity and competitive edge.

Training, once a grudging concession to workers, has become a fundamental corporate need. A survey of industries in Costa Rica, Honduras, and Panama showed that more than half had launched some form of training activity to encourage expansion, product diversification, improvements to quality, and the introduction of advanced technologies (FICR 1991).

Research, far from being a luxury, has now become a basic part of corporate activity. Radical changes have been made to institutionalize an atmosphere in which knowledge can be created, assimilated, and applied and in which the results of research efforts will be promoted on the market. Research is also being contracted with associations or interest groups. In either case, business will soon become more like institutions of knowledge.

From enterprise to university

Case studies (Potworowski 1989; Blais 1990) show that business seeks to cooperate with universities and research centres in many different ways, by

- Inviting university scientists to be members of corporate consultative committees;
- Sending staff and management to continue their studies under special agreements with the universities;
- Developing contracts with universities to support research with donations;

- Sponsoring faculty posts on subjects of interest to industry;
- Providing financing or support for degree thesis work;
- Offering students the opportunity for practical work on leave from regular courses;
- Offering research opportunities to teaching staff;
- Organizing corporate units to establish links with universities or research centres;
- Contributing laboratory equipment; and
- Supporting programs for "technology parks" and "incubators" for new ideas from universities.

The main reasons companies approach universities and research centres are to gain access to technology, to increase institutional capacity, to develop improved procedures, and to secure better qualified personnel. The interests of many companies extend beyond technological innovation to encompass the social and economic problems of production, issues of education and training, and types of occupations.

Although the incursions of industry into higher education have increased, industry still provides universities with proportionately less funding than other sources and has less influence on academic life than did the classical disciplines of theology, medicine, or law in the past (Kerr 1990). However, the signs indicate that the influence of industry on academic life will expand and deepen in the future.

CHAPTER 10

ELEMENTS FOR A RESEARCH AGENDA

Roberto Martínez Nogueira

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What are the problem areas in defining a research agenda for the institutional development of Latin American organizations that generate and transfer scientific and technological knowledge? This chapter reflects on this question, identifying critical problems, asking important questions, and, finally, outlining a research agenda.

The Problem

The issue of institutional development is a growing concern. This is because organizational factors have been identified as critical to development, especially to the generation, transfer, and use of knowledge. Bearing this in mind, a number of observations and examples can be discussed and analyzed.

First, the central actors in the development process are organizations. Even if development is expressed through individual, group, or social actions, these actions are deployed in an organization, or will have an effect on an organization, be it the State, a private enterprise, a political party, a union, a university, or a research centre. Therefore, the quality and effectiveness of organizations are both the cause and effect of development.

This view implies that the institutional factor is hierarchical; it is the framework and the space that regulates and governs individual and group activity. In this way, any consideration of specific aspects of a society — such as economy, education, health, and scientific research — must include the framework and the space. Not only is this relevant from an

analytical perspective, but it will also raise the problem of coherence between institutional frameworks and organizational models with the attributes and requirements of each level of action in society. In other words, it leads to the empirical question of the suitability, compatibility, and potential of organizational models with respect to current circumstances and future prospects. This is the central issue addressed in this chapter.

In recent years, the subject of institutional strengthening has become part of many national strategies and the focus of much international cooperation. Certainly, the institutional factor and efforts to bring about its development have always been present in the literature. Nonetheless, for several reasons, the subject has acquired a new urgency and relevance. Latin America is experiencing a process of radical transformation: development models are being reviewed, economies are being liberalized, and the role of the state is being reformulated. The effects of these transformations are being felt very unevenly throughout our society, and priority must be given to eradicating poverty, which grows more dramatic every day.

This panorama poses great challenges to research organizations. The ability to compete and be innovative has become an essential attribute for feasible development. Equally, sustainability to maintain development and equity is a requisite for the benefits of transformation to contribute eventually to eradicating poverty. All this notably affects the demands on research organizations and suggests that the mission of each institution, its strategies, its programs, and even the culture and procedures adopted must be examined.

Researchers in the 1960s introduced the concept of institution building. This line of thought was based on the assumption that development was a process of increasing complexity in which new activities would have to be performed by organizational structures that were differentiated within the framework of functional specialization. In this way, the creation of new organizations was both a consequence and one of the preconditions of the development process.

As a result of this line of thinking, action designed to promote development based on international financial resources, on policies

executed by an activist state promoting them, and on economic and social planning was accompanied by a proliferation of new organizations. These organizations were different from their predecessors in their approach, in many of their attributes, and in the way in which they went about their work.

This phenomenon was of great importance. In addition to the traditional organizations — universities, science museums, experimental stations for agriculture, teacher-training centres — a new generation of scientific and technological institutions was created. Those who worked for them had precise definitions of their objectives and of their degree of independence or autonomy from central state administration. Their activities were grouped into programs and projects, they had sufficient resources including scientists and technicians who had been trained abroad, symbolic content, and external articulation that gave them social legitimacy. All these attributes were considered to be necessary and sufficient for them to be effective: this was the reason for all the attention given to design, resources, and the definition of activities. The context was not part of the analysis, which explains why institutional models were repeated all over Latin America, taking as their basic characteristics those features of institutions in developed countries that had apparently brought them success.

The new generation of institutions responded to a particular concept of what knowledge could contribute to development. Production would be rapid, and the results would be automatically incorporated into policy by decision-makers or transferred to the productive sector, thus creating legitimacy for the institutions. These organizations were both expressions of modernization and a part of their times, and it is within this context that we must explain how they were constituted and how and why they operated.

These organizations had to operate in a context that was not as receptive as had been predicted. Several problems recurred. The difference between initial expectations and actual achievement began to cause concern.

A common organizational response was a request for policies and incentives to stimulate demand, either through the creation of local

captive markets or through protectionism. Another common response was to seek local financing from central revenues diverted specifically to sustain the organization. The first response was an attempt to secure transfer by restricting the choices of the end user. The second was to protect research and development from the changing winds of politics, economic contingencies, and even the demands of those who, supposedly, were to use the knowledge generated. Both mechanisms were shown to be inefficient in consolidating the capacity of these organizations to innovate, but both concentrated attention on the external aspects of the organization.

The evidence that demand did not arise automatically from supply and that the simple existence of specialist organizations did not guarantee either the generation of knowledge or its transfer led to doubt about policy, instruments, and mechanisms. As experience was gained, the importance of contextual articulation was increasingly plain: the legitimacy of the activities of the organizations remained fragile, and local support was insufficient to insure continuity and growth. Therefore, the conviction grew that organizations could be viewed as variables that explained problems and failures, either because they were too rigid or, sometimes, because they were too malleable. Bureaucratic inertia, the lack of flexibility in programs and in the execution of the organization's tasks, their inability to find resources to protect themselves from fluctuations in the world around them, and other considerations were all factors that continued despite substantial changes in their framework of operation. In addition, however — and apparently paradoxically — their vulnerability and dependence made them extremely sensitive to change and led to frequent changes of objectives and deterioration in efficiency and efficacy.

In imitation of experience in the financing of investment projects, attempts were made to increase effectiveness through programs that included actions designed to create and consolidate management capacity (for example, planning, management control, handling of resources, and so forth). However, integrated attempts to attack the overall problem were rare. All too often attempts to strengthen the organizations came to nothing when the program ended. With respect to research activities, the

phenomenon was similar: financing was secured to execute the project, but it failed to reduce the extreme dependence and institutional fragility.

In other words, attempts to resolve the problem were cyclical: institutional development was first identified with a set of attributes and qualities linked to design, resources, and the definition of activities. Then, the emphasis changed to performance of the functions of government and to organizational action. The sequence of disappointments and failures meant that an alternative concept progressively gained ground, based on strategic, procedural, and interactive aspects.

The cycle repeats, however imperfectly and slowly, a sequence in the theory of organizations. Since Weber (1947), many have advanced the argument that design and effectiveness are related. However, the identity of an ideal bureaucratic type with rationality of process and effectiveness has been discarded on the basis of overwhelming evidence. This evidence has also led to a questioning of later approaches that concentrated on functional specialization and structural differentiation, principles on which organizational systems for development were constructed from the 1950s on.

This evidence revealed the "disfunctionality" of organizations constructed on these principles, especially in certain contexts — turbulence and uncertainty — and technological and operational conditions — a low level of program activity. Therefore, other approaches began to gain ground in which context and technology dominated design and determined the most suitable processes, associating effectiveness with the appreciation of situations, and appropriateness to circumstance. Thus, progressively, the emphasis on design faded, and dynamic qualities of management and action took their place. Following this route, strategies, cultures, and the comportment of actors became the critical elements in ensuring effectiveness. So too, the concept of institutional or organizational development began to form:

- A desired state, a design with a set of attributes or stock of abilities that would together explain effectiveness; a broad concept that includes the achievement of objectives, efficiency in operations, flexibility and adaptability, and learning as a possibility to be exploited, with an active role in the modification of context; and

- A process by which attributes are acquired or consolidated on a permanent basis, with constant reconstruction of organizational capacity.

Following this notion, success is defined not only by survival or by performance, but also by the possibility of securing those achievements over time and making the institution sustainable. Achievements are, therefore, relative, being referred to a level of ambition governed by the uncertain.

This is useful for the orientation of research and defines the complexity of the problem. Nonetheless, it is not precise enough as a criterion for the evaluation of activity and should be enriched from outside the organization. That is, evaluation should not be limited to products and results, which refer to creativity, efficiency, and continuity of production, but should also include impact, social relevance, and use by other agents in society. These dimensions transcend the processes of conversion or production and refer to their consequences as well.

Central Questions

This sections deals with some questions raised in the literature, identifying subjects that may be pertinent to the design of the research agenda.

First, because of the heterogeneity of research organizations, the various types must be described to understand the problem. An institution is made up of a set of elements: its legal or formal status, whether it is public or private, its central mission, its range of activities, and so forth. Its nature can be empirically identified. The literature agrees on this point, offering the following five types:

- Public institutions, specialized by sector or by discipline, with a wide range of activities (from basic research to the delivery of services), a relatively homogeneous clientele, specific demands, and regular mechanisms for the preservation and development of capacity through the training of human resources (these institutes are usually used for the resolution of conflict and for mediation among the levels of public policy);
- Universities, in which research is closely related to teaching, with a

greater interest in basic and applied research, and lines of work that arise from the initiative of the researchers themselves (these are organizations with multiple objectives that are not highly concentrated in terms of subject or discipline);

- Private institutes, linked with the international academic community and depending on funds from external agencies (these institutes have more concentrated lines of work, a stronger focus on applied research, and a greater degree of autonomy);
- Service institutions, with a considerable capacity for identifying problems and generating demand for knowledge, but with limited resources for ongoing activity or systematic research; and
- Public institutions preparing policies and plans, conducting the research activities required for their work, in particular in the fields of education, health, and economics, with a low level of autonomy and responding to specific demands.

These organizational configurations prompt some interesting questions in designing research: Is the institution dependent or independent? Does it determine the type of activity that is most appropriate for the institution to carry out? These questions can be formulated in other terms: What attributes does an institution require for each type of research? The answer may reveal the nature of the relation between organizational attributes and research requirements that will secure greater efficiency and efficacy.

The hypothesis that the type of activity (such as basic, strategic, applied, or adaptive research, or development and validation of technologies) is the only variable that can explain organizational attributes is not entirely unfounded. Nonetheless, its basis seems largely to be part of the epistemological and methodological debate rather than part of the sociology of the production of knowledge. Further, it responds to a concept that production may be represented as a continuum. Various types of research differ with respect to the "distance" between their results and their effective use by the productive system. Therefore, they also differ in the application of criteria for validation and relevance of results, the

specificity of demand, and the methods used to evaluate results and their immediate impact.

Much evidence suggests that putting research into an institutional context is very complex. Efficiency and efficacy are not the reasons why some forms of activity are most frequently found in a particular type of organization (for example, basic or scientific research is usually focused in universities), but the reproduction of a universal model based on the initiative of a research and teaching community. In many cases, the same type of research is conducted in many different contexts, which are not the result of rational allocation of institutional roles. The hypothesis that positioning is the result of an historical process that expresses objectives, strategies, and the interests of various areas of society, bringing about allocation of activities through specific organizations (or their abandonment) seems not only more reasonable, but also a much more powerful argument for directing research.

This process should have its own logic, and many possibilities can be considered. To the extent that technological development is increasingly dependent on scientific advance, strategic considerations, and competition, not only are the distances in the continuum reduced and the boundaries of each type of activity extended, but also scientific research is incorporated into social problems that may be outside the scope of the research institution's original purpose. Therefore, the institutions responsible for generating technology to meet a highly predictable demand in the productive sector often contain units for basic research or sciences to produce the necessary inputs for technological development. Such units include agricultural research institutes, atomic energy commissions, specific health programs, and the laboratories of the larger companies in both private and public sectors. This might indicate that a basic issue is the need to secure links between the results of the various activities undertaken.

In economic terms, logic will govern the allocation of activity within the institution. Cost of the products of research for the end user will be minimized, reducing uncertainty and transaction costs associated with transfer from one organization to another. This would explain the fact that the products of research that are most in demand in the productive

sector are found in the most specialized contexts, isolating individual tasks to reduce the competition for resources and legitimacy.

In Chapter 4, Ardila introduces the economic nature of knowledge (the degree to which it can be appropriated) as an essential factor to explain the social context of research and, therefore, the strategies used to control the activity depending on the types of users, and to explain the predominantly private character of the activity. At the same time, the degree to which a technology can be appropriated is not sufficient to explain the quality or effectiveness of an organization. In the case of agricultural research, the stage at which institutes produce only the end product was highly effective, because the task was to adapt available technologies for use rather than to generate new ones. This suggests that strong external pressure is not sufficient for achieving high levels of effectiveness.

An examination of these questions may help to define the role of institutions. But for this purpose, it seems advisable to identify sets of organizations that go further than formal definition of the nature of an institution, a type of research, or specific discipline.

The mission and strategy of organizations

The basic documents refer to contexts and circumstances that organizations have had to face, emphasizing their importance in explaining

- The mission, strategic orientation, and definition of program activity, emphasizing restrictions and degrees of freedom to choose resources, programs, projects, structures, and methods; and
- The social needs to be satisfied and the end users of products, the source of demand, pressures, and the effort to give the institution legitimacy, obtain support, and secure a continuous flow of resources to guarantee survival and growth.

Urrutia (Chapter 5) says that the demand for economic research is determined by the level of technical development of the government sector and the universities and by the degree of social democratization. Ardila (Chapter 4) asserts that institutional capacity in agricultural research is a function of the government and the size of the country. His

analysis also mentions incidence of demand and markets as well as the offer of technology as the variables explaining institutional operations. The importance of policy definition is raised by Carrasquilla (Chapter 8).

To analyze the interaction between the structural situation and basic organizational definitions, we need to introduce the notion of context. Context has a long tradition in the literature on organizations, although it also has an ambiguous connotation. Context must be specified so that it identifies relations, definitions, restrictions, and opportunities (Scott 1993).

Except in the field of agricultural research, this issue has been little explored. Several studies have suggested the extraordinary importance of the social aspect of national research institutes in agriculture to explain their efficacy and their ability to transfer knowledge. They emphasize the importance of this in defining strategies for organizational change, such as decentralization and creating a context for the participation of local producers. The experience of INTA in Argentina is perhaps the most interesting example.

Some work refers to generic conditions experienced in different disciplines and types of activity. However, their usefulness is limited as factors affecting institutional profile, organizational development, and effectiveness. On the other hand, few studies identify and explain the factors that determine levels of effectiveness in relation to type of institution, disciplinary approach, research type, or organizational model. There are also few studies on specific organizations or groups of organizations with respect to the transactions in which they are involved and social articulation.

As a result, we must return to the organization as a unit for analysis and define context as interorganizational. For this purpose, a study must be made of the institutional framework, public policy regulating or affecting the institution, the legitimacy of its mission and tasks, the position of its products in the matrix of social transactions, the nature and behaviour of the networks that are involved in those transactions, the activities being exchanged, and so forth. (These points are included in the concept of competition used by Israel (1987).)

Looking at successes and failures helps us determine what strategic options and alternatives for social articulation are most appropriate for each context. At the same time, attention should be paid to interorganizational relations to identify complementary relations, collaboration, and competition, so that sets of organizations can be analyzed. For example, the development of networks in Latin America has become highly efficient in several fields, such as agricultural research, education, and tropical diseases (Chapters 4, 6, and 8).

Institutional models

The interaction between structure and effectiveness is determined by the organizational model adopted. In a given context, effectiveness results from adapting the institutional model to preserve institutional identity, to update its capacity, and to permit it to play an active part in the formation of the context itself. In other words, if the organization does not systematically examine its mission, design, and the way it functions in terms of adapting to its context, its effectiveness may easily decline, even if the model for its original creation was appropriate. For this reason, consideration must be given to the initial homogeneity of the Latin American models, the increasing ambiguity that they came to accept, the incremental changes they suffered, and the current need for a radical review because of changes in the context in which they operate.

The similarity and persistence with which Latin American countries have patched up their institutions is remarkable. It demonstrates the existence of a problem that is not confined to the organizations. The models result from processes of social innovation in response to contemporary challenges. Once their validity and efficacy have been accepted, these virtues are unquestioned (Olsen and March 1981). The demonstrative effect has played a central role, along with technical assistance and international funding. Structures, lines of programming, and methods of operation show a similarity that reveals problems of common interest and creates a degree of independence from conditions faced by specific organizations. Indeed, the scale of organization was also not sufficiently differentiated; the model was simply copied.

After the installation stage, tensions arose between expectations,

requirements, possibilities, and results. Adjustments and adaptations were required, but these did not radically alter the models and gave rise to a growing ambiguity in the missions of the organizations and to inconsistencies in strategy, program planning, and administration. The preservation of the institution may have been matched by a decline in its effectiveness. This trend must be examined to determine how to end it or turn it into a productive process.

Some of the changes are a result of a long process of growth in the complexity of individual countries, illustrated by the emergence of new institutional actors and by the development of new agents. Many organizations arose as innovations to deal with specific problems, and, in some cases, they maintained a monopoly in the field for many years. This situation has changed radically. There has been a proliferation of private universities with high-quality programs in areas previously reserved for public institutions. Each country now has a number of government research centres that are competing for prestige and resources. There are also a number of companies in the private sector and associated organizations that play an active role in technological development. The initial mission of institutions has progressively lost its meaning.

Other changes have resulted from changes in policy and from international conditions. Structural adjustment, which has been affecting many countries in Latin America, has caused a rethinking of the role of the state; privatization of services and devolution of authority from the national to provincial and local administration has occurred. Further, the liberalization of economies and the impact of new technologies require innovation to preserve and increase competition. Scientific and technological organizations must keep apprised of the rapid innovations in technology and other fields. The new focus on poverty and social policy requires greater accuracy of information, analytical capacity, and operational ability. The scenario and priorities have changed bringing a corresponding need to reanalyze existing institutional models.

The new scenario puts management resources to the test, creates new tensions with regard to programs, and makes capacities, structures, and procedures obsolete. The changes in context are now the main reason for action in institutional development. This assumes a redefinition of

missions and strategies, a deliberate search for niches of specialization, and attempts to develop competitive advantage. The redesign of institutions and the change in organizational culture must be a consequence of this review of strategy.

Social demand

All organizations need resources, legitimacy, and support. Survival and effectiveness are associated with satisfaction of some need or specific interest, and the institution will give pride of place to the groups on which it depends for these elements (Pfeffer and Salancick 1978). This leads to an analysis of the "force-field" in which an organization finds itself, of the demand for its products, and the strategies of the actors involved. These should be part of the research agenda.

The base documents analyze cases in which institutionalization was sustained for a relatively long period regardless of effectiveness. Many organizations found working methods and subjects for investigation that had little local demand, but they achieved a high level of production. This allowed them to enjoy a sense of internal appreciation of their mission, strategies, and programs that went unquestioned while resources were abundant and mechanisms protected the institutions from the demands of society. When this situation changed radically during the 1980s, the institutions were faced with a crisis that they have still not overcome.

This progression demonstrates the importance of factors related to the provision of resources and the satisfaction of demand. What is the interested public? For whom does the institution produce? What role does the institution play in redirecting the resources it requires (economic, support, legitimacy)? To what extent are the supposed final users dependent on the products of the organization? To what degree can these products be appropriated by society on a collective or individual basis? What is the impact of these issues on the effectiveness of the organization?

The base documents offer varied answers depending on the discipline studied, the nature of the institution, and the type of research it does. However, there are points of convergence from which a hypothesis

can be formulated regarding the relation between an organization's external links and its internal attributes and the strategic behaviour of the actors. For example:

- The more easily a product can be appropriated, the greater the specific demand on the organization and, therefore, the more intense the pressure on the organization to concentrate its efforts to satisfy the demand;
- The greater the dependence of the end users on the products of the organization, the greater its deployment of power to control its operations; and
- Inversely, the greater the dependence of the organization on the provision of resources, support, and legitimacy by society, the higher the probability that society will have a strong influence on the lines of research followed and on the destination of the results.

The consequences are obvious, but paradoxical. A greater capacity to respond to demand might be accompanied by a loss of autonomy and, therefore, a long-term deterioration in the capacity of the institution to create and maintain levels of production. Research will also probably be oriented toward lines of work that are of most use to the suppliers of resources, diverting the organization from its mission. These examples show the complexity of the consequences for organizations of the demand for the products of research.

These issues are important in terms of operation. There is much discussion about mechanisms for funding based on private contributions, "contracting out," and joint ventures. These alternatives presuppose that progress has been made toward greater linkage between production of knowledge and use, but, at the same time, there are new reasons to continue work on products that may not be immediately transferable to the productive sector.

The appropriate management of these complex relations is a central component of institutional development, because organizational effectiveness will, to a great extent, result from successful challenges of contingencies and restrictions. For this reason, diagnosis and action are required to obtain support and to generate demand that is more socially

relevant to ensure the continuous flow of critical inputs to the organization, regularity in its operations, and social acceptance of its products. Pfeffer and Salancick (1978, p. 3) state:

> Despite the importance of context for organizations, little attention has been paid to these aspects, most authors have treated the subject of the use of resources, rather than their source. The theories of individual comportment in organizations and theories of motivation, leadership and inter-personal communication, as well as organizational design, have all emphasized the use of resources. The central objective of many theories is the optimization of the product from given levels of resource. But questions as to how those resources are obtained remain unanswered or simply ignored.

Independence

Context not only generates conditions and restrictions, it also allows for decision-making that makes the impact of demand and pressure relative. Organizations can select the mix of their activities, define the areas and the sequence of various kinds of research, and tailor demand to suit their capabilities. Opportunities to exercise discretion are greater in the area of basic research and fewer for organizations dealing with products that are of more immediate use in policymaking or production. For specific demand, research inputs and processes may be multiple, another opportunity for discretionary judgement. There are many other examples: agricultural research institutes must supply validated technologies, but the institution will decide how far "upstream" to go. Applied research can be designed to incorporate objectives intended to advance basic knowledge in fields such as economics, health, and education.

Organizations can also choose how they will operate and what they need. Here, making the right choices is the basis of effectiveness.

In brief, demand is not enough to explain all the activities undertaken, because organizations have some degree of freedom to decide how to satisfy that demand. Thus, organizations can be classified according to the degree to which they are embedded in a given context. A looser connection gives them greater freedom to define lines of action, operating processes, and products. In this case, the effectiveness of structure and

operations must be analyzed in conjunction with the strategies used by management to preserve the capacity to make decisions and maintain freedom from its clients.

Design and function

If organizations are "subjects" and their success is determined not simply by external forces and demand, other questions must be asked. A study of the ways in which institutions make use of their various degrees of freedom has many benefits: the consequences of alternative production processes within the same institution can be defined, efficiency can be measured, the effects of different strategies for the incorporation and use of factors can be illustrated, and their contribution to the accumulation of scientific capacity and effectiveness can be assessed. The following issues must be considered:

- Internal conversion processes (division of labour in the context of the technologies used and the controls imposed), namely, the technical dimensions of work and, therefore, operational efficiency; and
- Social dimensions (leadership, the culture of the organization, identity, integration, and motivation), supporting flexible, innovative, productive, and socially responsible attitudes.

Examining the degree of freedom to decide on the production process and define strategies for using resources leads us to the organization's activities themselves and the degree to which they are concentrated and specific. If we combine these two dimensions, a number of situations can be constructed, for example:

- High concentration of objectives and products, associated with low specificity in task structures and, therefore, in the profiles of members of the organization and action expected; or
- Low specificity in objectives, with a highly formal and specialized operating system.

A range of other situations is possible. Thus, analysis presents some specific challenges. What are the consequences of each of these situations on the external articulation of the organization? How do we reconcile different demands within the organization if there is a low concentration

of objectives? What impact does specificity have on the capacity to respond to demand and build alliances promoting legitimacy and guaranteeing a sustained flow of resources? What part does task specificity play in the effectiveness of research?

These questions are important. Unlike organizations that execute development programs and projects in which there is a visible goal or result as well as the technological process for achieving it, these factors are not clearly defined in research. Therefore, an understanding of the relation between specificity and productivity would be enriched by analysis of a particular impact in structurally different situations, namely, horizontal integration of disciplines or sequential articulation of types of research.

Consequences relate to the structure of the organization. Here, the organization is an artifact governed by an instrumental rationale. Therefore, we should examine the usefulness of each alternative in the allocation of tasks to particular units and the relation between them and the methods used to program, coordinate, and control the work.

The structure of our organizations varies widely. In some cases, it reflects divisions between disciplines (like universities and institutes for basic research). In other cases, especially those involved in the social sciences, structure is extremely fluid, often depending on the project in hand. It seems to be universally difficult, however, to assemble interdisciplinary groups to work toward common goals in an integrated manner, while preserving the complementary nature of individual contributions.

Research has little to offer in this area. The instruments for analysis of organizations are well enough developed to warrant fresh efforts in the generation of organizational technologies to solve problems of this kind. Case studies may allow comparison of different structural arrangements and their consequences with regard to tasks, product types, or relations with context in similar organizations.

The organization must have management. In this field, many questions need to be asked and many approaches, concepts, and technologies exist. As noted, the management of an organization can manipulate its structure, but often faces significant limitations as a result of inertia, political opposition, and regulation (Kaimovitz 1990). This also applies

to day-to-day management: the director contributes "sense" to the mission and strategies of the organization and builds up cultures through his or her capacity to establish norms and symbolic universes, give them coherence, and administer them; the director's comportment is a critical variable in motivation.

However, in addition to giving "sense," the director can have an impact on productivity and effectiveness. There is a consensus in specialist literature regarding the attributes needed to direct a research organization successfully. The prime function of a director is integration — of the world within and the world outside, of work groups, of the contributions of different units and disciplines, of conflict and competition with collaboration, and of resources and procedures with specific tasks. How is this integration best provided? In what environment should management act? Research is needed on these questions, and interesting contributions could be obtained by comparing technologies and strategies used in specific types of organizations to facilitate the transfer of knowledge and feed the process of development of the institution.

One plausible suggestion is that the nature, origin, and condition of an organization's financial resources are associated with institutional strategy, product type, and operational characteristics. Two further considerations reinforce this notion. First, the financial crisis in research has led many institutions to try to diversify their sources of funds; they are resorting to unheard-of measures with various impacts on strategies, priorities, and activities. Second, institutions face growing acceptance of new criteria for funding based on competition and the sale of services, forcing them to become more aggressive in identifying their clients. In either case, knowing the consequences of alternative strategies is advisable in the search for more effective fundraising policies.

Studies of this kind could well include an investigation of the impact of funding on a project-by-project basis. This has been the practice of international cooperation agencies, and one that has been repeatedly questioned on the grounds that the contribution to the strengthening of institutions is small, or often actually negative. The alternatives (financing programs, endowments, and matching funds) should be evaluated and their impacts compared.

The uncertainty of financial support is an obstacle to institutional development. Such a theoretical statement needs to be supported by empirical verification. If an institution can rely on its sources of funding, its work may be less innovative and productivity may be low. An objective of any work in this area would be to establish the effects of one or another degree of certainty on the ability of organizations to increase their effectiveness.

Networks

The base documents show that organizations acquire social significance by forming groups of institutions that complement each other, as colleagues or competitors, facing challenges and taking advantage of opportunities together. The connections between institutions can be studied using one of two alternative strategies.

One way is through the study of networks, defined as spaces for regular interaction. Exchanges among the member organizations are nonhierarchical, relatively open, and of mutual benefit. Examples can be found in the fields of agricultural, education, and tropical disease research. Studies should establish the contribution of the networks to strengthening of the member institutions, the courses of action they adopt, the relative efficacy of each area in which exchange occurs, and the mechanisms promoting joint efforts and economies of scale. Work should also be done on the way in which participation in a network contributes to greater effectiveness of the organization and its impact at the national and international level.

The other strategy is through the study of organizational chains: groups of organizations with different missions, where the product of one organization is an input for the next. Here, dependence and competition can be identified, and the trend toward self-sufficiency may be illustrated by the tendency to take on additional functions to enable the chains to complete the cycle from basic research to transfer to users (or conversely, to concentrate exclusively on some parts of the cycle). Studies of the various stages of agricultural research and its transfer and use are good examples of this study method (Kaimovitz 1990). Another example is the study of the relation among donor agencies, research organizations,

and the users of research products (such as in tropical disease, biotechnology, social, and economic research).

Processes of change

Research on institutional development should not focus on the development of organizational technology and management but on the impact of certain technologies on productivity, its place in society, learning, and effectiveness. There is, however, one field of study that should have an important effect in terms of operations: the experience of institutional development.

Research organizations in Latin America are being forced to review their missions, activities, structure, and management methods. Research is necessary regarding the assumptions behind their experiences, strategies adopted, the organizational dimensions adjusted, the agents involved, effectiveness of the changes introduced, and results and impact.

Haas (1990) and Martinez Nogueira (1990) offer models, concepts, and conclusions that are useful for formulating hypotheses. Organizations that have undergone change (total or partial, incremental or large scale, structural or functional, technical or cultural and behavioural) can be compared with those where there has been no change in times of turbulence, or where unplanned change has occurred as they adapt to external circumstances.

Evaluation

There has been little research on the evaluation of our organizations. Evaluation is conducted regularly only in agricultural research, where it concentrates on analysis of products, results, and impact. For exampe, the International Service for National Agricultural Research (ISNAR), one of CGIAR's international centres, does an integrated review of organizational aspects of national institutions for agricultural research. It uses proven methods and its experience enables it to make assessments in light of policy and the level of development of the country concerned.

The most common and reliable methods are those used to evaluate programs and projects. There are also instruments tailored to specific types of research and particular disciplines. This is not the case for

integrated evaluation of organizations, evaluation that considers strategic management, conversion processes, resource structure, and products, results, and impact. Case studies can provide some information for refining the instruments of analysis for use on institutions.

Evolution

The base documents show that research institutions have changed strategies over time, redirected their fields of work, faced various challenges, and achieved different levels of effectiveness. Changes in strategy are attributed to a variety of factors: economic or social pressures, advances in knowledge and changes in mission or the subjects to be broached (Chapter 8), and the life cycle of the technology (Chapter 4). Going beyond the simple identification of causes, however, the base documents all insist on the existence of an historical sequence in the development of organizations.

- The appearance of institutions tied to the requirements of production (Chapters 4 and 8) or national development projects with strong backing from political elites (Chapter 3), with important service components, little autonomy to develop individual lines of work (such as parasitology and microbiology in health, importation and acclimatization of species, and experimental management in agricultural research), and contributions from international cooperation through the participation of scientists in national development.

- Emphasis on the training of human resources, cooperation in the form of financial support, and the inclusion of research in multipurpose institutions (like large hospitals and ministries). The development of research accompanies increasing resources, the diversification of the institution, and the multiplication of its lines of work. It gains in complexity and relative autonomy.

- New institutions whose professed objectives are to produce knowledge to feed development processes, with a more integrated view of the problem to be attacked, a notable increase in the training of human resources, and consolidation of infrastructure and financial

resources. The new lines of work are more focused, and objectives are more specific. Maturity brings diversification of work and some dilution of profile, which in turn weakens the original consensus.

- This situation is followed by efforts to rationalize costs and attempts to plan and program support action in a context in which demand changes substantially.
- The development of international networks strengthens external connections, offers access to new knowledge, and overcomes some of the limitations on small-scale operations, but without significant impact on local status.
- Efforts intended to redirect activities, emphasizing the establishment of links with the productive sector.

An overall view of this evolution hypothesizes the existence of a logic of development that, within a framework of increasing complexity, would show a recurrent tension between concentration and diversification. At first, there is concentration; as the organization becomes stronger, there is a tendency to diversify, which leads to crisis and a swing of the pendulum back to concentration — but only after a redefinition of the strategies and products to be adopted. What factors affect the cycle? What part does changes in demand for research products play? Might institutional frameworks be too narrow and inflexible to admit changes in the definition of the problems being researched?

The base documents concentrate on experiences in medium to large countries in Latin America that are relatively advanced in research. The cycle described here is probably not an accurate reflection of what occurs in other countries and institutions operating in less complex contexts. A linear view of development would lead to the hypothesis that the cycle would occur, although at noticeably longer intervals. Indeed, this was the assumption made in attempts to reproduce models borrowed from other contexts in Latin America. However, common sense and accumulated evidence suggest that the hypothesis is not plausible, but there is certainly a lack of work allowing proper understanding of the factors that do influence institutional development. New information must be acquired before the role of the institution, organizational models, and

operational strategies can be defined to meet needs and demand within the limits of available resources.

Just as we can identify a life cycle for research in Latin America, we can also establish some order in the development of individual institutions. The theory presupposes accumulation of resources, capacity, and connections. Complexity increases over time as a consequence of achieving mastery of the work in hand and of progressive attempts to minimize sources of uncertainty. This, in turn, leads to increased size, incorporation of new activities, attempts to build alliances with other agents, and the introduction of more variables into decision-making in management.

We have no similar appreciation of the process of deterioration. Therefore, attempts to reverse it have been weakly based on reflection, analysis, and intuition on the part of decision-makers. Currently, many organizations are deteriorating in terms of capacity, and their essential assets face destruction. This is especially true of organizations financed by the state and even those depending on international cooperation, which has not reached acceptable levels of sustainability.

It is easy to describe deterioration, but hard to determine the reasons for it. Usually, a financial crisis occurs at the same time as a crisis in legitimacy. Existing structures and resources cannot withstand a change in priorities or demand, leadership is questioned, motivation is lost, and staff begin to leave. There was no warning of change and the established culture of the organization is too rigid to redirect strategy. Old alliances tie the organization to corporate interests, and the organization loses the independence it needs to adopt new strategies. An analysis of this situation may yield important lessons for the management of organizations in times of crisis.

A Research Agenda

The following outlines an agenda for research, constructed on the basis of comments made up to this point. All issues and avenues of research are not covered in the agenda. The intention is to define a research strategy with specific focus, identifying areas and means of execution that will have positive consequences for institutional development in

science and technology organizations in Latin America. The objectives of the agenda are

- To achieve fuller knowledge of the processes of institutional development in organizations accumulating and deploying scientific and technological capacity;
- To identify critical variables as a basis for strengthening research organizations, providing elements for the definition of strategies, and improving linkages guaranteeing a steady stream of resources, support, and legitimacy in the future, coupled with an increase in effectiveness;
- To obtain sufficient information to develop technologies for the internal management of institutions; and
- To accumulate knowledge that can be transferred to institutions to enhance their internal management capacity.

A variety of users can benefit from research on institutional development studies: the science and technology community and directors of institutions; those responsible for public policy, especially for science and technology and institutional policy, and for sectors under study; and members of funding agencies and agencies for the formulation and implementation of policies and programs for technical and scientific cooperation.

The priority areas for research are frameworks and models for institutions; strategic management; operational management; and resources.

Frameworks and models

The specific objectives in this area would be to provide elements for the reformulation of frameworks within which research organizations operate and redefine profiles and strategies. The results of such studies would permit the identification of the "force field" around research organizations and the transactions in which they are involved; evaluation of the impact of alternative frameworks; the reconstruction and evaluation of strategies within individual frameworks; and the development of new institutional models.

Strategic management

Objectives in this line of research would be to advance understanding of the factors explaining organizational success and failure; to identify components of the effectiveness of institutions with regard to scientific, political, and administrative capacity; and to design alternative strategies as a function of identified factors to be used as inputs in decision-making.

Issues include life cycles (identification of critical stages and landmarks in evolution); options for each of these situations, including definition of terms, restrictions overcome, and opportunities taken; changes in institutional context; conception of subject of research; behaviour of relevant actors in their fields; capacity-building, the role of management, leadership, motivation, formation of staff, choice of work agenda; and the process of deterioration, illustrated by the loss of social relevance of the mission and activities, obsolescence or weakening of resources, isolation, and decline in quality of production.

Operations and the evaluation of operations

This area would focus on two topics: the intergration of the organization and evaluation of its activities. Its objectives would be to provide information about the "integrative" function of management, with respect to external factors and day-to-day work inside the organization; and to develop methods for evaluating research organizations.

Resource management

This line of work would focus on both human and research resources. It would be aimed at developing ways of managing resources to secure effectiveness in the organization. Among its results would be recommendations for funding agencies and national policy organizations concerning criteria, mechanisms, and modes of allocation of budget resources; and information on the structure of values and motivation of human resources as a basis for designing incentive systems.

Acronyms and Abbreviations

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AIDS	acquired immune deficiency syndrome
AUCC	Association of Universities and Colleges of Canada
AVRDC	Asian Vegetable Research and Development Center
CARDI	Caribbean Agricultural Research and Development Institute
CATIE	Tropical Agricultural Research and Training Centre
CENICAFE	Centre for Coffee Research (Colombia)
CENICAÑA	Research Centre for Sugarcane (Colombia)
CEPLAC	Executive Commission of the Plan for the Economic Recuperation of Cacao (Brazil)
CGIAR	Consultative Group for International Agricultural Research
CHRD	Commission on Health Research for Development
CIAT	International Center for Tropical Agriculture
CIDEIM	International Centre of Cooperative Medical Research (Colombia)
CIFOR	Center for International Forest Research
CIMMYT	International Centre for Maize and Wheat Improvement
CIP	International Potato Center

CNI	National Confederation of Industry (Brazil)
CNPQ	National Council for Scientific and Technological Development (Brazil)
COA	Araracuara Corporation (Colombia)
COLCIENCIAS	Fondo Colombiano de Investigaciones Científicas y Proyectos Especiales Francisco José de Caldas (Colombia)
CONACYT	Consejo Nacional de Ciencia y Tecnología (Mexico)
CONICIT	Consejo Nacional de Investigaciones Cientificas y Técnologicas (Venezuela)
CONICYT	Comisión Nacional de Investigación Cientifica y Tecnologica (Chile)
ECLAC	Economic Commission for Latin America and the Caribbean
EMBRAPA	Brazilian Agricultural Research Organization
EMBRATER	Brazilian Technical Assistance and Rural Extension Corporation
FAO	Food and Agriculture Organization of the United Nations
FHIA	Agricultural Research Foundation of Honduras (Honduras)
FICR	Fundación Interamericana de Costa Rica
FONAIAP	Fondo Nacional de Investigaciones Agropecuarias (Venezuela)
GDP	gross domestic product
IAP	Research Institute on Peruvian Amazon (Peru)
IBPGR	International Board for Plant Genetic Resources

IBSRAM	International Board for Soil Research and Management
ICA	Colombian Agricultural and Livestock Institute
ICARDA	International Center for Agricultural Research in the Dry Areas
ICIPE	International Centre of Insect Physiology and Ecology
ICLARM	International Center for Living Aquatic Resources Management
ICRAF	International Centre for Research on Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICSU	International Council for Scientific Unions
IDB	Inter-American Development Bank
IDRC	International Development Research Centre
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
IICA	Inter-American Institute for Cooperation on Agriculture
IIMI	International Irrigation Management Institute
IITA	International Institute of Tropical Agriculture
ILCA	International Livestock Centre for Africa
ILO	International Labour Office
ILRAD	International Laboratory for Research on Animal Diseases
INIAP	National Institute of Agricultural Research (Ecuador)

INIA	National Institute of Agricultural Research (Chile)
INIA	National Institute of Agricultural Research (Mexico)
INIBAP	International Network for the Improvement of Banana and Plantain
INPE	National Space Research Institute (Brazil)
INTA	National Institute of Farming Technology (Argentina)
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research
IVIC	Instituto Venezolano de Investigaciones Cientificas
NGO	nongovernmental organization
NRIs	national research institutes
OAS	Organization of American States
OECD	Organisation for Economic Co-operation and Development
REDUC	Latin American Network on Information and Documentation
RELAB	Latin American Network for Biological Sciences
RIDALC	Regional Network of Researcher Exchange for the Development of Latin America and the Caribbean
SIPA	Servicio de Extensión y Promoción Agraria (Peru)
SNI	National Researchers System (Mexico)
TDR	Special Training and Research Program on Tropical Diseases
UAM	Universidad Agraria La Molina (Peru)
UNDP	United Nations Development Programme

Unesco	United Nations Educational, Scientific and Cultural Organisation
UNICAMP	Universidade Estadual de Campinas (Brazil)
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
USD	United States dollars
WARDA	West Africa Rice Development Association
WHO	World Health Organization

BIBLIOGRAPHY

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Chapter 1

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This book should be read by anyone interested in institutional development, especially policymakers, funding agencies, researchers, and administrators in science and technology.

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