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THE ESSENCE OF COLLABORATION
SCIENCE AND TECHNOLOGY IN A POSITIVE-SUM GAME

by

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Preface

It has been observed that the United States Foreign Service provides some degree of training for any junior officer headed for the most insignificant overseas post, but it does virtually nothing to provide its Washington assignees with adequate preparation to cope with complex "intermestic" issues such as energy, the transnational corporation (TNC), and foreign assistance.¹ Although the general public has become more aware of these issues, there is an even more serious failure to educate Americans in all walks of life to the full implications of the blurring of international and domestic distinctions. Without assiduous attempts to map out and enunciate the congruence of interests that binds together "the domestic priorities that govern the political life of states, and the external imperatives of /world/ order",² the rhetoric of interdependence will remain just that and the opportunities to collaborate on a global basis to solve global problems will slip through our fingers.

A serious domestic misperception that prejudices cooperation with the developing countries stems from an exaggerated sense of the one-way flow of benefits. Indeed, the debate over who benefits from foreign assistance usually

¹See Robert Pringle, "Creeping Irrelevance at Foggy Bottom", Foreign Policy, No. 29 (Winter 1977-78), pp.136-137.

²Stanley Hoffman, Primacy or World Order: American Foreign Policy Since the Cold War, (New York, McGraw-Hill, 1978), pp.140-141.

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narrows down to two primary contenders: affluent elites and the desperate "poorest of the poor". In effect, neither putative beneficiary approaches the level of real economic value extracted from the aid transaction by the donor. That nearly eighty percent of the foreign aid allocation is currently spent in the United States, and that the supplies, equipment, and materials purchased from the American private sector account for more than twelve percent of the country's exports and that seven hundred thousand jobs are directly linked to production for this purpose are considerations frequently sloughed over.³ In this vein, it is not surprising that Governor John J. Gilligan, the Agency for International Development (AID) Administrator, reported to his employees that the 1979 foreign assistance appropriations bill received the support of the National AFL-CIO, the United Auto Workers, and the National Chamber of Commerce, which each sent letters endorsing the bill to every member of Congress.⁴ Gene E. Godley, Treasury's principal lobbyist on the Hill, calculates that there is presently a hard core of fifty-one supporters of foreign aid in the House of Representatives and, he believes this number is growing as constituencies beyond the grain belts of PL-480 renown, gain a better understanding of their vested interests in the transfer of resources to the developing world.⁵

³Figures provided by the Office of Public Affairs, AID.

⁴"Notes from the Administrator's Desk", Front Lines, Vol. 16, No. 13 (August 3, 1978), p.3

⁵Oral remarks made at Secretary Blumenthal's Seminar on Economic Issues, July 19, 1978.

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Where the effort has been made, foreign aid has been justified on political grounds as well; in certain impoverished countries, United States ambassadors derive considerable leverage from their influence on the sluice gate that controls the foreign aid lifeline. And there are humanitarian grounds. Foreign aid is a small price to pay for a salved conscience, and in any case, few Americans adhere to the Athenian dictum to the Melians recorded by Thucydides: "That the powerful exact what they can, and the weak grant what they must".⁶ However, frequently overlooked are the science and technology benefits of foreign aid.

In the business of technical assistance, technology transfer, science and technology collaboration--whatever designation is given to scientific and technological interaction between developed and developing countries--there are myriad mutual benefits that range from good specs of dust to polished carbuncles, which frequently are dynamic catalysts for further research and development. An esoteric example is the AID-financed National Institute of Health research in Iran during the early sixties which led to the discovery that dwarfism due to zinc deficiency is completely reversible. An immediate result of this pioneer work was the establishment of two research centers on trace elements in the United States.⁷ More recently, United States Department of Agriculture (USDA) scientists, using PL-480 local currency funds learned that children with kwashiordor (extreme protein malnutrition)

⁶Quoted in Fouad Ajami, "The Global Logic of the Neoconservatives", World Politics, Vol. 30, No. 3 (April 1978) p. 454.

⁷Annual Report, Inter-Departmental Committee on Nutrition for National Defense, 1964.

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in Nigeria and Jordan suffer from a chromium deficiency. Their work abroad provided impetus to domestic research on diabetes and led to the discovery that chromium supplementation prevents minor forms of diabetes.⁸

The present study is the product of an effort to determine the extent and types of benefits that have accrued to the United States from technical assistance activities developed, in the main, as part of the foreign aid program. These activities are largely based on the premise that the overseas effort will contribute to the solution of a particular problem in a developing country, contribute to the development of a particular sector in the host government's economy, or increase the capability of the host government to initiate and carry out development planning on its own--all designed to help the people of these countries fulfill their aspirations for justice, dignity and a better life. At the same time, many of these activities have been found to have produced benefits to the United States itself. While the economics of social benefits to the United States of an individual project are frequently open-ended and difficult to quantify, the collective domestic impact of these projects is impressive.

⁸L. Hopkins, Project Evaluation, ARS/USDA, September 9, 1974.

Beyond the specific instances of mutual benefit, there is the theoretical importance of articulating the overarching mutuality of interest that informs United States policies favoring collaboration with the developing countries. The sensibilities of many Third Worlders have been needlessly offended by indelicate or implausible justification for extending a helping hand to them. Ali Mazrui comments:

"The old school of foreign aid was to some extent a charitable impulse. Within that context, aid totally without strings should have been regarded as an insult to human dignity. For such aid, were it indeed given without strings, would have been unmitigated charity. And charity is not a relationship between equals, however virtuous it may be. Aid without strings never occurs among genuine equals. Any transfer of resources from, say, Britain to France, must always be conditional on some kind of quid pro quo. Equality implies exchange."⁹

Indeed, aid as either due or dole is unacceptable to donor and recipient respectively. By framing the canvass of collaborative assistance in the mutual benefits calculus, the donor can relate to the recipient in the more acceptable role of "primus inter pares". In an age when the nation-state suffers from an overdosage of suspicion as to the motives of other states, and we are not witnessing a radical departure from the past, the mutual benefits ideology lends credibility to the above-the-table, positive-sum nature of development cooperation.

The August 1979 United Nations Conference on Science and Technology for Development (UNCSTD) to convene in Vienna offers a propitious forum for a concerted pitch

⁹Ali A. Mazrui, Panel Discussion in Jagdish N. Bhagwati, The New International Economic Order: The North-South Debate, (Cambridge, Massachusetts: M.I.T. Press, 1977), p.371.

for international science and technology collaboration. The Conference can serve to disambiguate United States interests in the generation and application of science and technology for the promotion of national and world welfare. The immediate United States concern is its diminishing research and development prowess, which for some, has conjured scenarios of national decline. This, with clarification of the United States stake in technology transfer in relation to direct foreign investment, could galvanize United States public interest in the UNCSTD galaxy of issues. Equally important, it may highlight the need for, if you will, an inverse development perspective, i.e., a recognition of the preponderant direct benefits to the United States that are radially symmetrical to the collaborative assistance orbit. This perspective should not omit the indirect benefits, external economies, spillovers, linkages, or by whatever term secondary effects are denoted, which as Albert O. Hirschman tirelessly points out, may in reality be of primary importance to socioeconomic development.¹⁰ Seen through this optic, the foreign aid pill is not as bitter as it is popularly made out to be.

¹⁰See Albert O. Hirschman, Development Projects Observed, (Washington, D.C.: The Brookings Institution, 1967), p.160.

For encouraging me to essay the Washington perspective, I am grateful to John P. Lewis and Donald Stokes. To Ambassador Jean Wilkowski, her deputy James Stromayer and staff, I owe profound gratitude for a stimulating initiation to public service of the highest caliber. I come away impressed by the singular dedication of those who backstop the many diplomatic outposts scattered around the world and who simultaneously, grapple with the formulation of United States foreign policy.

In preparing the present study I am indebted to many individuals in and out of government who were generous of their time and helpful in every sense of the word. These include: Joel Bernstein, Harvey Brooks, Maurice Brown, Norman Brown, Curtis Farrar, Thomas Fox, Gerald Garvey, James Grant, Gordon Hiebert, Theodore Moran, Claire Nader, Joseph Nye, John Sewell, Robert Smith, and Herbert Turner. I would like to acknowledge the influence on this study of a meeting held at the United Nations that saw assembled Gustave Ranis, John P. Lewis, and senior officials of the UNCSTD Secretariat. Exposure to the views of most of the assistant secretaries of the Treasury Department during the course of the Secretary's Seminar on Economic Issues has been of value. I would like to express appreciation for the diligent work of Helen Davidson and Susan Weintraube in combing the government literature and locating useful materials. Nora Lateef receives special thanks for being a resourceful and unfailingly cheerful research assistant. The failings of this paper are entirely my own.

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Setting the Stage For
Scientific Collaboration

"Philosophers make imaginary laws for imaginary commonwealths, and their discourses are as the stars' which give little light because they are so high."

Bacon, On the Advancement of Learning

"The roads to human power and to human knowledge lie close together and are nearly the same; nevertheless, on account of the pernicious and inveterate habit of dwelling on abstractions, it is safe to begin and raise the sciences from those foundations which have relation to practice, and let the active part be as the seal which prints and determines the contemplative part."

Id., Novum Organum

Francis Bacon, lawyer, statesman, essayist--at one time Lord Chancellor of England in 1618--was not a scientist. It has been remarked that if all of Bacon's writings were somehow expunged from history, not a single scientific concept, not a single scientific result, would be lost.¹¹ Yet, his was an invaluable contribution to the advancement of science and man. For Bacon, the endless pursuit of knowledge had one central purpose--utility. In shaping the scientific credo, he stamped his conviction upon the normative role science should play in mitigating human suffering. In his utopia, the primacy of the philosopher-king was challenged and the ascendancy of the research-scientist all but assured.

Bacon flagged the essence of collaboration in the transcultural pursuit of knowledge. Of the scientific continuum, Edward Zilsel has observed:

¹¹Alexander Koyré quoted by Daniel Bell, "Technology, Nature, and Society" in Brook Hindle (ed.), The Frontiers of Knowledge (New York: Doubleday & Co., Inc., 1975), p.44.

"The modern scientist looks upon science as a great building erected stone by stone through the work of his predecessors and his contemporary fellow-scientists, a structure that will be continued but never be completed by his successors.... /Science/ is regarded as the product of a cooperation for non-personal ends, a cooperation in which all scientists of the past, the present and the future have a part. Today this idea or ideal seems almost self-evident. Yet no Brahmanic, Buddhistic, Moslem or Catholic Scholastic, no Confucian scholar or Renaissance Humanist, no philosopher or rhetor of classical antiquity ever achieved it. It is a special characteristic of the scientific spirit and of modern western civilization. It appeared for the first time fully developed in the works of Francis Bacon."¹²

Although the on-going scientific revolution is unprecedented in its global impact--reshaping the lives and prospects of people everywhere, including those who know very little about science--we would be remiss if we failed to acknowledge the power of raw science and, when it has met the test of doneness, technology, even at the lowest rungs of the historical ladder.¹³

More than just his ability to use tools, Homo faber is separated from subhuman primates and lower animals by his ability to communicate the features of this innovation

¹²Edgar Zilsel, "The Genesis of the Concept of Scientific Progress" in Philip Viener and Aaron Noland (eds.), Roots of Scientific Thought, (New York: Basic Books, 1960), p.251.

¹³The words "science" and "technology" are bandied about rather indiscriminately. Admittedly, these terms are difficult to define precisely, both because they embody broad domains of contemporary activity, and because they are susceptible to various degrees of subjective judgment. Despite these difficulties, it will facilitate discussion of our topic to specify definitions which, if not unique, are at least compatible with one another, and can serve as coordinates for our analysis. Robert G. Jahn, Dean of Princeton's School of Engineering and Applied Science uses an etymological approach: "...the word 'science' ultimately derives from the Latin verb 'scire': to know; and it is knowledge which is the principal goal of science.... The word technology derives from the Greek 'texon', or equivalently the French, 'techne' both of which denote an art, craft, or skill.... and technology's implicit 'old ideal' is to improve the quality of human life by judicious deployment of technical facilities and processes." "Technology's Tightening Grip: Ours to Control?", University: A Princeton Quarterly, No. 69, (Summer 1976), pp.1-2.

without tapping the time-honored but intellectually-limited heuristic devices of mimicry. Given the extent of scientific and technological dissemination, one can infer that man is a fairly garrulous creature. But more than being simply a compulsive communicator, man has always been driven by some kind of moral imperative which, under certain conditions, has manifested itself all too feebly to make itself felt powerfully on other occasions. The underpinnings of this ancient impulse are essentially collaborative. In the words of Richard E. Leakey and Roger Lewis: "Sharing, not hunting or gathering as such, is what made us human. We are human because our ancestors learned to share their food and their skills in an honored network of obligation."¹⁴

Nowhere in the disciplines of human endeavor has sharing counted for as much as in science. Thomas S. Kuhn has gone so far as to say that "scientific knowledge, like language, is intrinsically the common property of a group or else nothing at all."¹⁵ Indeed, the scientific "lingua franca" is the vehicular language of our times. The emphasis on the scientific method has intensified during the last three to four centuries to the point that it has overshadowed all other ways of looking at reality. In its technological incarnation, science has radically altered contemporary life

¹⁴Richard E. Leakey and Roger Lewis, People of the Lake, (New York: Anchor Press/Doubleday, 1978), p.82.

¹⁵Thomas S. Kuhn, The Structure of Scientific Revolutions, (Chicago: The University of Chicago Press, 1970), 2nd edition, p.210.

patterns by triggering a revolutionary change of scale. The Athenian "polis" is now played out on the scale of Zeno's "cosmopolis".¹⁶ Increasingly the fulcrum of this decidedly tangled and technetronically miniturized world is the scientific capability to meet human needs so basic as to be human rights.

In the fifties and early sixties, the United States along with other western countries embarked on what John P. Lewis has described as a "program of creeping international justice".¹⁷ This venture assumed a benign convergence of per capita growth rates--coming together eventually at levels of per capita welfare still higher than those now prevailing in the West. The absence of convergence has come as a blow for those who took the evolution of the international economic system to be a goal-directed process. A resignedly passive view of this process has taken hold in the West, where it is now seen as a progression evolving in stages characterized by increasingly detailed and refined understanding of nature but, nonetheless, obdurately resistant to man's attempt to better the human condition on a nondiscriminatory basis.

¹⁶Daniel Bell posits that if any single principle dominates contemporary life it is this change of scale. For Bell the new scale ramifies powerfully in two ways: "One, it extends the range of control from a center of power. (What is Stalin, an unknown wit remarked, if not Genghis Khan with a telephone?) And two, when linear extension reaches certain thresholds, unsettling changes ensue." Ibid., p.57.

¹⁷John P. Lewis, "Oil, Other Scarcities, and the Poor Countries", World Politics, Vol. 27, No. 1, (October 1974) p.67.

The inadequacies of technical assistance, replete with such encumbrances as the recipients' suspicions of its motives, signaled the malaise that had overcome the classic development program, even before the sobering proposition of finiteness made its debut along the scarcity salient. This new variable has brought home much more forcefully than the Apollo vision of a lone planet, the necessity of global cooperation. It has left both North and South little choice other than to examine the marrow of that haggard skeleton that braces the international economic system, and to front its deformities.

The days of global bargains struck at someone's expense are over. The United States cannot help but extrapolate in its foreign policymaking from its own domestic Third World experiences and most recently, the unfortunate incidents that accompanied the New York City blackout of July 13, 1977, in which poverty, unemployment, and inflation were far from innocent bystanders.¹⁸ Abroad, United States citizens and increasingly vital national interests could be jeopardized in the future by similar poverty-induced sprees of vandalism should either an act of God or one of mortal making precipitate a similar collapse of the legal order.¹⁹

¹⁸See Robert Curvin and Bruce Porter, "The Social and Economic Causes for the Violence of July 13, 1977", Ford Foundation, July 1978.

¹⁹American corporations now own over half the world's total foreign direct investment and at the end of 1975, 26.2 percent of the outstanding book value of this investment was in the developing countries; the figure is 24.1 percent when petroleum is excluded. Source: Survey of Current Business, Vol. 56, (August 1976), p.46.

History has taught us, if nothing else, the sheer futility and astronomical rent of exclusivity both within individual nation-states and coalitions thereof.

The developing world has come to recognize that the centralized character of the global stock of scientific knowledge and technological capability is a distinctive feature that controls the ordering behavior of international life.²⁰ In due time, the developing countries will acquire the technical know-how they seek one way or the other. The key question is whether the West will facilitate the transaction or attempt to obstruct it. Will the scientific community, for instance, strive to ginger a consensus in the West that science and technology ought to be understood and used for the benefit of all mankind and not just those who first master its techniques. This value premise is implicit in the great motto of Columbia University: "Man's right to knowledge, and the free use thereof". The report to the Club of Rome entitled Reshaping the International Order contains a concluding thought in its chapter on scientific research and technological development that has become one of the rallying cries to the Third World proponents of a New International Economic Order (NIEO): "Ultimately, science and technology must be viewed as the common heritage of mankind."²¹ How the West reacts to this presumptuous-

²⁰"Nowhere is the disparity between the industrialized and Third World countries more marked than in the field of scientific and technological development. Although 90% of all the technologists and scientists that have ever lived are alive today, over 90% are at work in the industrialized countries. Over 90% of their activities are concentrated on research for the rich world and on converting their findings into protected technical processes". Reshaping the International Order-A Report to the Club of Rome, (New York: Signet, 1976), p.43.

²¹Ibid., p.192.

sounding proposition will ramify critically in western relations with the majority of the world's inhabitants and will set the tone for the on-going transition in world order. Should the West rigidify, and there will be much internal pressure for it to do so, the quest for international stability could be imperilled and the transnational willingness to cooperate retarded.

The argument for scientific and technological collaboration with the developing countries can be comfortably apparelled in many garments. We have elected in the present effort to try on the mutual benefits outfit for size. As will become apparent in the course of the discussion, this choice does not make for a snug fit. However, our subject is growth-oriented and the opportunities cited should illustrate the vast potential for expansion in both collaboration and benefits.

The time has come for a technological regime supportive of a world order firmly rooted in the fundamental logic of reciprocity. We must look beyond involuntary accomodation, adherence to norms, and military self-restraint to an emerging collaboration in science and technology that accents the mutual benefits inherent in such collaboration. The strength of reciprocity is increased in an interdependent world in which there is diminishing prospect of advantage from the exertion of superior force. As global conflicts become more unthinkable, there is every reason to transform structures of domination into structures of collaboration.

Can greater scientific and technological collaboration unite the world in a common enterprise that gives content to an international harmony of interest? How "sharable" are science and technology resources, especially where there is joint interest in weighting decisions in favor of inclusive over exclusive claims?

By "sharable resources", Myres S. McDougal refers to the oceans, air space over the oceans, international rivers, polar areas, and outer space. Seemingly abstract but no less tangible than the physical bodies cited, science and technology are inherently sharable. Of such resources McDougal observes:

"The cumulative experience of several centuries appears to establish that it is by such shared, inclusive use of resources that the peoples of the world, because of their interdependencies and the requirements of specialization, can create the greatest net gains both in the divisible values of wealth, enlightenment, well-being and so on, and in the indivisible value of general security. This same experience suggests, further, that the allocation of competences between the inclusive competence of particular states best designed to secure and protect the inclusive use of such resources-- with a fair division among peoples of the net gains of their cooperative exploitation and with the utmost encouragement of integrative solutions in which all gain and none lose--is an allocation heavily weighted in favor of the inclusive, shared competence of the general community of states."²²

²² McDougal and Associates, Studies in World Public Order, (New Haven: Yale University Press, 1960), pp. xiv-xv.

The jurisprudential edifice which McDougal constructed with Harold Lasswell has become a familiar landmark in our intellectual landscape.²³ But familiarity has not removed its disturbing character for some. Its conception of policy-oriented international law still evokes passionate reaction. Without becoming mired in the controversy over the "jurisprudence of values" and refraining from the insertion of science into its complex methodology for relating social phenomena, basic values, and law, it will suffice to note at this time, that McDougal provides a valuable touchstone for the collaborative theme. Instead of adopting an overly futuristic approach, permitting critics to invoke what Richard Falk calls the fallacy of premature specificity, it is preferable in the present effort to identify concrete examples of scientific and technological collaboration for development, past and present, which would justify a significantly enlarged program in the future.²⁴

²³For a well conceived festschriften see W. Michael Reisman and Burns H. Weston (eds.), Toward World Order and Human Dignity: Essays in Honor of Myres S. McDougal, (New York: The Free Press, 1976).

²⁴The Falk fallacy and much more, including a vivid delineation of the "McDougal breakthrough" and a provocative discussion of ongoing transition in world order are found in "A New Paradigm for International Legal Studies: Prospects and Proposals", Yale Law Journal, Vol. 84, (1975).

In Search of Mutual Benefits

It is generally assumed in the United States that technical assistance to the developing countries is a one-way street traversed solely for the purpose of aiding these same countries. There is much less understanding of the benefits which accrue to various sectors of the United States economy and society--that this form of collaboration is indeed an international highway whose traffic brings valuable exchange of "goods" and goodwill.

Designed into international exchange, mutual benefits stemming from technical assistance and economic cooperation have firmly established new patterns of international conduct and are making inroads on more traditional diplomatic and military patterns. The development of improved international relations has much to gain from joint and continuous efforts carried on between nation-states. There is no substitute for habits created when citizens of various countries work together in dealing with common problems. It is not only that techniques of mutual aid are furthered but, equally important, that unity of purpose and will is achieved. Sometimes, it requires the detachment of an outsider to crack troublesome chestnuts. Often these are common problems which, because they are proximate, preclude dispassionate treatment.

Combining experience and skills on both sides of the "poverty curtain" in devising new technologies to meet pressing needs on many fronts of the global struggle for survival could assure an optimal combination of technical efficiency and local fit. The mutuality of effort would have important psycho-political advantages, encouraging greater acceptance by the developing countries. It could also nurture a felicitous "esprit de corps" rarely encountered in North-South interactions. The collaborative participation by developing country experts and the similarity of many global needs increase the prospects of technical feedback that is useful to the United States.

Ideally, collaboration on research and development, technology testing, policy analysis, and other problem-solving work can eventuate in a net result greater than the sum of its individual parts. Such a synergism lowers the time threshold for discovery of solutions. When research protocols and evaluation processes are widely disseminated, pooled energies at experimental sites at different locations enhance the possibilities for new insights. The improvement of communications and transportation-coupled with the trend of many fields of science towards large-scale activity-have contributed to the evolution of recent international collaboration and more fundamentally to an influential global constituency comprised of scientists, engineers, and other academicians committed to the transnational pursuit of knowledge. Albeit funding for this cross-fertilization of minds and exchange of research technologies comes from national governments,

the explicit initiatives originate directly with working scientists. Harvey Brooks, a major spokesman for this constituency, articulates widespread sentiment among its ranks vis-a-vis interference from national actors: "Government ought to step in only when it can facilitate cooperation which is beyond the resources or organizational capabilities of the professional associations of science."²⁵

While a substantial number of American scientists and technologists have been "coopted" by government, the majority are spread out among institutions across the country. The consequent diffusion of responsibility for communicating concern about international collaborative issues has abetted carriers of the conventional wisdom that would have such issues falling to the wayside for lack of a constituency. The oft-cited observation, however, that election years spell trouble for foreign aid bills in Congress, since they are measures whose constituency does not vote, is deceiving.²⁶

Limited efforts have been made to determine the extent and types of benefits that have accrued to the United States from technical assistance activities developed as a part of the foreign aid program. One of the clear winners

²⁵Harvey Brooks, "Policies for Technology Transfer and International Investment" in Richard Mayne (ed.), The New Atlantic Challenge, (London: Chas. Knight and Company, Ltd., 1975), p.157.

²⁶This point is made in a recent Post editorial: "The vulnerability of foreign aid is always obvious at first glance." However, as this editorial relates, besides tactical skill, the passage of the 1979 foreign aid bill benefited from many allies. "A Victory For Foreign Aid", The Washington Post, August 18, 1978.

in the development business is academia. In 1977, three hundred seventy United States institutions of higher learning benefited to the tune of \$300,000,000. Over forty universities have received Section 211(d) grants to establish centers of competence in specific subject areas ranging from aquaculture and marine resources (Auburn University and University of Rhode Island) to comparative legislative studies (Duke University, University of Hawaii and University of Iowa). The programs selected to serve as a basis for these grants build into these centers a degree of permanence and, while developing competence on international development problems, they have given the institutions' program an international dimension. In some cases, departments of international studies have been formed. In all cases, faculties have been strengthened, teaching and research programs have been broadened, and libraries expanded. Such improvements have enriched American universities and furnished students and professionals unique information resources and consulting services.

Agricultural advancement has received priority. Examples include projects in land tenure, tropical soils and utilization of water resources for agriculture. A grant to the University of Wisconsin has greatly assisted that university in developing a center of excellence in land tenure and related problems. It has enabled the center to expand its instructional program with the addition of new courses and through the establishment of a vigorous Ph.D in Development

degree program. The Center has acquired one of the nation's most complete libraries relating to international agricultural development, agrarian reform and political changes associated with rural development. Much of the data accumulated and the studies conducted have application to some areas and conditions in the United States.

A tropical soils project joins five United States institutions in a cooperative program to strengthen and coordinate their competencies and resources in the following interrelated fields: Cornell University--cultural systems; University of Hawaii--biology and mineralogy; North Carolina State University--soil fertility and plant nutrition; Prairie View Agricultural and Mechanical College--savanna and prairie ecology; and the University of Puerto Rico--conservation and protection. And a water resources project brings together the capabilities of three institutions: University of Arizona--watershed management; Colorado State University--water delivery and removal systems; and Utah State University--farm water management. The tropical soil and water management principles and techniques shared during the course of inter-university activities, publications, seminars, and student-faculty interchange are significant spin-offs from this novel institutional cooperation. These grants have had a multiplier effect in stimulating the commitment of other resources to the program, in increased efficiency through pooling multi-university resources, and in capturing the interest of faculty, students, and professionals involved in the extension of technical services.

Most recently the Congress has created a new part of the foreign assistance act (so-called Title XII) to provide funds for American land-grant colleges to work on agricultural problems outside the United States. "In effect, the United States is coming to recognize that its own research and development capabilities can legitimately--in the sense that it is in the United States interest--be applied to international as well as domestic problems. This will be of limited value unless there is a concomitant growth in research and development capacity with LDC's but the two developments are complementary, and promise considerable benefit if both are carried out."²⁷ The Title XII legislation is also very palpable evidence of the presence of a thriving foreign aid constituency, a sector of which has moved to consolidate its primacy in the area of agriculture to the unfortunate exclusion of colleagues not associated with land-grant colleges.

Approximately seven thousand foreign participants are brought to the United States annually under the aegis of AID's training program. Since 1942, in more than one hundred countries, nearly two hundred thousand former participants have been trained--individuals with whom we share mutual interests and with whom the means of cooperation have been established. The United States' advantage inherent in their presence is very real. Likewise, there are intercultural benefits from a growing body of foreign students who come to the United

²⁷Harvey Brooks and Eugene B. Skolnikoff, "Science, Technology and International Relations", Text of speech delivered at the NATO Science Committee Twentieth Anniversary Commemoration Conference, Washington, D.C., April 12, 1978, p.23.

States on their own or under various forms of sponsorship in addition to the AID participants. In 1970 there were an estimated one hundred eighteen thousand non-immigrant foreign students and, by the end of 1978, the estimate is for two hundred fifty thousand.²⁸

One of the facts which is frequently overlooked is that investment abroad in capital equipment calls for the rational use of technology. As St. Augustine observed, man looks about the universe in awe at its wonders and forgets that he himself is the greatest wonder of all. Unless there are available trained personnel to manage, use, and maintain equipment, investment may be dissipated and development blocked.

Private investment, as well as loans and grants by government, create a stake in human resources development abroad. United States firms investing in developing countries depend heavily on indigenous personnel for performance on the job and for care and maintenance of costly equipment, as well as for management and protection of the investment. Furthermore, there are linkages between various aspects of technological advancement. Effective development and management in one industrial area may well bulwark investment in other industrial enterprises. Korea largely owes its record electric power production to two hundred seventy-five highly trained executives, management technicians and engineers who have studied and trained in the United States under AID

²⁸United States Advisory Commission on International Education and Cultural Affairs, "Fourteenth Report: The Unfinished Agenda", 1978, p.50.

sponsorship since 1954. Further investment opportunities resulting from the expansion and able management of that country's electric power industry are readily apparent. Increasingly, American transnational corporations (TNCs) are mounting particularized human resources development programs for their indigenous employees that build upon and follow in the train of the United States government effort.

One of the main objectives of participant training is to develop counterparts or opposite numbers in the governments of developing countries. This infiltration of foreign governments with policy-makers and technicians exposed to American acculturation is essential if critical capabilities in these governments are to be had. It is noteworthy, for instance, that in all Latin American countries either the Director General of Statistics, his Deputy, and/or key staff members have been trained as participants in the United States.

This technical subversion is important to American business since orders for purchase of equipment, materials, and services often result from participant training. In every field of training, participants come in contact with firms and organizations producing and selling equipment. The participant's familiarity with particular products is often directly responsible for placement of orders by his government or other employers after his return home. In numerous instances, participants have been directly responsible for effecting contractual or licensing agreements between

United States firms and their own.²⁹ As a consequence of these training programs, American businessmen angle more often than not in friendly waters.

²⁹See AID, Office of International Training, "United States Participant Training", mimeo., 1973.

"Who's Afraid of Trade and Not Aid?"

A technologized world is inevitable. We are moving inexorably in the direction of technopolis. Richard N. Cooper³⁰ has observed that with the accumulation of capital, the diffusion of technology has made national economies more similar in their basic characteristics of production; comparative cost differences have narrowed, suggesting that imports can be replaced by domestic production with less loss in national income than heretofore. "Whether a country imports a particular good or exports it thus becomes less dependent on the basic characteristics of the economy, more dependent on historical development and on relatively accidental and transitory features of recent investment decisions at home and abroad."³⁰ In effect, the invisible hand of economic interdependence is fostering a new if still amorphous technological regime.

The stated goal of the Group of 77, as expressed in the Declaration of Lima and reiterated in UNCTAD IV, is to increase their share of the world's output of manufactured goods to at least twenty-five percent by the year 2000.³¹

³⁰Richard N. Cooper, "National Economic Policy in an Interdependent World Economy", The Yale Law Journal, Vol. 76, (1976), p.1273.

³¹Historically, the Group of 77 is an informal association of developing nations which came into existence at the 1964 UNCTAD and which is now pressing the industrialized nations for a new international economic order. The Group of 77 now comprises 111 member countries of the United Nations.

These countries accounted for about eight percent of the manufactured goods market in 1976. Here we must be more discriminating in discussing the Group of 77 and its deceiving commonality of positions. The "local Leviathans" in this grouping, e.g. India, Brazil, Mexico, Algeria, South Korea, do most of the manufacturing and are focusing on new economic opportunities: access to the markets of the developed world, its capital, and its front-end technology. The low-end, so called Fourth World countries are in a wholly different ballpark. They continue to stress their need for resource transfers through the conventional channels of international assistance. However, they have lent their poverty to the NIEO cause and share with the Third World countries many of the same aspirations.

Growth through import substitution--the thrust of which is to make domestic manufacturing profitable--is the trend of the future in the developing countries.³² "The division of the world into developing countries that export agricultural products and import manufactures, and developed countries which do the reverse is on the verge of ending." W. Arthur Lewis also notes in his incisive Janeway Lectures on the evolution of the international economic order that since 1960, manufactures have become the fastest growing export of developing countries, constituting 33 percent of their exports by 1975, and if current trends continue, excluding the oil producing countries, by 1985 more than

³²See Lloyd G. Reynolds, Image and Reality in Economic Development, (New Haven, Yale University Press, 1978), pp.179-185.

half the exports of developing countries will be manufactures.³³ This erosion in western industrial supremacy is being accelerated as the West's advantages in manufacturing are being competed away. While this challenge has been cumulative rather than sudden and oblique rather than frontal, its psychological shock effect is likely to be felt very strongly in the United States. The "defi de tier monde" has all but replaced the "defi americain" in the international economic system.

In the past two years, the traditional United States trade surplus in manufactured goods has been declining and figures for the first half of 1978 reveal a mounting deficit of sixteen and thirty-seven one hundredths billion dollars. This deficit is in contrast with a surplus of twenty-one billion dollars in manufactured goods as recently as 1975. The country distribution of United States exports of manufactures has followed the general pattern of changes shown by the sources of United States manufactured imports: developing countries are becoming more important for the United States although the increase in developing country shares for United States exports is smaller than for United States imports. Six rapidly industrializing countries (Brazil, Hong Kong, Mexico, Singapore, South Korea, and Taiwan) supplied two-thirds of all Third World manufactured exports to the United States in 1977. Developing countries now buy 43 percent of United States manufactured exports.

³³W. Arthur Lewis, "The Evolution of the International Economic Order", Discussion Paper No. 74, Research Program in Development Studies, Woodrow Wilson School, Princeton University, (March 1977), p.25.

Developed countries purchase slightly more than half of United States exports, with Canada the largest single market. Communist countries remain comparatively unimportant as trade partners in manufactures, accounting for about one percent (see Table I).

The United States remains the world's largest exporter and importer. However, in manufactured exports, the United States was overtaken by West Germany in 1970. Germany had 19.1 percent of the world manufactured exports in 1976, compared with the United States share of 18.3 percent (Seventy-nine billion for the United States and ninety-one billion for Germany). Since 1970 Japan's share for manufactures has risen rapidly, reaching 14.8 percent in 1976. United States--Japanese trade in manufactures shows the greatest asymmetry of any major area, and the asymmetry has grown since 1970. In 1970, Japan accounted for 21.6 percent of United States manufactured imports and 6.6 percent of United States manufactured exports. In 1977, the comparable figure had risen to 23.5 percent on the United States import side and the United States export side had fallen to 4.6 percent.

The United States export share of world trade has been declining for nearly two decades.³⁴ This phenomenon is true not only for the mature markets in the industrialized countries but also, of late, for the developing countries

³⁴For a comprehensive treatment of United States trade performance since 1970 see National Association of Manufacturers, "Special Report on International Economic Policy", May 18, 1978.

Table I
Relative Importance of Major Areas
for United States Manufactures Trade
1970 and 1977

A. Source of U.S. Imports of Manufactures

	(percent of U.S. imports)	
	<u>1970</u>	<u>1977</u>
<u>Developed Countries</u> ¹	84.4	74.8
Canada	28.1	23.5
Western Europe ²	34.7	27.8
Japan	21.6	23.5
<u>Communist Areas in Europe and Asia</u>	0.5	0.8
<u>Developing Countries</u> ³	15.1	24.4
Brazil, Hong Kong, Mexico, South Korea, Singapore and Taiwan	8.6	16.2

B. Markets for U.S. Exports of Manufactures

	(percent of U.S. exports)	
	<u>1970</u>	<u>1977</u>
<u>Developed Countries</u> ¹	62.8	55.6
Canada	24.3	26.0
Western Europe ²	31.9	25.0
Japan	6.6	4.6
<u>Communist Areas in Europe and Asia</u>	0.5	1.1
<u>Developing Countries</u> ³	36.7	43.3
Brazil, Hong Kong, Mexico, South Korea, Singapore and Taiwan	9.5	11.2

¹OECD countries

²OECD in Europe

³All countries excluding OECD countries and Communist countries

Source: Commerce Department, FT 155, FT 455

and the lucrative O.P.E.C. market. While it is true that part of the decline reflects the rise in the value of oil's share of imports into all markets as well as lagging demand abroad for United States exports due to the slow recovery from the recent recession, the oil imports/business cycle response cannot account for all of the decline. One is forced to examine factors of a more permanent nature--those affecting United States long run comparative advantage.

There are many reasons which may contribute to the long run decline. One frequently cited looks to the fall in the growth rate of United States productivity. During the 1960's United States productivity growth rate lagged behind the major Western European countries and Canada. During the 1970's only the United Kingdom's productivity rate fell below the United States. This slowing of productivity reflects in part a shift of the labor force away from manufacturing and into services and employment in the government sector. Labor remaining in the manufacturing sector has been supplemented by a lower rate of real investment in the United States relative to its major trade competitors. Similarly the decline in basic research and development has retarded productivity gains in the 1970's. All of these factors bode ill for the United States long run competitive position in both traditional manufactured products and in new high technology industries.

Another hypothesis which has gained popularity of late attributes the shrinkage of United States exports to

the foreign direct investment activity of United States transnational corporations. The absolute amount of capital outflow in the form of foreign direct investment has risen steadily during the past two decades. The argument is that the capital and technology transferred to foreign affiliates could be productively used in the United States. The world sales now recorded on the books of foreign subsidiaries could be captured by United States exporters, thus maintaining our market share. The validity of this hypothesis is still under debate and will be discussed presently.

The virtually unimpeded flow of technology has unquestionably impacted the United States trade balance and altered the world economic picture.³⁵ This flow has diminished important margins of advantage which in the past enhanced the United State export position in manufactured goods. However, the monopoly an innovating country usually enjoys on a new product can be deceptively temporary. Hoarded technology ages poorly; Joseph Nye has drawn the analogy to Rhine wine, which grows worthless with time.³⁶ Brooks states: "The most important fact about a new technology is the knowledge that it can work. With that knowledge any nation with a reasonably sophisticated technical capability of its own can duplicate a technological development more cheaply than its originator, even without technology transfer."³⁷

³⁵See Jack Baranson, "Technology Exports Can Hurt Us", Foreign Policy, No. 25 (Winter 1976-77).

³⁶Joseph Nye, "Science and Technology: Technology Transfer Policies", Department of State Bulletin, (March 1978), p.38.

³⁷Brooks, "Technology and International Investment", p.173.

Furthermore, the innovating country does not necessarily have a long-run comparative advantage in every product that it develops. The American experience has been for nearly a century that the exports of one year have often become the imports of a later year. A laundry list of products to which this has happened would be long, including everything from sewing machines to television sets.

In general, "transfer of technology" is an unfortunate choice of words for it suggests taking from one group and giving to another without compensation or reciprocity--a process which is rarely harmonious. Historically, this has not been the case. The transfer of technology goes in both directions, albeit not concurrently. Thus, the Bessemer and open-hearth processes for making steel were imported to the United States from England in the last century and the oxygen process from Austria, Germany or Sweden, and the extrusion process of squeezing cold steel into desired shapes from Italy in more recent years. Also, there is a substantial amount of direct investment by transnational corporations other than those of United States origin. If the TNC is a transmitter of technology, it seems likely that a lot of foreign technology is also being diffused, and some of it to the United States.

The growing diffusion of technology has given rise to a demanding worldwide standard of performance that is fairly intolerant of inefficiencies. Initially, Japanese manufactures were the object of much derision for their poor quality. Now even with the quality of these products outgrading

American products, technologists in the United States continue to be indisposed to redirecting their efforts on the merit of foreign competition. Brooks has suggested that the great secret weapon of the Japanese in technological competition is the sense of technological inferiority and consequent lack of psychological resistance to learning from others, and adapting the innovations of the whole world to their own needs.³⁸ The premium placed by the Japanese on collaboration and learning from others is evident when Akio Morita, President of Sony Corporation, states:

"Up until the nineteenth century, creativity was exercised by individual geniuses, through voluntary effort, without outside incentives or stimulation, and sometimes they even had to create by pushing away obstructions by society. Today, however, it has become possible to stimulate many persons to be creative by providing them with a goal in the broad sense. Although it has become very unlikely that one person would create a new scholastic discipline or revolutionize an industry, as was done by Newton or Edison, it has now become possible to obtain collaboration from all corners of the globe, which neither Newton or Edison could ever have obtained."³⁹

The growing corpus of evidence that American innovation in commercial technology is becoming sluggish leads Robert Gilpin to predict an American climacteric.⁴⁰ He notes that ironically at a time when other industrial countries were developing industrial strategies, the United States weakened its support of science and technology. Although the United States invested great amounts in military and

³⁸Ibid.

³⁹Akio Morita, "Creativity in Modern Industry", Mimeo of Frank Nelson Doubleday Lecture at the National Museum of History and Technology, Smithsonian Institution, Washington, D.C., 1973.

⁴⁰Robert Gilpin, United States Power and the Multinational Corporation: The Political Economy of Foreign Direct Investment (New York: Basic Books, Inc., 1975) pp.191-209.

space research and development (80 percent of the approximately twenty billion spent each year by the government on research and development), it neglected research and develop for purposes of agriculture, civilian nuclear technology, civilian industrial technology, and infrastructure (transportation, communications and public utilities). In the 1960's, expenditures in these areas averaged about 1.1 percent of gross national product, in contrast to the major European countries, which were spending at 2.2 percent of GNP. European nations were also employing more technologically trained people in these areas of the economy.

According to the National Science Foundation, the total U.S. expenditure for research and development dropped from 2.8 percent of GNP in 1968 to 2.25 percent in 1976.⁴¹ During this time span, research and development outlays in other countries increased as a percent of GNP. The substantial drop in the United States patent balance (the number of foreign patents granted to Americans versus the number of patents granted to foreign nationals) highlights the incipient research and development gap. Between 1971 and 1976 patents granted to Americans fell by 21 percent. In the same period, the number of Japanese scientists and engineers performing non-defense research and development climbed close to the United States total--although Japan's population is less than half of the United States.

⁴¹Oral Communication from Gordon Heibert, NSF, July 28, 1978.

For some time recognition of the lag in United States research and development was localized to frustrated researchers in university laboratories who complained bitterly about unrealistically low levels of government support. These fears have now penetrated the system of priorities of decision makers at the national level. Recently, President Carter wrote to all members of the Congressional committees that oversee basic research, requesting that they not trim his budget for science. The proposed Administration budget for fiscal year 1979 boosts grants for fundamental research by almost five percent beyond the rate of inflation. However, equally worrisome is the lag in industrial research and development. Increasingly, United States industry is investing in short-term objectives and existing products. Due to a variety of reasons including economic uncertainty, many United States firms are leery about making long-term commitments. In 1977, the DuPont Company elected to allocate about 75 percent of its research budget to existing products.

The creative pulse of American scientists and technologies are crucial to the country's private enterprise. Fully four billion dollars of United States corporate profits overseas derives from royalties and fees for the use of United States technology. It is estimated by the United States Chamber of Commerce that United States firms would have to sell eighty-five billion dollars of conventional trade goods to reap a similar four billion dollars profit. ⁴²

⁴²See United States International Trade Commission, "Technology Transfer, A Review of the Economic Issues", Washington, D.C. (June 1978).

However, the present backlash against the export of technology despite the steady stream of revenue in the form of license fees and royalties, stems from a feeling that the United States should be "selling more milk and fewer cows." There is increasing resentment of technology sent elsewhere being turned against the United States, costing it markets abroad and jobs at home. The fear of Korean-made Boeing 747's is preceded by Korean shipbuilding, Romanian computers, Mexican aircraft parts, Venezuelan steel, using United States technology in competition with United States products."

"All this is prompting a new kind of protectionism, aimed not at halting cheap imports that threaten United States exports and profits but at exports, the dissemination overseas of information and American know-how"⁴³

The difficulty is not one that should be met head-on with protectionist efforts. A policy designed to eliminate disincentives and expand the supply of technology is a more practical and productive means of retaining the lead in front-end technology while increasing the safety margin for exporting greater amounts of technology.⁴⁴ Even more than enhancing its laboratory prowess, United States industry must improve its ability to compete in the world market. The acquisition of United States technology does not enable a foreign company to outsell United States companies in

⁴³Joanne Omang "A New Form of Protectionism", The Washington Post, July 23, 1978.

⁴⁴Herbert E. Meyer in "Those Worrisome Technology Exports", Fortune, (May 22, 1978), makes this point with éclat.

third markets--let alone in the United States--unless that foreign company also has some competitive advantage. To place the onus on technology transfer for the inability to compete with foreign firms is a kind of "reductio ad absurdum".

To hold their own overseas, American companies must refrain from the "holier than thou" attitude that smacks of a "Coca Colonization" ethos not uncommon in expatriate business communities. Sometimes American businessmen give others the impression that since they know the self-evident answer to each problem, others are expected to adopt the American solution because it is technically right. Not so paradoxically, this produces the opposite of what is intended: not consultation and the building of a common structure according to joint architecture, but a sense of haughtiness and arrogance, of disregarding other people's problems. American business overseas, which brings in one-third of United States corporate profits is also jeopardized if American businessmen do not work harder at getting and keeping export markets.

Many United States firms lag far behind Japanese and European competitors in such export-game strengths as detailed knowledge of foreign markets and flexibility in adapting products to customers' wishes. Some United States machine-tool manufacturers, for example, are losing considerable export business because they are reluctant to redesign their equipment to metric measurements. The transfer of technology from one country to another is, "ex vi termini", a bicultural endeavor.

Better understanding by government and business of each others constraints is essential if they are to work together successfully. Further dialogue between the two is needed in the areas of energy, regulation of business, inflation, taxation, and ethical standards of corporate behavior. By corotating with the United States Government in the mutual benefits orbit, a better government/business relationship could evolve. The promotion of national exports is no less valid a task for the United States government than it is for the say the Japanese or Brazilian governments.

Former Secretary of the Treasury Douglas Dillon, testifying on behalf of the United States investment tax credit in 1962, argued that the measure was required "if United States business firms are to be placed on substantially equal footing with their foreign competitors in this respect. It is essential," he said, "to our competitive position in markets both here at home and abroad, that American industry be put on the same basis as foreign industry. Unless this is done, increased imports and decreased exports will unnecessarily add to the burden of our balance of payments deficit."⁴⁵

President Carter has urged that United States industry and agriculture expand exports and has directed

⁴⁵Quoted in Cooper, p.1278.

that a national export expansion program be undertaken. World commerce is worth one trillion dollars and the 16% of this trade accounted for by the United States contributes to one out of every six American production jobs and the crop yield of one out of every three American farm acres. Given the high stakes involved, the United States needs to rethink its foreign economic policy with the goal of strengthening the competitiveness of United States exports. The introduction of Bill S.1990 by Senators William V. Roth, Sr. and Abraham Ribicoff in the first session of the 95th Congress points in the direction Government should take at home to strengthen and unify foreign economic policy. The bill proposes the consolidation of a number of agencies and offices throughout the Federal Government into a new Department of International Trade and Investment.

In introducing their bill, Senators Ribicoff and Roth pointed out that foreign trade and investment functions are now scattered throughout the Executive Branch. They assert that lack of a focal point for foreign economic policy handicaps effective export promotion at a time when the United States is facing record trade deficits; impedes effective protection against unfair or disruptive imports; and weakens our bargaining position with foreign nations, most of whom have specific ministries with primary responsibility for foreign trade policy.

"Research on Research"

Despite the fact that the United States government is the most generous benefactor science has ever known, government backstopping suffers from a glaring lacuna when it comes to a rational understanding of how one engenders the critical mass at the heart of the technical universe, namely the innovative process. The effective support and management of science and technology call for a full comprehension of the linkage between collaboration and innovation. The latter rarely derives from a stab in the dark nor is it an isolated, one-shot effort. As Bacon first observed, there is a whole chain of events that stretches from one idea to the next and that requires concerted effort to produce something tangibly and socially valuable. This chain is especially important in industrial application: "If any one step in the innovation process fails, the entire process fails."⁴⁶ Throwing money at problems without sponsoring the right kinds of research and development is like throwing money away. Hence, it is imperative that individuals with research oversight responsibilities be more than generous men of good will.

The need for "research on research" applies "a fortiori" to small businesses and small countries, whose scaled down capabilities and resources must be optimized.

⁴⁶Edwin A. Gee, "Moving Technology About", Journal of the Licensing Executives Society, Vol. XIII, No. 2, (June 1978), p.109.

With such an understanding the countless false starts in costly and time-consuming research and development may be avoided. "History precludes absolute freedom in the choice of either technology or institutions. We are all familiar with the fate of both technical and institutional innovations that have been in advance of "their time".⁴⁷ Moreover, unnecessary allocation of resources for, say, turning out nobel prize-winning scientists can be preempted. "The complementarity between screening and adaptive research "ceteris paribus", lowers the relative cost of adapting and tends to increase the probability that this will be the minimum-cost route to improvement."⁴⁸ A closer look at the dynamics of collaboration and innovation may ramify into non-scientific spheres where collective efforts are geared, if not always successfully, to yield creative results.

Creativity has flourished where it has been effectively joined with the collaborative process. Winston Churchill, who had one of the most creative minds in modern times, wrote his great biographies and histories with the aid of many, whom he organized and whose product he inspired and then quite properly used. Their work fostered by his organizational talents, enabled him to create his works far more quickly and effectively.

⁴⁷Hans P. Binswanger and Vernon W. Ruttan, Induced Innovation: Technology, Institutions, and Development, (Baltimore: The Johns Hopkins University Press, 1978), p.4.

⁴⁸Ibid, pp. 169-170. This work is a major contribution to an understanding of the innovative process; it develops an investment model of induced technical change that integrates and extends earlier work on the economics of research and development and on the theory of induced technical change.

The line between encouragement and domination is a thin one and varies culturally. The Japanese scientist, who is goal-directed and solidly committed to a shared responsibility ethic for goal attainment, may be less thin-skinned about pushiness and toe-stepping than his western counterpart with the same level of motivation and enthusiasm for team work. Collaboration in the West is informed by a hardened tradition of respect for the individual, whose identity can be subordinated only voluntarily to the societal boxes that perplex mainstream social science. The Western attitude has been to foster creativity by bringing together innovative individuals and giving them maximum freedom to think, to exchange and test ideas with competing ideas in the crucible of healthy skepticism. This is not to say that collaboration gives way to unbridled creativity. However, the cultural underpinnings are quite different and the organizational grid superimposed over creativity reflects this difference.

David Allison in the Research and Development Game concludes:

Complete freedom to pursue whatever one wants to pursue turns out not to be the most desirable condition for an industrial laboratory, either from the viewpoint of the corporate managers or from the viewpoint of the scientists themselves--and certainly it is not a desirable condition from the viewpoint of the society to be served by that laboratory."⁴⁹

In the United States business sector, a less-than-total freedom or freedom within a mission prevails. Within this milieu the research manager plays a brokerage role in the

⁴⁹ David Allison (ed.), The Research and Development Game, (Cambridge, Massachusetts: M.I.T. Press, 1969), p.9.

establishment of a viable accommodation between technicians and policy-makers. This role can be approached self-aggrandizingly when the brokerage function becomes the sole conduit for communication from either ends of the organizational spectrum or, it can stress the total resources of the group to the establishment of goals and the achievement of objectives. Not surprisingly this latter course is superior and experimental psychologists have substantiated the proposition that in relations with colleagues and supervisors related to productivity, mutual collaboration make for the highest performance and complete direction the worst.⁵⁰ The growth of individuals spawned by the collaborative quality, over the long haul, appreciates the value of human resources available to the organization as a whole. The argument that scientists are too specialized, too parochial in outlook to be accorded a prominent place in policy-making is in itself parochial. In many instances, scientists themselves must revise their self-concept.

The "technology gap" purported to have existed between Western Europe and the United States not too many years ago is instructive. At the height of the controversy, the Europeans complained bitterly about the United States lead in industrial development, which they feared would eventuate in a technological hegemony. Prime Minister Harold Wilson of Great Britain used some pointed language at a meeting of the Council of Europe at Strasbourg. He warned of "an industrial helotry under which we in Europe produce

⁵⁰ Donald C. Pelz, "Freedom in Research" in The Research and Development Game, pp. 56-72.

only the conventional apparatus of a modern economy, while becoming increasingly dependent on American business for the sophisticated apparatus which will call the industrial tune in the seventies and the eighties."⁵¹ The whole question landed in the agenda of NATO's ministerial meeting in 1966. The OECD published a report on the subject, and the Common Market was deeply concerned.

The Europeans were discovering that brains, on the whole, are like hearts, and that they go where they are appreciated. Scientists and technicians were leaving the Old World for the New in alarming numbers. A full-fledged brain drain seemed to be in the offing. The Europeans immediately initiated a damage limitation exercise. To reverse the trend, they took steps to create more favorable conditions under which those who would produce and apply knowledge could explore and build upon their own interests and learning patterns. Discovery--the attainment of new frontiers of knowledge--is intrinsically a learning experience. Aquinas in the thirteenth century and Aristotle fifteen hundred years before him both suggested that a teacher cannot strictly speaking, be the cause of a student's knowledge, but only the occasion of it. The administrative cadres charged with the responsibility of managing Western Europe's science and technology capability restructured the framework in which scientists collaborate and efficiently exercise

⁵¹Recorded in Robert S. McNamara, The Essence of Security, (New York: Harper & Row, 1968), p.108.

their initiative and creativity. Although basic, the missing framework was easy to construct. Once the Europeans focused their attention on the management dimension, they met with considerable success in regaining par with the United States in technological prowess. As Japan's Morita states:

"Perhaps it can be said that the most important matter in modern industry is to get countless numbers of persons working together in one direction without wasted effort. To bring into collaboration many persons in this way is the function and responsibility of management."⁵²

The developing countries too are presently concerned with the self-actualization of human capabilities. They have received much prescriptive advice on how to bridge the technology gap that now hinders their socioeconomic development. Education is one of the panaceas that crops up most frequently. However, even with improvement in education, both general and specific, and both quantitatively and qualitatively, more is required. Even in developing countries with strong educational foundations, human capabilities are not being realized and the hiatus remains unbridged. Yet without modern science and technology, and the facilitative organization to go with it, progress of any kind, spiritual, humanistic, socioeconomic, or otherwise, is throttled. From a political perspective, without advances in these areas, the world will remain explosively provincial.

⁵²Morita, "Creativity in Modern Industry".

Coping with Corporate Leviathans

The transnational corporation is the generator "par excellence" of modern technology and the principal agent of technological diffusion. As such, this global reaching, sovereignty baying organization has stirred considerable controversy. A Niagara of commentary has emerged, much of it emotionally charged and highly critical of TNCs. Much of the criticism is based on "a priori" reasoning that not only indicts the TNCs but the whole system within which large organizations can flourish. What is ignored by those who advocate drastic alternatives to TNCs is the essential role that can only be played by the large organization: the role that combines technical knowledge, capital, and capable management, and that culminates (when the process is working) in the attainment of something new and socially valuable, which otherwise would not exist.

Even their harshest critics in the developing countries concede that TNCs will long remain an important source of technology. The problem is to resolve divergences between exporters and importers of modern technology. The first bears on initial perceptions. TNCs view technology as an expensive commodity, whose useful commercial life is very short; therefore, they must sell it at a high price. Many Third World governments on the other hand, contend that research and development of technology conducted by TNCs is

amortized in their home countries. Hence technology exported to developing countries ought to be considered, if not as a free good, at least a modestly priced one. They further assert that technology should be transferred automatically along with direct equity investments made by foreigners. According to this view, when foreign suppliers license technology to developing countries, host governments are justified in placing ceiling on license payments with a view to keeping technology costs "within reasonable limits". Exporting corporations, on the contrary, regard such ceilings as arbitrary, unfair, and tampering with normal market mechanisms.⁵³ In a study on the contributions of research and development spending and foreign investing to corporate profitability, Alan K. Severn and Martin M. Laurence found that foreign investors tend to spend more and earn more than firms without investments abroad.⁵⁴ Even if the only link between foreign investing and profitability were their joint dependence on research and development effort, this result would obtain. By regressing a firm's rate of profits on the research and development level for its industry and on one or the other proxy for its foreign investment position, the authors obtained a consistently positive coefficient on the research and development measure and a positive coefficient on one of the foreign investment

⁵³Denis Goulet, "The Suppliers and Purchasers of Technology: A Conflict of Interests", International Development Review, Vol. 18, No. 3, (March 1978), pp.14-20.

⁵⁴Alan K. Severn and Martin M. Laurence, "Direct Investment, Research Intensity, and Profitability", Division of International Finance discussion paper No. 30, Washington, D.C., (May 31, 1973).

measures but not on the other. They reached the conclusion that foreign investment makes no direct contribution to profitability but does allow firms to spread their research and development costs over a larger base. Evidence of this kind indicates that TNCs have room to be flexible in their dealings with the developing countries.

By the same token, in attempting to establish a mutually beneficial relationship between a technology owner and a potential technology transferee, a principal responsibility rests with the host country to effect a balance between legitimate protective measures and inducement to encourage the TNC to effect a technology transfer. It is of great consequence that the host government recognize that private sector technology is a private asset which has been created as a result of the expenditure of substantial sums over a significant period of time with the high inherent risk of loss of such investment. While the host country undoubtedly has legitimate objectives in seeking to obtain technological advancement in prompt fashion, such objectives should not be allowed to totally obscure the context within which the technology was generated and is owned.

The research and development expenditures of TNCs contribute significantly to the global storehouse of scientific and technological knowledge. At their best, TNCs have contributed much that is conducive to the social and economic development of an interdependent world. While abuses should be curbed, it would not be wise for either

developed or developing worlds to ignore the future benefits that can be derived from TNCs. Developing countries do themselves a serious disservice when they maintain that TNCs are a net liability in the global application of science and technology. The more constructive approach would be to seek to maximize the contribution TNCs can make to world welfare and the welfare of individual countries by eliminating distortions now affecting these corporate Leviathans. In addition to the behavior of the TNCs themselves, these distortions stem from conflictual policies adopted by both home and host country governments.

There is a growing international mutuality of interest in coping with TNCs. "There is little conceptual difference between, for example, public interest groups in the United States calling for drastic, legal and regulatory reforms in order to make large corporations 'more accountable' and foreign host governments seeking to restrict the freedom of multinational companies operating within their borders."⁵⁵ Revelations of corporate participation in political subversion at home and abroad, involvement in large-scale bribery, and the use of foreign subsidiaries to conceal illegal domestic activities call for greater transgovernmental oversight of the TNCs' international operations.⁵⁶ Because of black box

⁵⁵Peter P. Gabriel, "The MNC in the New International Economic Order" in Gerald Garvey and Lou Ann Garvey (eds.), International Resource Flows, (Lexington, Massachusetts: Lexington Books, 1977), p.67.

⁵⁶For documentation of political activities of American TNCs abroad see: "Multinational Corporation and US Foreign Policy", Hearings before the Subcommittee on Multinational Corporations of the Committee of Foreign Relations, United States Senate; First Session on "Political Contributions to Foreign Governments" Part 12, (Washington: United States Government Printing Office).

policies in some countries, TNCs have been able to get away with contradictory disclosures in their international operations. The need for transparency on the part of TNCs by making available data on their activities in all countries is self-evident and can be obtained only through cooperation among governments. America's leading consumer advocate has gone even further by calling for all countries "to formulate parallel and strict terms in their chartering mechanism covering such areas as corporate disclosure, antitrust, shareholder rights, management liabilities, and affirmative duty to report on a wide variety of matters to all nations where the firm is doing business."⁵⁷ The citizens of all countries would benefit from the development of international standards for product safety, environmental protection and effective performance.

The argument that both sets of countries linked by TNC activities have ample reason to cooperate in forging a common approach to these firms is too suasive to be ignored. In the balance is an important force in the promotion of global efficiency and equity. However, without an international consensual approach the transnational corporation remains an ominously ticking apple of discord between countries big and small. The scarcity factor that could give way to dangerous scrambles for raw materials, the various incentives and

⁵⁷Statement of Ralph Nader and Mark J. Green, "United Nations Inquiry into Multinational Corporations", September 12, 1973.

disincentives of countries seeking to tilt the benefits of foreign direct investment in their direction, are the fuels that require only a spark to start investment wars.⁵⁸

Harmonization of antitrust strategies throughout the world has long been a goal of American foreign policy. Justice Department officials have worked energetically toward this goal, at United Nations meetings, in expert committees of the OECD, and by means of bilateral cooperation and exchange programs. When anti-trust policy are rendered impotent by national borders, free trade and free market values are jeopardized and the international business climate destabilized. "Foreign take-overs by American firms reduce potential competition in the American market, and Americans have every reason to be concerned about the long-range consequences of that."⁵⁹ Domestic market power in the United States and foreign direct investment are inextricably linked through the elements of domestic industry structure; through the ability of foreign investment itself to impede new entry into domestic product markets; and through the propensity of oligopolists to turn to foreign markets for further growth and profits.⁶⁰

⁵⁸See C. Fred Bergsten, "Coming Investment Wars", Foreign Affairs, Vol. 53, No. 1, (October 1974).

⁵⁹Richard N. Cooper, Panel Discussion, in The New International Economic Order: The North-South Debate, p.358

⁶⁰Robert J. Barnett and Ronald E. Muller have argued that the corporate globalization process has led to an acceleration in industrial and financial concentration of the United States domestic sector. See Global Reach: The Power of the Multinational Corporations, (New York: Simon and Schuster, 1974), especially chapter 10.

Transfer pricing has led to abuses which work to the detriment of both home and host countries, with tax havens absorbing the profits. Again, obstacles stemming from extraterritoriality preclude unilateral actions. The only workable solution is intergovernmental agreement on arm's-length pricing practices, with vigorous national enforcement by all countries. The international equivalent of section 482 of the United States Internal Revenue Code has already been discussed in the OECD forum.

"Neglect and indifference rather than 'exploitation'", Peter F. Drucker claims, "is the justified grievance of the developing countries in respect to the multinationals."⁶¹ As more TNCs opt for investment sites increasingly remote from the American mainland, United States domestic clamor is beginning to corroborate the Drucker statement. Several distinguished scholars, notably Fred Bergsten and Robert Gilpin have entered the caveat that the main impact of foreign direct investment is on the home country of the TNC.⁶² In particular, they warn, it falls most heavily on the United States, the largest home country by far. Gilpin's thoughtful study entitled United States Power and the Multinational Corporation is animated by the argument that the American national interest dictates an emphasis on trade and the reinvigoration of the American economy rather than on foreign direct investment.

⁶¹Peter F. Drucker, "Multinationals and Developing Countries", Foreign Affairs, Vol. 53, No. 1, (October 1974), p.123.

⁶²See Bergsten, "Coming Investment Wars?", p.144 and Robert Gilpin, U.S. Power and the Multinational Corporation, p.214.

Because of its protean qualities, the trans-national corporation intersects with the United States economy at many different and important coordinates including the terms of United States access to foreign natural resources, the volume and composition of exports and imports, the balance of payments, the employment and earnings of United States labor, the taxes collected or uncollected by the United States Treasury, etc. However, our knowledge of the domestic consequences of American investments abroad particularly in the application of science and technology, remains fuzzy.

In an excellent benefit-cost analysis of direct foreign investment from the viewpoint of the host country, Daniel M. Schydrowski states by way of introduction:

"...broad generalizations claiming either that foreign investment is good because it brings in scarce factors or that foreign investment is bad because it preempts scarce investment opportunities are not very useful. Rather, it is essential to calculate the benefits and costs relating to each individual case. On the basis of such calculations, one would expect to find that a particular investment adds to the welfare of the country but nevertheless is better postponed to the future, another investment may represent a net loss to the country, and yet a third may be desirable and should be taken forthwith."⁶³

Similarly, one would expect that direct foreign investment, depending on the individual case would have a differential impact on the economy of the home country. In point of fact, the analysis of the contributions of the transfers of technology to both the home and the host countries will produce different results according to the sectors that

⁶³ Daniel M. Schydrowski, "Benefit-Cost Analysis of Foreign Investment Proposals", Economic Development Report No. 170, Center for International Affairs, Harvard University, June 1976, p.70.

are under examination. The markets to be served are not always the same among the different industrial sectors; the effects on various aspects of the economies are different; and the home and host countries are interested in different impacts.

Historically, the United States has been committed to permitting the outflow of technology under criteria desired by the owner and to stimulate such outflows to developing countries. More recently, however, the United States government has become increasingly concerned with the outflow of technology in the manufacturing sector--as distinct from that in the other sectors--as a result of the complaints of labor unions and some congressmen that the results of transfer are damaging the United States economy. This damage is seen in the loss of export potentials, the increase of imports, and the loss of particular jobs through the transfer of production overseas. Similar charges are not made for the other sectors, since the alternative of export does not appear to be feasible. It also may not be feasible in some of the manufacturing sectors, as a result of government policy of the host countries, but bargaining among countries may maintain certain export opportunities--at least this is the suggestion of opponents of technology transfers.

There appears to be no inclination on the part of home governments to restrict the outflow of know-how from members of the service sector. This results from the fact

that there is no way to serve the foreign market other than to enter it physically. Whatever is returned from this activity is a net plus in the balance of payments and contribution to home country income and employment. No complaints have been directed by interest groups against this sector in terms of its activities overseas.

The United States government has strongly favored the development of agribusiness activities in developing countries, and little complaint has been heard from domestic groups, with the exception of those affected by import of vegetables and processed food from Mexico. Most of the activity in this sector is for products to be sold locally or for export to the United States of products not grown domestically.

The extractive sector is distinct in the nature of transfers, since there is increasingly less opportunity for investment, and transfers of technology and expertise are made more frequently among independent companies. These are made under contracts for exploration (concession agreements), technical service, management, and even shipping and distribution. The complexities surrounding this sector force governments into separate policy formation, introducing sectorial discrimination, within which further discrimination occurs between private and state-owned companies.⁶⁴

⁶⁴Jack N. Behrman, "Industry Characteristics and Policy Suggestions" in Fund for Multinational Management Education, "Public Policy and Technology Transfer", Vol. II, March 1978, p.37.

For unknown reasons the need to disaggregate foreign investment into types and effects has not taken, especially from the home country perspective. One exception is Thomas Horst. After reviewing the existing literature and analyzing the available data, Horst concludes that there are both competition and complementarity between different types of American foreign investment and American exports. Direct investment, in varying degrees helps exports, although slightly. The complementarity results from shared information about market opportunities and shared distribution networks. Specifically, Horst concludes:

"While on average subsidiary activity has tended to complement United States exports, complementarity has been strongest in the consumer goods industries, somewhat weaker in the countries where most of our trade and investment goes, and offset or reversed in the high-technology industries."⁶⁵

Thus, in the important area of high-technology industries, exporting and subsidiary production are alternative means for American firms to exploit their comparative advantages.⁶⁶

⁶⁵Thomas Horst, "The Impact of U.S. Investment on U.S. Foreign Trade", Mimeo., Washington, D.C., The Brookings Institution, (January 1974).

⁶⁶There is also a time sequence factor. In industries or countries with minimal American investment, an expansion of United States investment is likely to be matched by an expansion of United States exports. The apparent complementarity between exporting and investing is probably because subsidiaries focus their initial activity on marketing and assembling their United States parents' product line, themselves. Over time, however, foreign investment becomes less the complement of, and more the substitute for United States exports. Essentially, we refer to the product cycle theory elaborated by Raymond Vernon. See "International Trade in the Product Cycle", Quarterly Journal of Economics, Vol. 80, (May 1977), pp.190-207.

The Overseas Private Investment Corporation (OPIC) has compiled data which substantiate the Horst analyses. The corporation is required by law to estimate the effect on the United States economy and on the host country of all insured investments. Firms applying for insurance must make a five-year projection of the effects of the proposed investment on United States trade, on the United States balance of payments, and on employment in the United States and compare those effects with the most plausible alternative to that investment. OPIC also investigates the alternative of United States production, particularly when exports to the United States are planned. OPIC's conclusions are thus highly relevant to the broader policy issue. And the OPIC conclusion is that the overall effects of foreign investment are generally favorable to both the United States balance of payments and United States employment. Of the fifty applications that OPIC formally rejected between January 1971 and May 1973, eleven were deemed adverse to United States economic interests. In addition OPIC frequently discourages formal applications when informal analyses suggest that the proposed investment would have negative effects on the United States balance of trade.⁶⁷

In a voluminous landmark study coauthored with Fred Bergsten and Theodore Moran, Horst arrives at the

⁶⁷Carl H. Middleton, "Analysis of OPIC Insurance Rejections", (May 1973), OPIC.

conclusion that "foreign direct investment by American multinationals does not have a single, preponderant net impact of any kind on the economy of the United States, the functioning of the international economic system, or the foreign policy goals of the United States."⁶⁸ W. Arthur Lewis expresses a similar perception with respect to the world economy, when he states parenthetically and with the blissful brevity of one sentence: "Transnational corporations were already very much in evidence in 1913; the recent discovery of their existence puzzles the historian a little."⁶⁹ In part, the substitution of the efficiency argument for Western industrial primacy with a still inchoate but equity-tinged outlook informed by a slow-down in labor productivity and falling trade margins has focused western attention on the greatest efficiency-monger of them all: the transnational corporation. The independent stance of TNCs in recent years forced the controversial issue of whether the latter advance national or world interests.⁷⁰

Labor has spearheaded the domestic assault on the TNC. United States labor unions have raised the issue of the adverse effects of technology transfer on domestic employment levels. Lane Kirkland encapsulates the bewilderment of this pressure group and reveals the extent to

⁶⁸C. Fred Bergsten, Thomas Horst, Theodore H. Moran, American Multinationals and American Interests, (Washington, D.C.: The Brookings Institution, 1978), p.492.

⁶⁹W. Arthur Lewis, p.46.

⁷⁰This point has been driven home by Bergsten, who argues that although United States subsidiaries account for a swelling share of world output and world trade and investment, there is an empty chair at negotiations between TNCs and host countries. No one represents American interests broader than those of the firms themselves at times to the detriment of United States national security. See "Coming Investment Wars?", p.146.

which the labor position is informed by the realities of a moribund era when he states:

"Comparative advantage is now movable and saleable; it can be dismantled and packaged for shipment to avoid taxes, to avoid minimum wage standards, to avoid the full range of social laws and responsibilities. We used to think that comparative advantage meant that Taiwan should produce rice, that Brazil should produce coffee, and not Philco television sets nor Florsheim shoes."⁷¹

However, there is at least some validity to the claim made by American TNC's that their establishment of production abroad was necessary to protect their holdings of the foreign market against potential foreign competition. To the extent to which this is true, foreign production and even foreign exports from foreign plants may not be at the expense of United States imports, and the profits from foreign operations a possible net gain to the United States balance of payments, depending upon the use to which they are put. While it is true that the transfer of technology from the United States to a developing country permits that country to produce goods that otherwise may have been imported from the United States, it is also true that the boost given to the economic and social conditions in the recipient country will augment its absorptive capacity for other United States products and that effect may equal or surpass the loss in market due to the additional production within that country.

⁷¹Lane Kirkland, "Comment", The Atlantic Challenge, p.187.

From the standard factor proportions model of international trade, it is clear that the higher growth rate of the labor force in developing countries will bring about a gradual shift in comparative advantage, in favor of the the developing countries, for manufactured goods whose production processes use relatively abundant amounts of unskilled or low-skilled labor. Keeping in mind that the developing countries spend their export earnings on imports, this situation could just as well be described as one of a gradual shift in comparative advantage, in favor of the industrial countries, for manufactured goods (and services) whose production processes use relatively abundant amounts of skilled labor and capital--especially capital in the form of knowledge acquired through investment in research and development. The growth of trade and welfare would be stimulated by these shifts because the increased imports into both areas would come primarily at the expense of inefficient domestic production. While this proposition is impossible to verify empirically, it is widely held and provides a basis in self-interest for United States foreign assistance. There is considerable wisdom in not losing track of the fact that the developing countries, containing two-thirds of the world's population, represent an enormous potential market for United States exports.

On the assumption that foreign investment is defensive (through following the product cycle and preempting foreign competition) and often the only way to penetrate

foreign markets, one study estimates that direct investment saves about two hundred fifty thousand production jobs in the United States. If one adds managerial, technical and support workers, approximately six hundred thousand jobs in the United States are dependent upon direct investment. Furthermore, it is argued that these positions are at a higher level of wages and skills than would have prevailed in the absence of foreign investment.⁷²

The beauty of the latest Horst study is that it conclusively counters labor's allegations that TNCs export American jobs. Using statistics for the last thirty years on the overall distribution of United States income as well as data on labor earnings in different manufacturing industries, Horst et alli tested models of international investment and income distribution to determine whether the substantial flow of United States investment abroad over the last few decades had brought about substantial redistribution of income from domestic labor to internationally mobile capital and management. According to traditional theory, the share of employee compensation and domestic capital should have fallen, and total capital should have risen over the period. The actual experience does not bear this out. From 1945 to 1976 (the period in question), the share of employee compensation edged slowly upward from 66 percent to

⁷²Robert Stobaugh, "How Investment Abroad Creates Jobs at Home", Harvard Business Review, No. 50, (September-October 1972), pp.118-120.

75 percent. There was a detectable decline during 1972-73, but this was due, they surmise, to rapid inflation of prices and the presence of wage-price controls rather than to foreign direct investment. They conclude that the statistics lend little credence to the notion that the surge in foreign direct investment over the last decades significantly affected United States income shares.⁷³

Because labor speaks mainly for incumbents on the job and not for consumers or for newly employed workers, the current theme in their current posture "vis-a-vis" the TNC, direct foreign investment, and liberalized international trade is hostility. Yet workers who suffer transitional unemployment due to the displacement effects of broader competition can be helped by the provision of adjustment assistance: that is, the distribution of government funds to compensate those who suffer transitional declines in income, and to help cover the costs to workers of searching for new employment opportunities and (if necessary) moving and/or retraining. Programs of adjustment assistance already exist in some countries. In the United States, for example, the 1974 Trade Act established a new adjustment assistance program with a basic benefit of 70 percent of salary to be paid for a maximum of fifty-two weeks (78 weeks for workers over 60 years of age, and those enrolled in a training program), plus counselling, a relocation allowance, and a job search allowance. A recent evaluation of this program offers some insight into the question of the duration of transitional unemployment associated with increased

⁷³American Multinationals and American Interests, pp. 242-260.

competition from imports. Statistics for the period April 1975 through September 1976 reveal that the average benefit check was for a 30 week period.⁷⁴ That is, the average period of unemployment for workers who became involuntarily unemployed because of increased imports, in the midst of the worst recession in forty years, was thirty weeks (well within the benefit period). This is not a description of a situation in which trade liberalization leads to chronic unemployment problems.

Protectionism "vis-a-vis" technology transfer is fundamentally inimical to the free-enterprise system, particularly when the motive is to safeguard jobs. Surely, no one would argue that it would be appropriate to guarantee any industry or firm against a reduction in its level of employment. Any move along these lines obviously would promote a hothouse economy pockmarked with artificially maintained prices for commodities serving needs that could be more cheaply provided for in a free market.

George H. Hildebrand observes: "To search for ways to obstruct the export of capital is to look for inefficient and inequitable methods to redistribute income, paradoxical as it may seem."⁷⁵ The insulation of particular individuals from such disruptions can be achieved only at the expense of the majority who would stand to suffer in a competitive

⁷⁴Peter Henle, "Trade Adjustment Assistance for Workers", Library of Congress, Congressional Research Service, mimeo., November 1976.

vacuum from reduced consumer choice and dulled stimulus to innovation; higher inflationary prices; and reduced United States participation in world trade, thus lowering the national income and rate of growth. In sum, the economic costs of curtailed technology exports would be very high. The political and diplomatic consequences that would rebound from this move could be even more costly.

Industrialization and Mutual Benefits

Since the early 1970s, leaders of developing nations have been emphasizing the key role played by technology in industrial development and in related programs for generating employment and expanding trade. Previously, they had put greater stress on increasing stocks of capital and physical infrastructure. This new emphasis on technology has substantial basis. Technology is an important determinant of economic growth in all major industrialized countries.

Growing interest in technology for industrialization coincides with the firmly held belief among many policymakers in developing countries that industrialization is a precondition of national economic well-being, adequate employment, and national autonomy. While it is possible to question the validity of such a generalization on analytical grounds (for example, in a developing country with strong comparative advantage in world markets for mineral or agricultural products), the belief itself is sufficiently rooted in the economic history of the presently industrialized countries as to stand beyond challenge. Hence the logic that technology will foster industrialization, increase employment, and stimulate trade, thus leading to improved economic well-being, has become a dominant theme.

W. Arthur Lewis states: "Their development /the Third World's/ does not in the long run depend on the existence of the developed countries, and their potential for growth would be unaffected even if all the developed countries were to sink under the sea."⁷⁶ Yet he admits that the engine of growth should be technological change, with international trade serving as lubricating oil and not as fuel. This technology is likely to come from the West and will be exchanged for a "quid pro quo". The kinds of technologies exported by the West will have important policy and performance conditioning effects on the industrial strategies adopted by the developing countries. It can be surmised that attempts will be made to influence the developing countries to gear themselves for domestic markets as their main targets for production. This at a time when it is becoming increasingly evident that there is no necessary contradiction between donor and recipient commitment to basic human needs and a more forthcoming attitude "vis-a-vis" technical assistance relative to industrialization.

There is a felt need to establish theoretical grounds for optimal choice of industry and technology. Such a breakthrough could be mutually beneficial to developed and developing countries. We know very little about industrialization and economic development from the standpoint of their technological characteristics. Hans P. Binswanger and

⁷⁶W. Arthur Lewis, P.57.

Vernon W. Ruttan note in a seminal contribution to the industrialization literature that an examination of alternative methods for achieving technology transfer revealed that even the direct transfer option may be costly, as it requires sufficient screening activity to determine which among many technologies are best suited to particular local conditions.⁷⁷ In their international operations, TNCs have accumulated over time considerable experience in the area of scanning. While the mechanics of this vital process can be analysed without divulging proprietary information few attempts have been made to do so.

With considered policies toward global industrialization, real world product can rise substantially. However, existing knowledge of the industrialization process is too limited, localized, and unsystematic, and its applicability to current and emerging needs too unexplored, to provide an adequate basis for effective industrialization policies. In this vein, the National Academy of Sciences prepared a feasibility study for an International Industrialization Institute at the request of AID.⁷⁸ This study singled out the benefits of applied industrial policy research that could evolve from collaboration with local institutes worldwide that would permit development of data and analyses specific to national conditions and policy sets. Heretofore,

⁷⁷See Induced Innovation: Technology Institutions, and Development

⁷⁸National Academy of Sciences, "Meeting the Challenge of Industrialization", Washington, D.C.: 1973.

this kind of data as well as information on host of other policy determinants has been gleaned largely through technical assistance projects.

The "political reportage" that filters out of development assistance programs is valued in intelligence circles. Peace Corps volunteers and AID advisers have a privileged position in interacting with "the masses" in whose midst the seeds of unrest usually spring. Less widely appreciated is the valuable industrial intelligence that can be culled from development projects, some of which have as their explicit purpose the overt collection of such information. An example of this kind of activity is the National Science Foundation's deep-sea ocean drilling project and AID's oceanography training project. Both projects are global in reach and provide important data to the United States private sector at a time when the ocean's tremendous mineral resources appear exploitable. The AID project which is contracted to the National Oceanic and Atmospheric Administration and the United States Department of Commerce, encourages developing countries participating in the training exercise to establish their oceanographic data collection and analysis systems either in the United States image or in ways which are compatible with the United States system. As the United States is a major consumer of oceanographic data, improvement of the quality of this data will be of particular benefit to it.

A "prima facie" case can always be made for the arms length attitude of the United States government towards

the private sector, with the regulatory style of Government agencies being mechanistic and nondiscriminatory, as compared with the style of other countries. However, the United States government-business relationship is more incestuous than popularly believed. Foreign aid activities highlight this deliberately low-profile aspect of the relationship. For illustrative purposes, we can cite an AID project contracted to the United States Department of Commerce.

The project in reference is known as "Use of Computers in Economic Planning". The documentation for this project notes that computers are not extensively used around the world in economic development and that the state of the technical art of planning is considerably ahead of the level of application by practitioners. The project seeks to correct this deficiency, and to develop efficient use of computers as a planning tool. "The United States has a strong comparative advantage in computer hardware and software. The success of this project may be of mutual benefit to the United States and less developed countries, for the expansion of the use of computers will be supportive of demand in an area in which the United States is an important participant."⁷⁹

United States government participant training, as we mentioned earlier, benefits the United States private sector. A memorable program that began in 1965 and lasted

⁷⁹See AID, Project Paper, Project 995-970, 1972.

through 1969 is known in AID as "Korean Top Management Training Teams". This program was designed to expose Korean entrepreneurs to United States management techniques for adaptation to the Korean industrial sector. This observation-type training and related contacts resulted in team members consummating either joint ventures or licensing arrangements with Caltex, Eastman-Kodak, Ford, General Electric, General Tire, Lucky Chemical Company, Peerless Pump, Ralston Purina, Sears Roebuck, Upjohn, United States Pipe and Foundry, and Westinghouse.

Another form of government-business entanglement transpires in the developing country. An example is a Food and Drug Administration project in Turkey and Iran to improve inspection and quality control of pistachio nuts prior to their importation to the United States. This preemptive measure assists not only the United States firms marketing the pistachios but the developing countries in question who stand to improve net export income. The United States government action in these cases usually originates as a response to requests for help by developing countries in locating United States technologies and in transplanting desired American skills. In the last analysis, the present dimensions of United States government-business collusion are harmless and, indeed, can promote greater technological evenness in the world economy.

The prediction that the world today is on the brink of an intense mercantilistic struggle because of the closing of the technology gap in commercial though not military technology among the industrialized and certain industrializing countries need not materialize if national actors seize the opportunity for policy collaboration on an equal footing. Collaboration cum competition can preclude the formulation of policies that defeat everyone's objectives and sidetrack the principals from their national goals in a situation, Cooper admonishes, analagous to the members of a crowd rising to their tiptoes to see a parade better but in the end merely standing uncomfortably.⁸⁰ Secretary W. Michael Blumenthal has called for the United States and other governments to take steps to stop the downward spiral of protectionism and government competition for the benefits of foreign direct investment. "All would stand to benefit from the establishment of 'rules of the road' for international investment."⁸¹ Similarly, greater transparency of developed and developing country policies "vis-a-vis" technology, be they couched in issues ranging from industrialization to the development of indigenous science and technology capabilities, would be conducive to either incrementalist or structuralist attempts to maximize national and world welfare.

⁸⁰Cooper, "National Economic Policy in an Interdependent World", p.1298.

⁸¹W. Michael Blumenthal in closing remarks at the Secretary's Seminar on Economic Issues, August 9, 1978.

Gilpin concludes that

"the inherent contradiction of capitalism is that it develops rather than it exploits the world. A capitalist international economy plants the seeds of its own destruction in that it diffuses economic growth, industry, and technology, and thereby undermines the distribution of power upon which the liberal, interdependent economy has rested."⁸²

While the intuitive appeal of this observation is strong, the inherent political dangers of overdependence are not accounted for. The exploitative practices of the colonial era saw the prewar economic order eclipsed. Interdependencies have a stabilizing effect and it is precisely the indiscriminate and equalizing character of technology that may, in the long haul, assure the longevity of the liberal, international economy.

When C. P. Snow noted in the course of his celebrated lecture on "The Two Cultures and the Scientific Revolution" that "Technology is rather easy", he meant it in the sense that the uneducated can quickly master the operations of the factory and that engineers and technicians can soon be trained. While performance may vary, technology takes to many terrains. Its easy extension to countries in all stages of development is a comparatively new fact of human experience, a matter of a century at most. Indeed, in this new circumstance is a major hope for the socioeconomic well-being of millions who suffer unspeakable deprivation--a hope that can be translated into reality to the mutual benefit of both poor and rich countries.

⁸²Gilpin, p.260.

Health Comes First

Better health is linked directly to increased productivity in the world economy. Morbidity and malnutrition in the developing countries are major deterrents to their socioeconomic development. In a labor-intensive agricultural system, the inhabitants of the Sahel typically suffer two major debilitating diseases per lifetime. The cost in terms of lost output alone is egregiously high but the resources available for attacking health problems are limited.⁸³ For lack of sufficient resources, the widely hailed twenty-year-old malaria eradication program sponsored by the World Health Organization has petered out and, consequently, in those countries of Asia and Latin America where the disease had nearly been wiped out, there is now a serious resurgence. For example, India cut reported malaria cases from one hundred million in 1952 to sixty thousand by 1962, but the incidence had grown to six million by 1976.⁸⁴

It is worth noting that many "tropical diseases", now largely confined to the developing countries, were seen as recently as fifty years ago in the developed world. These diseases may not be related to the tropics so much as to a lack of preventive care, inadequate services,

⁸³See Noel V. Lateef, "The Sahel's Uncertain Future", The Progressive, June 1975.

⁸⁴Anil Agarwal, "Malaria Makes a Comeback", New Scientist, February 2, 1978.

other conditions of poverty, together with an inappropriate allocation of scarce resources. Furthermore, it is in the United States interest to help fight infectious diseases. Study of how trypanosomes, schistosomes, and leishmania block host defenses, for example, is likely to produce research leads of considerable significance to domestic health problems such as cancer. Also, since diseases do not respect national borders, there is some risk of importing such diseases as Lassa fever and Marburg disease (a hemorrhagic viral disease) to the United States and a continuing risk to United States citizens traveling abroad.

Although past research at United States institutions has not been as extensive as it might have been, work on infectious diseases is currently underway at several universities and federal government agencies such as the National Institute for Health (NIH), the Center for Disease Control, and specialized research facilities, including the Gorgas Memorial Laboratory and the United States Army and Navy Laboratories. An analogous set of university, industrial, and government research institutions exists in Europe and, to a lesser extent, in the developing countries themselves. Some of the internationally funded medical research institutes located in developing countries are the proposed International Centre for Health Research (formerly Cholera Research Lab) in Dacca (supported in part by NIH and AID), the International Center for Insect Physiology and Ecology in Nairobi, and national or regional institutions in India, the Philippines, Thailand, and elsewhere.

The investment of fiscal, human, and organizational resources in biomedical research should not detract from, or overbalance, investment in the development of basic health services and the organization of health, nutrition, and family planning delivery systems. These are of equal or higher priority.

Learning how to improve the organization and delivery of health services for deprived populations will benefit rural areas and urban ghettos in the United States encountering difficulties with these services. The transferrability of experiences accumulated abroad in the delivery of health services is demonstrated by an AID project ("Health Center Manpower Planning") contracted to Johns Hopkins University to develop a methodology for adapting available community resources for upgrading low-cost health care services in developing countries. Researchers studied the necessary functions which should be performed by health and family planning units, taking into consideration available sources, especially the optimum balance between highly trained versus less trained personnel. Using new "functional analysis" methods, better ways of meeting community health needs were developed, and are now being applied in India, Turkey, and Taiwan. After introducing the new approach into its own course work on health planning, Johns Hopkins presented the method to the Bureau of Indian Affairs for application on Indian reservations. Subsequently, one Johns Hopkins researcher initiated a pilot project in

Appalachia drawing on his experiences in India, and another collaborating doctor who had conducted research in Lagos is presently in Harlem--supervising another domestic pilot project.

Management institutes in many developing countries are already directing more attention to the health sector. The potential for United States participation is colored by an apparent paradox. On the one hand, the United States is characterized by a distinctly pragmatic, problem-solving orientation and considerable experience with the development and use of management systems. On the other hand, United States domestic progress in managing primary health care has lagged, so that attention to this section could substantially benefit the United States as well as developing countries.

To stimulate interest and action in addressing health services problems, politicians, planners, and decision makers need to be shown that basic health services can be provided and that desirable results can be produced. Furthermore, a carefully planned package, based to the largest extent possible on local or community resources (including community health workers), need not be extravagantly expensive. It has been pointed out that the current health care/nutrition package in Sri Lanka has produced a life expectancy at birth greater than that in Washington, D.C., at a cost of less than fifteen dollars per person per year.⁸⁵

⁸⁵James Grant, Overseas Development Council.

More than eighty countries, with more than 90 percent of the population of the developing world, have adopted policies aimed at lowering population growth and fertility, or making family planning services available. Population has been an important issue in the developed world as well. In the United States, for example, much attention has been given in recent years to fertility control, with emphasis on making family planning services more accessible to the poor. The 1972 report of the Commission on Population Growth and the American Future, entitled "Population and the American Future", was a unique and comprehensive review of issues relating to population growth in the United States. Although some of its recommendations were not implemented, it remains a model effort of its type and a useful reference for population commissions in other countries.

AID has striven to develop in various parts of the developing world institutional capabilities and resources for improved demographic statistics gathering analyses in order to enhance reliability of population data for policy formulation and socioeconomic planning. Population laboratories established in four developing countries under one AID project (Project No. 570-861) are testing methodological approaches for vital events surveillance through dual report systems and other methods for measuring population change.

Although the course of fertility in the United States is dramatically downward, the domestic vital statistics systems provide little information about why the fertility trend is down. Set up originally to accomplish other objectives, these systems are somewhat slow and costly when they are required to produce information on fertility rates, and some of the information--especially of the "why" type--they cannot produce at all. The work carried out under the population laboratories project will be useful in devising better methods for acquiring expanded information about fertility changes in the United States.

Improved contraceptive technology is widely recognized as a high priority need in both developing and developed nations, and was so identified in the World Population Plan of Action. More recently, the reproductive sciences and contraceptive development were systematically reviewed by more than one hundred sixty experts from twenty-six nations, under the sponsorship of the Ford and Rockefeller foundations and the International Development Research Centre of Canada (IDRC).⁸⁶ This report called for a significant increase in research in this field.

⁸⁶See R. O. Greep, et al., Reproduction and Human Welfare: A Challenge to Research, (Cambridge: M.I.T. Press, 1976).

Although the need for improved contraceptive methods to bolster family planning programs is particularly acute in developing countries, many Americans also need access to more effective methods. Furthermore, there is a growing medical concern about the potential health hazards of long-term reliance on oral contraceptives by millions of young women in the United States and other countries. Medical complications secondary to the use of the intra-uterine device are also of concern. For the most part, methods developed for mass use in international family planning programs would also be appropriate for use in the United States.

Several AID projects initiated in the early seventies could have immediate relevance to domestic contraceptive technology:

- AID has contracted with the Worcester Foundation (Project No. 931-17-580-520) to determine whether prostagladins might be developed as a contraceptive agent that would incorporate the major attributes of an "ideal" contraceptive: it would be self-administered monthly and it would be post-coitally as well as pre-coitally effective.
- A project contracted to the University of Pittsburgh (Project No. 570-526) has the purpose of developing an intravaginal agent for pre-coital use with the dual properties of contraception against unwanted pregnancy and prophylaxis against venereal disease.

-The incidence of venereal diseases has increased sharply in the United States in the last few years. An effective intravaginal contraceptive that is bacteriacidal as well as spermicidal may make it possible to effect a significant reduction in the domestic prevalence of venereal diseases. The Salk Institute was contracted (Project No. 931-17-518) to develop an orally-active, once-a-month contraceptive which acts by inhibiting the "luteinizing hormone releasing factor" and hence, ovulation. The approach investigated in this project may reduce serious side effects that sometimes occur with the contraceptive pills currently in use. Additionally, there is a possibility that research on this project may produce a means for achieving ovulation regularity making it possible to avoid the use of chemical and mechanical means that may conflict with religious and personal beliefs.

-A project undertaken by the Battelle Memorial Institute (Project No. 570-527) seeks to refine and clinically evaluate new and improved intrauterine devices (IUDs). Currently used by some two million women in the United States, IUDs are a relatively low cost contraceptive means. Success in overcoming some of the side effects that can accompany the use of IUDs may make available a more acceptable, low cost means of contraception that could benefit the increasing number of American users.

Improved contraceptive methods could have a large impact, both in terms of the ability of couples to control family size and child spacing more effectively, and in terms of demographic effects on national fertility patterns. While the latter are controlled by the complex interplay of a number of social and economic forces, more acceptable methods of fertility control that might be adopted by larger proportions of couples for longer periods of time would certainly influence fertility patterns and family size, and could have a major impact worldwide on economies overburdened in a losing struggle to improve national living standards.

Among the low-end poor, pregnant and lactating women, infants, and young children constitute a deprived majority and the core of the serious nutrition problem of both developed and developing worlds. They tend to get the least food or the least protein of all family members and are the first to suffer and the last to recover from temporary or chronic food shortages. The damage that malnutrition inflicts on these populations is visited upon both themselves and future generations.⁸⁷ The problem is exacerbated by the relatively low priority given to nutrition in the social sciences and medical education. One factor inhibiting a shift in emphasis is that many social scientists resist and look down on "applied" work, which is currently underemphasized in training curricula.

⁸⁷John E. Gordon, "Synergism of Malnutrition and Infectious Disease" World Health Organization Monograph No. 62, Geneva, 1975 and Michael Winick, Malnutrition and Brain Development, (New York: Wiley, 1976).

Findings from several AID projects in Chile to develop low-cost food supplements to help prevent brain damage and other irreversible damage due to malnutrition among the young have been applied in research and/or nutrition programs benefitting United States low-income groups. Applying the results of the AID research effort in Chile, the United States Public Health Service provided grants to five Indian reservations to improve the nutrition of preschool children and initiated research work related to malnutrition problems among migrant workers in Colorado.

Studies under an AID-sponsored project at Kansas State University led to the discovery that the addition of a dough conditioner (sodium-stearoyl-2-lactylate) allows the incorporation of significant levels of low-cost protein concentrates derived from legumes or oilseeds in wheat-based products. These products (mainly fortified bread) are presently used in the United States school lunch programs for the improvement of child nutrition. Concurrently, a ten year project initiated in the late sixties at the Institutional of Nutritional Research, Lima Peru, with AID support determined the relative biological value of new foodstuffs developed from non-traditional protein sources for feeding infants and pre-school children. The Institute developed low-cost, high-protein foods from cotton seed, soy beans, peanuts, fish, and mixtures of wheat, corn, and soy that could be valuable supplements to American diets.

By way of follow-up, AID financed several market feasibility studies to find ways of marketing textured vegetable protein (TVP) in forms acceptable to low-income families deficient in protein. The contractees, namely, General Mills Corporation, Swift and Company, and Archer-Daniels-Midland Company are market-testing a variety of instant foods with TVP ingredients in Thailand, India, and Brazil. They have also begun selling similar products on the United States commercial market. If and when the knowledge gained abroad is applied to "infant formulas" in the United States, TVP could become a big seller in this segment of the United States market. In the meantime, the United States Department of Agriculture is using a number of these products in the public school program benefiting underprivileged American children.

Under a similar AID market feasibility contract, a macaroni-like food developed by General Foods Corporation from corn, soy, and wheat, was introduced to protein-deficient groups in Brazil. The noodles have a protein content of 21 percent or seven times the nutritional quality of conventional pasta. General Foods is now selling this product to many United States institutions feeding hundreds of thousands of people including hospitals, public schools, children's homes, and prisons. It is not yet on the retail market due to definitional problems with the Food and Drug Administration.

AID contracted with Dorr-Oliver Company to find an inexpensive way to remove the toxins (gossypol, a toxic saccharide) from cotton seed mill, so that it could be used as a nutrititious, inexpensive food resource. The Dorr-Oliver Company, which manufactures food separation equipment, established a pilot plant in India capable of producing three tons of high protein, gossypol-free cotton seed meal daily. The Plains Cotton Corp. Oil Mill Company of Texas is using the same process on a full-scale commercial basis to make cotton seed available as a cheap source of protein for human and animal consumption in the United States.

The United States government-business connection, as mentioned earlier, is particularly evident in the foreign aid arena and has occasionally given rise to controversy. Charges that the United States has lubricated demand in developing country markets are not unfounded. The reason for paving the way for American products, however, is often less than accurate. Essentially good-willed, the motivation for some projects may be overly tinted by ethnocentric perceptions that fail to take into consideration the disparate conditions encountered in developing areas.

The provision of skimmed milk powder to low-end poor in Latin America has provoked harsh criticism of United States foreign aid and its tendency to make impoverished peoples dependent on United States private enterprise. However, the most devastating aspect of this particular resource transfer is its effect on infants whose mothers

prematurely cease to breastfeed, despite evidence that breastfeeding is important to antibody protection and reduces the likelihood of bacteriological contamination which serve to protect the infant.⁸⁸ This project illustrates well the dangers inherent in assuming equivalent benefits to the United States and the developing countries from a given project when conditions vary so drastically.

The origins of the milk powder project are innocent enough. AID-supported research conducted by Washington University field teams in Brazil revealed that Vitamin A added to skimmed milk powder could be assimilated by children consuming powdered milk. Prior to this study, it was believed that some fat was necessary in the human diet for the proper absorption of Vitamin A. The absence of this essential vitamin in the diets of children in developing countries is the cause of hundreds of thousands of cases of total blindness, and where there is a Vitamin A deficiency, night blindness. The Washington University discovery led to Vitamin A and D fortification in 1965 of all AID shipments of powdered milk abroad and by the fall of 1968 to the similar fortification of all United States powdered milk supplies distributed within the United States under the domestic commodity distribution program. In addition to helping the United States milk industry set the guidelines for enriching skimmed milk powder with the two vitamins, AID subsidized the effort for the first year for overseas shipments, as an incentive to the producers.

⁸⁸M. L. Berman, et al., "Effect of Breastfeeding on Pregnancy" American Journal of Obstetrics and Gynecology, October 15, 1972.

A National Research Council report commissioned in preparation for UNCSTD suggests that United States interests in such interventions have three components beyond humanitarian compassion for suffering: (1) an effective means of modifying dietary behavior will be important in relation to United States problems of obesity and excessive caloric and "junk food" intake; (2) understanding the functional significance of malnutrition for individuals will facilitate better food and nutrition policymaking and planning in the United States; and (3) most importantly, the reduced human potential caused by poor maternal and child nutrition has indirect but definite effects worldwide.⁸⁹

The National Research Council report states that increased collaborative research is needed on the relationships among dietary intake, local environment, and human performance (e.g., performance at work or school, the frequency and severity of infections, physical and mental growth, pregnancy, lactation, family spacing, and general vitality). Additional knowledge is needed to plan, design, and evaluate more effective nutritional interventions. Research should be greatly extended on the development of new foods, such as the vegetable protein supplement Incaparina, which could be used as a weaning food with local modifications of the basic formulation. Also, test marketing of potential foodstuffs is needed, along with more exploration of the possibility of fortifying local staple foods.

⁸⁹National Research Council, "United States Science and Technology for Development: A Contribution to the 1979 United Nations Conference", April 1978, p.96.

The extravagance of current American resource consumption patterns covers a broad spectrum, from medical facilities to diets to modes of recreation and transportation. The health benefits of a simpler diet, with less meat, fat, and sugar, could be substantial for the average American and additional benefits can be expected from less resource-intensive life-styles in other dimensions. "The need for Americans to consume a smaller proportion of the world's resources should be taken as an opportunity to reap some of these benefits, rather than as a threat to material well-being."⁹⁰

⁹⁰Ibid, p.110.

The Anatomy of Agricultural
Research Collaboration

"The greatest service which can be rendered any country is to add a useful plant to its culture."

Thomas Jefferson

Jefferson's insight of two hundred years ago applies "a fortiori" to a world increasingly vulnerable to famine and malnutrition in the face of mounting population pressure. The problem of supplying enough food worldwide is clearly before us. To reach our present and inadequate food production, agriculture has already invaded most arable land. Consequently, what counts most now is the development of new agricultural techniques to coax higher yields. This means that the brunt of food sufficiency lies with the "a priori" development of new, more resistant and productive staple crop strains.

The United States has benefited greatly from the hybrid plant. The most widely grown race of corn, the country's most valuable crop (nine billion dollars in 1975), is a product of the nation's westward expansion, with the settlement of the prairie lands of the midwest. This corn, Corn Belt Dent, is a hybrid race whose two parents were cultivated by the Indians on the eastern coast. However, of the ten most valuable crops in the United States only corn is native to the Americas. The geographic origins of the other nine crops are truly kaleidoscopic and include among other homelands China (soybeans), Chile (alfalfa), India

(wheat), Egypt (cotton), Cuba (tobacco), Sudan (sorghum), Latin America (potatoes), Brazil (oranges), and Madagascar (rice).⁹¹ This worldwide contribution to American plant breeding is a key factor in the richness of the United States experience with agricultural productivity.

The paramount importance of global interaction in the advancement of agricultural sciences has spawned several international agricultural research institutes, which have been relatively successful in structuring quite elaborate forms of international collaboration. They take leadership in organizing and providing logistical support for collaborative research projects and other programs involving dozens of nationally-based institutions; they sponsor workshops and symposia on common problems and provide training; and they provide management services for research information and materials.⁹² The Consultative Group on International Agricultural Research, established to finance and help coordinate the work of these institutes, now directs the use of almost ninety million dollars annually by eleven organizations; funds are contributed by the United States (20 to 25 percent) and twenty-eight other governments, international agencies, and private foundations.

⁹¹The "roots" saga of the world's basic food plants drawn upon here is the effort of Garrison Wilkes, "The World's Crop Plant Germplasm--An Endangered Resource", The Bulletin of the Atomic Scientists, Vol. 33, No. 2 (February 1977), p.14.

⁹²See Appendix C of the World Food and Nutrition Study (NRC 1977) for a detailed description of the international rice research centers in this network.

The cooperation of a number of nations and international foundations in the planning development, and support of international research centers is a recent innovation. Several unique features have been helpful in making the programs of these centers effective, among them an international diversity of scientists, continuing support assured for relatively long periods, relative freedom from political and social pressures in the individual participating countries, and strong commitments to the solution of specific problems. The United States benefits in many ways from this intricate network of research centers. The breakthroughs, for instance of the International Maize and Wheat Improvement Center (CIMMYT) of Green Revolution fame, have rebounded to United States interests.

CIMMYT sends its experimental seed and related research findings, on request, to government research stations, universities and private seed companies in the United States. CIMMYT maintains the leading corn germ plasm bank in the world and supplies hundreds of requests each year from United States corn breeders seeking breeding materials to meet specific problems. When the United States corn crop was attacked in 1970 by the fungus disease Helminthosporium maydis, almost all United States hybrid varieties carried the Texas male sterile cytoplasm, which was vulnerable to the attack. CIMMYT was the seed source for El Salvador male sterile germ plasm which was widely used by United States breeders and seed companies in

1971 and 1972, to provide resistance to the race of Helminthosporium which caused the attack. Altogether, CIMMYT has provided twenty-eight different male sterile populations from the CIMMYT in continuing the fight against the races of Helminthosporium. Diversifying the United States germ plasm resources from the CIMMYT world collection should help to avoid another disaster in the future.

CIMMYT's experimental wheat lines were grown at four hundred ninety locations in sixty-one countries in 1978. The best performing items are assembled at CIMMYT for distribution to all collaborators. CIMMYT's international wheat nurseries are presently grown in fifty-five institutions in the United States, and those institutions are free to take from CIMMYT nurseries whatever items that will help in their own breeding programs. Mexican short wheats, developed at CIMMYT are now widely grown in the United States. These strains have been used in the breeding of new United States bred wheat varieties including Era, Fletcher, Bounty, Bonanza, and Red River.⁹³

Centers like CIMMYT serve the vital function of a germplasm bank to guard against the inadvertant elimination of plants.⁹⁴ The present twelve thousand corn entries at CIMMYT come from forty-seven countries. Several other banks have been established to collect, store, and keep alive germplasm. Rice is stored in the International Rice Research

⁹³For more information, see CIMMYT Annual Report.

⁹⁴The urgency of an "insurance program" is cogently posited by Wilkes.

Institute in the Philippines. Sorghums and millets are being kept at the Indian Agricultural Research Institute in New Delhi pending eventual storage in the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) at Hyderabad. The United States maintains a world wheat collection at Beltsville, Maryland, and plans eventually to deposit duplicate samples of major crops at the National Seed Storage Laboratory in Fort Collins, Colorado.

The United States germplasm collection has been substantially enhanced with additions resulting from work of United States scientists abroad in collaboration with foreign counterparts. These interactions have been and will be important in breeding plants for higher yields and improved nutrient content. Some examples of direct benefits to the United States from abroad include:

-A strain of wild oats with an unusually high protein content was found in Israel. That strain has been used in United States breeding programs to produce a variety of oats for United States use with a higher protein content. These rust-resistant varieties from Israel under the PL 480 program are now in commercial production and represent a significant part of United States total oat acreage.

-A wheat collected in Turkey and introduced to the United States as germplasm for improving United States wheat varieties has provided resistance to all known races of common and dwarf bunts, resistance to stripe rust and flag smut, plus field resistance to powdery mildew and snow mold. It has contributed genes to many commercial varieties. The magnitude of benefits deriving from this one foreign plant introduction is in the order of fifty million dollars annually.

-A United States Department of Agriculture (USDA) contract at the University of Ankara, Turkey, to develop crops that could be grown in lieu of opium poppy, has produced the first winter lentils. Planted in the fall, like opium poppy and winter wheat, they are harvested in early summer. These new winter lentils give two to four times the yield of traditional summer grown lentils. They are showing very high promise in

the United States lentil production area in the Pacific Northwest. In addition to giving higher yields than presently grown varieties, they have the potential of providing badly needed ground cover during periods when soil erosion is serious.

-As a historical footnote, two soybean introductions from Nanking, China, that proved to be well adapted to a wide range of soil and climatic conditions gave impetus to large scale production of soybeans in the southern United States. All major soybean varieties now grown in the South contain genes from one or both of these plant introductions. Farm gate value of the soybean crop in the South exceeded two and a half billion dollars in 1975.⁹⁵

Pest problems are so severe and widespread that large areas of otherwise productive land may be removed from cultivation because of the depredations of a few harmful organisms. In the Philippines, six million acres of formerly cultivated land have become highly infested with a low palatable weed Imperara cylindrica and abandoned for agricultural use. In India, weeds cost agriculture an estimated six hundred million dollars per year and in the United States as much as five billion dollars per year. They reduce world rice yields by a third.⁹⁶ In Africa, trypanosomiasis and East Coast fever largely prevent cattle production in a large belt south of the Sahara covering one-third of the continent. The part of this region infested with the tsetse fly, which carries the trypanosomiasis blood parasite organism, could support two hundred million head of cattle.

⁹⁵Additional benefits can be tracked down in "Agriculture and Related Agencies Appropriations for 1977", Hearings before the Subcommittee on Agriculture and Related Agencies, Part 3, pp.75-336.

⁹⁶NRC, "U.S. Science and Technology for Development: A Contribution to 1979 Conference", p.132.

These organisms are a diverse and dynamic group. They adjust so rapidly to chemical or other treatments that resistant strains of crops or new control methods must be developed each decade to keep them in check. Intensive research in the United States and other countries has identified many of these pests, recorded their life cycles, and revealed numerous details about their strengths and weaknesses in relation to their management and control. Through such background information, new types of pest control technologies can be developed.

Modern transportation has greatly increased the possibility of introducing new pests into the United States. By the same token greater scientific collaboration in this area has augmented opportunities to locate, identify, and evaluate beneficial insects such as parasites and predators of insects which could be introduced into the United States for pest control. Sustained collaboration is needed to maintain an early warning system against new pests and to test new strains of crops and animals under the more severe conditions often encountered in developing countries. Developments in disease and pest control that reflect the importance of work in this area abroad include:

-A research program in Nigeria identified a single gene source of resistance to the Southern corn leaf blight. New corn lines with this gene are now available in the United States.

-Varieties of sorghum resistant to attack by the sorghum green bug were found in India, introduced into the United States, and are being extensively used by both commercial and private breeders.

-Southern corn leaf rust has been a serious problem in the Southern one-third of the United States. Corn varieties resistant to this rust have been found in Africa and introduced into this country.

-A tiny wasp, found in Yugoslavia and Poland, that parasitizes the eggs of the cereal leaf beetle was introduced in beetle-infested areas of the United States and is now helping to control the beetle without the use of pesticide chemicals.

-Research on exotic animal disease not presently found in the United States, such as foot and mouth disease and rinderpest, is forbidden by law from being conducted in the United States except at the USDA's Plum Island facility. Preparation for eradication of such diseases, should they ever be introduced into this country, relies upon research findings from countries where such disease are endemic.

Given the centrality of water management to agriculture, AID, in particular, has concentrated resources in this area. As part of an AID water management research project (Project No. 120-489), Colorado State University has been actively engaged in researching the hydraulics of fresh-salt water aquifers. The primary thrust has been toward developing means by which fresh water can be recovered from thin layers which float on extensive bodies of saline water in Pakistan. This research, while oriented toward the mathematical formulation of principles which govern the behavior of fresh-salt water aquifers and then toward the engineering application of these developments to Pakistan problems, would be useful in any part of the world where fresh-salt water aquifers are being developed from fresh water supplies.

The problems of developing fresh water supplies from fresh-salt water aquifers are encountered in a great many locations around the world. For example, in the United

States, salt water encroachment in the coastal aquifers is a problem in Connecticut, New York, New Jersey, Florida, Texas and California to name a few localities.

Technology assessment and the methodology to accomplish it have become a major concern of public and private authorities in the United States. The problem is to devise a methodology for assessment of first, second and third order impact of technology so as to be able to determine more fully the range of cost and benefits. Technology assessment methodologies are important to improvement of decision making in the United States just as in lesser developing nations. Although the social-cultural setting in Pakistan will yield data unique to that setting, the methodological assessment can be applied to other social-cultural regions including the United States.

The project research involves the application of principles developed largely in the United States to new and broader soil-water-climate situations than heretofore studied. As a consequence the research will provide additional supporting data for the verification of the principles which then can be further applied to United States agricultural problems. Pakistan is already confronted with a salinity problem in much of the irrigated lands of the Indus Valley. In certain areas of the United States the problem of soil and water salinity is constantly increasing and is becoming more and more a source of concern. If the United States is unable to halt increasing domestic salinity thousands of acres of productive land could eventually

become agriculturally worthless. This is the situation which faces Pakistan at present. Consequently, research results in Pakistan are pertinent in helping to solve current problems of mineral pollution of irrigation supplies in the United States thus preventing, or at least retarding this type of pollution in the United States.

Another major AID water management project (Project No. 120-480) is sponsoring research designed to improve the efficiency of interaction experiments relative to size of field. These tests have been useful in developing designs to increase efficiency in United States agriculture. Components of this ten-year-old project, terminating in 1978, have resulted in the following:

- The Christiansen-Hargreaves method of determining crop water requirements has been proven to be much more realistic and reliable over a wide variety of climatic conditions than existing methods. The impact of this on system design, delivery programs, irrigation methods and other related activities will be very significant not only in the United States but world-wide.
- New mold plows designed under this project are shaped to make a significant improvement in maintaining the mold drains open and minimizing power requirements. These have application in the United States wherever soils are suitable.
- Salinity leaching studies in Colombia undertaken by this project are providing United States soil scientists an understanding of how to control the effect of sodium in soils.
- Water law designs prepared under this project for Andean Pact countries will provide some solutions to difficult problems such as trade water rights in order to more efficiently distribute water.
- A simulation study in Colombia has improved United States understanding of modeling application to hydrologic-economic problems. This directly contributed to the development of the Atlantico-3 computer program used to model the Provo River Basin in Utah. This program will have wide application wherever groundwater modeling is a component.

Despite the immediate and direct effects international agriculture collaboration is having on agricultural productivity everywhere, experience demonstrates that agricultural trade will be the most difficult area for negotiating improvements in international economic relations. The reasons are apparent. Barriers to expanded international exchanges of farm and food products stem directly from domestic intervention and support policies. Typically, these domestic policies have taken precedence over general commitments to liberalization in international trade. As a consequence, comparative advantage has yielded to other considerations as a major determinant of the volume, composition, and location of agricultural production.

By virtue of the fact that agricultural exports have become an increasingly important part of United States trade and have contributed substantially to the United States balance of payments position, the question arises as to whether United States interests would be damaged by successfully undertaking initiatives that would help to increase food production in developing countries. In this regard, two forces are at work which typically move in opposite directions. On the one hand, a "substitution effect" occurs rather quickly when food produced abroad results in a reduction of food exports. On the other hand, increased food production abroad will result in higher incomes and greater demand for goods and services generally, including food--this might be called an "expansion effect". Much empirical evidence indicates that the expansion effects

will outweigh the substitution effects from increased food production abroad. Thus, while there may be adjustment problems for certain United States producers, they would tend to be offset by other gains for United States agriculture and the United States economy.

Indeed, the National Research Council enumerates five major ways in which the United States could benefit by financing and supporting research to increase the quantity and quality of world food supply:

- more profitable farm production and increased incentives to expand production, by countering the rising costs of food production;
- Increased supplies of food at reasonable prices, which would help control inflation;
- longer-term markets for exports and sources of low-cost imports for food and other commodities, by stimulating productivity and economic growth in the developing countries;
- reduction of environmental degradation associated with increased use of chemicals in agriculture;
- conservation of scarce petroleum and natural gas used to produce fertilizers and energy for food production.⁹⁷

Ancillary industries in the United States would stand to gain considerably from greater agricultural productivity in the developing world. Two AID transactions illuminate some of these benefits: The first project known as the "Seed Program and Industry Development" (Project No. 130-203) has been around for nearly twenty years. The purpose

⁹⁷"World Food and Nutrition Study", pp.32-33.

of this project is to increase the developing country's capability to supply farmers' requirements for improved seeds. This project has been a boon to United States seed exporters and under the project's aegis a Model Seed Law has been developed in collaboration with Seed Trade Associations in the United States, Europe, and the developing countries. In the past, seed laws in most countries, including the United States had evolved from custom and usage and were not designed to facilitate movement or exchange. The Model Seed Law provides a basis for uniform seed law legislation in the developing countries, which is extremely advantageous to United States seed exporters by making the United States sources more competitive than at present.

The second project (Project No. 190-832) terminated in 1977 after ten years duration and was contracted with the Tennessee Valley Authority. The impact of this project lay in the transfer of fertilizer production, marketing, and technology to the developing countries. The contribution to the United States of this assistance is summarized in an AID evaluation document as follows:

"By assisting developing country fertilizer programs this project has helped to identify new markets for United States materials, industrial plant and equipment facilities, new technology and concepts in manufacturing, distributing, and use of fertilizers. Evidence of this is that United States technology is being widely accepted throughout the world rather than European. Also, the developing countries have served as an experimental and proving ground for new fertilizer technology.

"The statistical phase of this project has made it possible to obtain technical production data on more than two thousand fertilizer plants around the world.

The primary beneficiary of these data is the United States industry, universities, and public and private research institutions and foundations. Additionally, through automated data processing techniques world-wide fertilizer consumption data by country inclusive of imports and exports is maintained and disseminated. Again the principal beneficiaries are United States public and private institutions."⁹⁸

Resources for international agricultural development are glaringly scarce. Information provided by economic research can be used to guide decisions on the use of those scarce resources. It is a major concern of the United States that the resources committed to development are used in the most efficient manner possible. For example, economic analyses revealed that agricultural development efforts in the past were having little impact on the well-being of the small farmers and landless laborers of many developing countries, who are among the low-end poor of those countries. The result has been new emphasis in United States and international development programs on rural development and the small farmer.⁹⁹ Sharp focusing of this thrust requires the types of information developed by social science research, much of which has been and will be conducted by scientists in the developing countries in collaboration with United States and other developed country scientists.

⁹⁸AID, Fertilizers Technical Assistance Project Evaluation Report, 1973, p.A-3-b.

⁹⁹See Noel V. Lateef, "Targeting Foreign Aid to the Low-End Poor", Vol. 54, No. 12, (December, 1977).

An intangible, but nevertheless real, benefit from collaboration in international research activities which is often overlooked is the development of human resources in the United States. Increasing interdependence requires that national scientific communities maintain an international perspective as they conduct their work. Since the United States is a leader of science in the world, it is especially important that this international perspective be fostered in its scientific community. Through greater collaboration with colleagues in other countries, this international perspective becomes stronger, and the resulting increase in United States capabilities permits it to carry out more effectively its leadership role. Since the United States properly prides itself on exceptionally strong competence in agricultural science and technology, at a time when food and nutrition problems are at the top of the world's agenda, it is imperative that the United States continue to assist in solving these problems by increasing its participation in internationally-focused research efforts.

As we noted earlier in this paper, the feedback from this kind of involvement rebounds to the direct benefit of United States institutions of higher learning. John T. Murdock, who directs the International Agricultural Programs of the University of Wisconsin states:

Perhaps the greatest benefits from our participation abroad is related to the influence of these activities on our education programs in the University. Through

participation in international activities, University of Wisconsin staff have expanded their awareness and concern of world agricultural problems and are better able to teach foreign and United States students who will be involved in food and nutrition research. Also, foreign students who come to our University (approximately 30 percent of our graduate students in agriculture) make a direct contribution by conducting food and nutrition research in international agriculture in providing United States students with scientific, social, and cultural contacts in many foreign countries.

There are many other specific contributions which our contacts in the international sector have made to Wisconsin agriculture. I will mention two examples.

1. Some of the more promising genetic material for our potato research program has been provided through our contacts with research institutions and former students from the Andean region of South America.
2. The basic thrust of our research program to improve the nutritional quality of beans had its origin in the research activities of one of our scientists working on our University Development Contract in Nigeria.¹⁰⁰

The United States does not know it all and has much to gain from international agricultural collaboration. On occasion, technologies originally developed in the United States have been improved upon abroad. Trickle irrigation exemplifies this point. After being perfected in extensive use in Israel, it was reintroduced in the United States, where it has found widespread use in California. Cross-cultural study of food production systems may yield valuable findings which could be imported for use in the United States. For instance, the use of multiple cropping, while increasing, is still uncommon in the United States. (Some 25 percent of the soybeans grown in North Carolina are

¹⁰⁰November 29, 1976 correspondence from John T. Murdock, University of Wisconsin-Madison.

multicropped with grain, and interplanting of maize and soybeans in Minnesota has been shown to increase grain yields significantly.) Nowhere in the United States does one find the diversity of plant (and animal) species grown in close proximity and/or sequentially that are found in numerous places abroad. Almost nowhere does the United States reach the levels of production per unit of land achieved in some systems in developing countries.

Environmental Cooperation

The seventies have been notable for the extent to which synanthropy has become recognized as a global concern involving the integrity of crucial physical resources and systems shared by the human race. The etymology of the word "ecology" has its root in the Greek word "oikos" or "home". Man's future, it is now manifestly clear, depends on a less haphazard regard for "home economics" in this wider sense. This field remains the most backward branch of technology and therefore, the one most urgently in need of development.

In recent years, environmental and human health problems have emerged attributable to the excessive use of pesticides, the use of long-lived pesticides, and the use of inappropriate pesticides, particularly insecticides. In the seventy or so developing countries that grow substantial quantities of cotton, for example, misuse of pesticides has resulted in injury to farm workers, evolution of insecticide-resistant pests, reduced cotton yields, and contamination of nearby food crops and animals, including commodities scheduled for United States markets. Moreover, in some places concentrated efforts to eliminate primary pests have upset the ecological balance, and insects that had previously been of only

secondary importance have become primary pests. While the environmental damage from misuse of pesticides cannot be quantified, this topic is of concern to health, agricultural, and environmental officials in many regions of the developing world and reflects the growing international concern for matters environmental.

The Government of Venezuela and the Department of Interior, for instance, jointly financed a project to determine appropriate types, concentrations, and schedule of use of agricultural biocides. The contractor was the Bureau of Sport Fisheries and Wildlife, directed by United States law to "provide for the conservation of ...migratory birds, that are threatened with extinction". The Bureau has determined that ingestion of agricultural biocides threatens the survival of some species. Data from the Venezuelan project is being combined with data on the same species during their United States sojourn to provide the Bureau with an improved understanding of how to protect these species.

In Egypt, international support for the struggle to combat bilharzia, a debilitating disease that currently affects over two hundred million people in Africa, Asia, and Latin America, has led to the dramatic discovery of an effective and environmentally safe molluscicide. The solution is a weed popularly known as "damassissa" which is part of the ragweed family. The weed has an established place in the ecology of the Nile River valley and does

not have harmful side-effects on either fish or livestock. However, under laboratory conditions, infusions of 1:1000 part damassissa to water decimates all the common snail hosts of bilharziasis exposed to it.¹¹¹

AID has initiated mosquito and tsetse fly control projects that are attempting to verify the feasibility of eradication via non-chemical means. The methodology of insect control by sterilization--as contrasted with the use of chemical insecticides, is in the early research and application stage. Based upon past successes, there is good reason to believe that these long-range AID research projects will also be successful. Such success would have two benefits to the United States:

-A significant reduction in the use of insecticides anywhere in the world will have ecological benefits, by tending (a) to reduce the level of pollution of our neighboring oceans, and (b) to reduce the incidence of fish poisoning.

-Improved methodology in application of these new types of control systems may lead to economic savings--to the extent that the cost of control methods by sterilization become less than the cost of control by insecticide production, distribution and use.

¹¹¹See Rowan Shirke, "Weeds May Be Key to Wiping Out Bilharzia, IDRC Reports, Vol. 7, No. 2, (June 1978), pp.22-23.

Effective approaches to pest management, including such techniques as water management and crop rotation as well as use of pesticides, are just evolving and are not well understood or even fully appreciated in developing and developed countries. Thus there are many opportunities for collaborative efforts to address a problem of common interest to many countries. Brooks speaks highly of an unusual experiment to institutionalize international collaboration in this area, namely, the International Centre for Insect Physiology and Ecology in Nairobi:

"This is a multinational collaboration between an underdeveloped country (Kenya) and a consortium of national academies in western countries, but the managerial initiative really came from the United States through the American Academy of Arts and Sciences in Boston. The future and ultimate accomplishment of I.C.I.P.E. are still in doubt, but in terms of initial momentum in building up a quality scientific institution in a less developed country within an amazingly short period, it is an interesting model, which probably has a degree of replicability. This is an interesting case because it represents a genuine collaboration between African and Western scientists on problems of common interest."¹⁰²

In this vein, a distinguished panel concluded that given the need for a wide range of new energy technology options in developing countries and significant parallel needs for new energy technology options in the United States, "the transfer of technology is likely to be particularly fruitful when it occurs as an integral part of joint problem-solving (research and development) processes."¹⁰³

¹⁰²July 8, 1978 correspondence from Harvey Brooks, Beaverbrook, Bread Loaf, Vermont.

¹⁰³Panel of the National Academy of Public Administration, "Energy Organization Options", Washington, D.C., December 30, 1977, p.20.

The important interface between energy and environment, which we shall refer to as "enenvironment" is likely to expand as the developing world industrializes. Philip Handler, President of the National Academy of Sciences, estimates that to bring all the world, including the Chinese, up to American standards of living would require man to multiply his use of critical minerals by seventeen.¹⁰⁴ Although some observers feel that concerns for enenvironmental problems will constrain economic development efforts, it should be pointed out that environmental protection can expedite development at a lower cost. Prevention is usually less expensive than cure.

Despite its impressive achievements, the United States continues to encounter problems associated with the use of natural resources, including energy and "free goods" such as air and water. Much research and development is still needed, for example, on:

- more efficient use of energy and materials in providing goods and services; recycling and reuse of materials;
- improved technologies and procedures for coal mining and utilization;
- development of acceptable technologies to facilitate the transition from fossil energy to renewable energy sources;

¹⁰⁴ "Science and Technology with a Human Face", Technology Review, M.I.T., (October/November 1975), p. 69.

--substitution of more plentiful resources for those that are becoming scarce, e.g., coal for petroleum, aluminum for copper, insulation and solar energy for heating fuel.¹⁰⁵

The United States has considerable experience and knowledge that can be shared with other nations. It began several decades ago to encounter problems somewhat analogous to those faced by developing countries (e.g., deforestation) and thus has had more time to develop responses than have many of the latter countries. The United States can also share its equally important experience of negative consequences and mistaken choices.¹⁰⁶

For example, development of improved photovoltaic or other solid-state means of converting sunlight into electricity could bring enormous benefits to developing countries and hasten the advent of commercial solar energy systems in the United States, with consequent savings of petroleum and natural gas resources.

The potential for renewable energy devices and technologies ranging from improved cooking stoves to burn scarce firewood more efficiently to solar "power towers" to generate electricity for large industries or towns and cities is just beginning to be realized and added to the

¹⁰⁵See NRC, "U.S. Science and Technology for Development: A Contribution to the 1979 UN Conference", Chapter 5.

¹⁰⁶See OST-AID, "RANN Program: Potential Benefits to Developing Countries", January 1973, pp.6-12.

already-established list of "conventional" energy technology options available to developing and developed countries.

A growing number of examples suggest some of the potential of these and related technologies: in China some sixty thousand small and mini-hydroelectric generators averaging 40 kilowatts in capacity supply most of the electricity used by three quarters of the rural communes and there are nearly five million family and multi-family biodigestors providing biogas for cooking, heating, and powering tractors and yielding residue that is a rich fertilizer. Tens of thousands of small farmers in India are now using gobar (cow dung) gas digestors for similar purposes and at least one large dairy cooperative is using solar energy to substitute for a significant proportion of the fuel necessary to dehydrate milk. In Niger, solar water heaters designed and manufactured by local scientists provide hot water for several hundred residences and some hotels. In the Omo River Valley in southeastern Ethiopia, wind pumpers of an ancient Cretan design now enable irrigated production of several crops a year where a few years ago barely one crop a year could be grown. Relatively much more sophisticated (and much more expensive) solar-powered irrigation pumps marketed by the French are operating successfully in nearly a dozen developing countries, with the Mexican government recently purchasing the rights to produce several thousand for rural villages throughout

Mexico. Also under a French program, photovoltaic cells have been successfully powering twenty-two educational televisions in remote school in rural Niger since 1967.¹⁰⁷

Existing or prospective research and development in or for developing countries could produce technology of direct value to the United States:

--Brazil, for example, is engaged in a major national program aimed at increasing alcohol production from sugar cane and cassava with the goal of providing 50 percent of the nation's need for liquid fuel by 1990.

--Technology for using agricultural residues to provide most of the chemicals now based on petroleum was developed in the 1920s but was shelved because low oil and gas costs made the petrochemical source more attractive economically. This technology is being reexamined and upgraded through application of chemical engineering advances made during the past 50 years.

--Information developed to maximize the production of methane from small-scale anaerobic digesters, for example, may well apply to large-scale urban sewage digesters or to United States work on converting kelp to methane.

--solar crop-drying techniques developed for regions of developing countries could also be applied in the United States with substantial energy savings.

¹⁰⁷"Energy Organization Options", Appendix B.

--Modular photovoltaic devices could be used to power high-cost remote communications (e.g., television, radio) and other electrical needs. The acquired production experience and resulting cost reductions will directly benefit the United States.

Such developments provide expanded market for United States technology. Commercialization could mean accelerated price reductions and accelerated economic competitiveness in the United States of many technologies not yet economically competitive here but potentially applicable in rural areas.

The United States currently imports about a third of its mineral requirements from other countries and it is likely that import requirements will rise to two-thirds or more within the next thirty years. Faced with increasingly stiff competition from other developed countries for supplies of minerals, the United States must have accurate information about foreign minerals resources and contacts in other countries that can help facilitate access to these resources. AID's exploratory technical assistance projects have provided large amounts of information about actual or potential sources of minerals in other countries, and also have helped to develop contacts and institutional linkages with other countries that will facilitate access to these sources of supply as they are developed.

Under the National Minerals Policy Act passed in 1971, the Secretary of Interior has been charged with the responsibility of keeping the Congress and the President informed on the United States position in the mineral field. This can be done only if the Department of Interior has adequate knowledge of world resources and resource potential as a "base line". Technical assistance projects sponsored by AID give United States mineral specialists the opportunity to collect and evaluate data on minerals in other countries--in other words the projects help to establish the "base line". Data so collected also provides some measure of availability of supplies in other countries, some estimate of future competition for foreign sources of raw materials that may affect the domestic supply situation. Thus, almost without exception, AID-sponsored assistance projects in the minerals sub-sector contribute directly to the fulfillment of the National Minerals Policy Act. AID assistance projects in the minerals field have also contributed valuable data which has led to exploration and development of foreign minerals in areas of particular significant to United States industry. A specific example is data developed by AID in conjunction with the United States Geological Survey. At the request of the Government of Brazil, AID assisted in making geological and mining surveys of Brazilian iron, manganese, and bauxite. Utilizing these surveys, Hanna Mining Co. has invested two hundred fifty million dollars in iron ore production in Minas Gerais, and may invest much more. The United States will receive twenty

million tons of iron ore per year from this source. United States firms (Bethlehem Steel and United States Steel) have made major investments in manganese at Amapa and Urucum, providing a major source of manganese for the United States. Alcoa and Hanna are making large investments in Pocas de Caldas aluminum production. The development of Brazilian mines has also resulted in the purchase of millions of dollars of United States trucks, drills, earth-moving, and processing equipment.

Similar bilateral projects have been initiated by AID and its predecessor agencies for Colombia, Indonesia, Liberia, and the Philippines. More recently, the Department of Energy (DOE) has become engaged in the business of conducting energy assessment surveys in the developing countries, with two such surveys completed for Egypt and Peru. The purpose of these surveys is to assist governments in their national energy analysis and planning so that they may make better investment, allocation, and strategy decisions "vis-a-vis" energy supply and utilization to meet both immediate and long-term socioeconomic goals. This information is valuable to the United States for projecting global energy consumption and in assessing patterns of supply.

Effective use of the skills and technological capabilities developed by NASA in its aeronautics and space activities is being made in a variety of technology areas in support of DOE. The results of work in several of these areas is of direct application to the energy needs of developing countries. As part of the National Photovoltaic

Conversion Program, DOE has assigned NASA responsibility for advancing the technology for the production of low cost silicon solar cells. In conjunction with the cell technology program, demonstration projects have been implemented for a variety of application in the United States. Consideration is now being given to a joint project with AID to use a solar cell power supply in Upper Volta to power a cereal grinder and water pump. This may be the first demonstration outside the United States of DOE/NASA technology. Some of the United States demonstrations are:

- Power for refrigeration and lighting on the Papago Indian Reservation in Arizona for the Indian Health Service.
- Powering remote weather stations for the National Oceanographic and Atmospheric Administration (NOAA) in several states.
- Power for water, lights, radio, and refrigerator for several forest lookout stations in California.

The Landsat series of satellites for the survey and management of natural resources and related surface features has engendered substantial benefits to the world community as a whole. The Landsat program is a going concern. More than one hundred thirty countries have purchased data from the United States data distribution center (EROS) in South Dakota. Seven countries in Europe, Latin America, Africa and the Middle East have already concluded agreements with NASA to establish receiving, processing and data dissemination facilities for direct

reception of Landsat data. Some of the benefits of the Landsat satellites include:

- Egypt has reported the discovery of a major iron ore deposit.
- Copper deposits have been discovered in Pakistan.
- A major deposit of lithium and another of potassium have been located in Bolivia.
- Brazil is providing multi-purpose data for its entire territory at a cost of roughly four cents per kilometer, compared with much more limited data provided through airborne side-looking radar surveys at eighteen dollars a kilometer.
- Numerous other examples include precise surveys of desert encroachment, mapping of salt domes, new insights for correcting the salting of fresh water rivers and the reclamation of desertified range land, the selection and management of pasturage, the control of coastal and river erosion and silting, the management of hydrologic resources, etc.¹⁰⁸

Remote sensing from space warrants special attention in the context of the 1979 United Nations Conference, because it represents technology in which the United States has clear strengths and in which the potential benefits from its use are great both to developing countries and to the United States.¹⁰⁹ As a major user of raw materials and a

¹⁰⁸March 31, 1978 correspondence from James V. Zimmerman, International Planning and Programs Office, NASA.

¹⁰⁹See NRC, "Resource Sensing from Space: Prospects for Developing Countries", Washington, D.C., 1977.

major supplier of food, the United States also has an interest in better mapping and assessment of the world's natural resources. United States economic forecasting and planning can be significantly aided by better information on strategic resources. Better information also enhances the possibilities for United States public and private organizations to collaborate in exploration and utilization activities with other countries. Greater use of remote sensing technologies increases the commercial opportunities for United States firms to provide equipment and support services related to data analysis and interpretation. Finally, monitoring changing resources and environmental patterns may enable the United States to work more closely with other countries to prevent or alleviate serious environmental problems that would be harmful to all nations.

A mutual benefits strategy legitimizes greater research and development expenditure by the United States when benefits may also accrue to the developing world. The proposed Federal budget for fiscal year 1979 for the development of solar heating and cooling equipment has been cut by more than a third, from sixty million five hundred thousand dollars to thirty-six million dollars. Yet, this is an "intermestic" area of innovation in which the developing countries have much at stake and are actively seeking breakthroughs. The additional expenditure to meet the full needs of United States technologists could be properly allocated under foreign aid.

The potential for state mutual benefits programs with the developing countries is enormous. In January, 1978, Governor Jerry Brown unveiled a five hundred million dollar energy program for California to experiment with windmills, wood chips, walnut shells, solar panels, coal gasification, and hot water as alternatives to fossil fuels. Says Brown: "Americans seem to be getting less inventive. I'm going to try to stimulate things the best I can through energy innovation."¹⁰ It is clear that Americans are becoming very interested in appropriate technologies. Thomas H. Fox of Volunteers in Technical Assistance (VITA) reports that he has received since 1977 close to seven thousand requests from Americans for one of three VITA publications ("Low Cost Development of Small Water Power Sites", "Hydraulic Ram for Village Use", and "Low Cost Windmill for Developing Countries").¹¹¹ A logical component of the California state-wide program would be an international collaborative effort to screen appropriate technology innovations abroad that may be applicable in California and to pool resources with interested developing countries so as to avoid needless duplication.

¹¹⁰"A Jerry-Built Energy Program", Time, January 30, 1978, p.28.

¹¹¹August 4, 1978 correspondence from Thomas H. Fox, Mt. Ranier, Maryland.

Technology as an Adhesive Agent
in a New World Order

Clearly realizing our dependence on the small steps and giant leaps of others widely dispersed in time and geography creates a sense of humility which, in the arrogance of contemporary accomplishments, Americans have tended to take for granted. In responding to the primordial question, "What is in it for us?", the preceding sections accented the benefits to the United States from the ongoing international exchange of technology. These transactions are too often believed to be liabilities by a good many Americans. Yet the countervailing evidence that we have marshalled here only scratches the surface. Specific examples of how this cooperation has fructified in direct as well as indirect benefits to the advancement of science and technology, and ultimately, to man, abound, but are documented rarely.

There are many other mutual benefits that can be had via close cooperation in science and technology between developed and developing countries. We have reached the point where some technologies can only be efficiently and beneficently employed through international cooperation. Witness the Intelsat communications system, the management of the radiowave spectrum, the movement of hydrocarbons by ship or pipeline, or the eradication of smallpox. Other technologies, while currently available only to the United States and other developed countries, have international

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implications because, like deep-sea mining, they exploit the global commons, or, like weather observation, they yield data usable by all. Each of these examples--and many more could be given--are technologies that must somehow be dealt with today in our international milieu, giving rise to an agenda of international issues that was simply absent several decades ago.

We began this paper by making reference to Hoffman's "race" between the domestic priorities that govern the political life of states, and the external imperatives of order. He identifies an equally important second race, this one "between technology and the capacity of the fragmented international milieu to master it."¹¹² To a great extent such mastery in the North-South theater will depend on how effectively areas, where the knotty questions raised by "transfers" arise if at all in muted form, are exploited in support of a mutuality of interests. However, in all cases, neither "transferor" nor "transferee" should lose sight of the need for a well articulated "quid pro quo", the essential condition of transfers between sovereign states. More than a fair deal is at stake; in question is human dignity, a putty-like substance that collectivities striving for equality in the international system mold with reckless ease.

¹¹²Hoffman, pp.140-141.

In arguing for a world order policy, Hoffman states: "There is not topic familiar to foreign affairs specialists that does not have a world order aspect, however much we may be used to looking at it from another angle."¹¹³ As we have stressed throughout this paper, the potential for mutual gains from a new world order and from global efficiency is marked in many areas and, particularly in acquiring a handle on population, food, and environment problems. The developed countries will face rising costs if they do not support the efforts of the developing countries to create the better health programs that are indispensable to achieving population stabilization, to increase food production, and to develop new sources of energy that are not hazardous to the environment. In each case, joint action on these important problems will also bring gains to the developing countries and help support their efforts to meet the basic needs of their own populations. An enlightened technological regime will be the essential if not sufficient factor in the successful application of this collaborative approach.

Crosscutting technology will play in one embodiment or another an increasingly important role in the meetings of international organizations like the United Nations Conference on Trade and Development (UNCTAD), the United Nations Industrial Development Organization (UNIDO), the United Nations Commission on Transnational Corporations, and the Organization for Economic Cooperation (OECD).

¹¹³Ibid., p.201.

Technology has snowballed into prominence in such United Nations Conferences as the one on technical cooperation among developing countries (TCDC) and has made its presence felt in the Law of the Seas Conference. (Elliot Richardson threatened United States withdrawal from the latter when transfer of technology was inserted as a condition of access to the deep seabed.) In Caracas, on March 29, 1978, President Carter affirmed:

"To become more self-reliant developing nations need to strengthen their technological capabilities. To assist them, I am proposing a United States Foundation for Technological Collaboration. Through private and public foundations and through our increasing participation in the United Nations Conferences, we can make technical and scientific cooperation a key element in our relationship."

The forthcoming United Nations Conference on Science and Technology can figure prominently in laying the blueprint for this new strand in the "seamless web" of North-South relations. However, UNCSTD must go beyond an airing of technology cum development issues--although this is important. In the preparations for this conference lies a major opportunity for each United Nations member state to make political and intellectual progress at the international level towards an array of mutually beneficial policies beginning with science and technology. The "technology route", not to be confused with the "technology fix", may open new doors where none were thought to exist. For all the platitudes of dehumanizing mechanization, the triumph of technology is that it introduces hope where only fatalism seemed to prevail. It offers encouragement to those who are despondent about the prospects of progressive world ordering.

A quick "tour d'horizon" of North-South issues outstanding continues to suggest an inadequate recognition of the inescapable policy choices in world ordering and an excessive concentration on crisis management.

As things stand, individual national policies, which are often out of phase with one another preclude integrated rational planning and foresight. As scarcities are exacerbated, few national actors will have sufficient incentive to consider the larger context of a decision in their desire to insure that policy preferences are fully protected in the outcome, escalating the "transaction costs" of even the most innocuous international decisions. Hence it is not without a sense of urgency that global interest policies must be formulated. Already, there is growing acceptance of one such de facto policy on violation of what have come to be regarded as universal human rights and, there is heightened global consciousness of the condition of natural and man-made habitats. Finally, it is worth considering whether policies that are mutually beneficial to both sets of countries could give rise to a redesigned international economic order or whether this is a classic chicken and egg question.

Unresolved at this critical juncture in the last quarter of the twentieth century is whether the United States can in a post-Atlanticist, Trilateral Alliance, defibrillate the international economic order it created after the Second World War or whether it should collaborate with a growing host of revisionist actors on the world stage to usher in a wholly new order. Succinctly put, the dystopia of the

proponents of the first course is instability and they prefer to risk failure in rehabilitating the old order rather than enter into a new and uncertain geopolitical arrangement. Those who oppose a static, foot-shuffling approach to world order consecration seek to mobilize a consensus that challenges ethical currents of neo-Darwinian sentiment and policy. In many respects, this clash between the prescriptive and the normative is an old one. Albert Sorel goes further: "It is the eternal dispute between those who imagine the world to suit their policy, and those who arrange their policy to suit the realities of the world."¹¹⁴

While the United States recognizes some community of interests with the developing world, it is not moving fast enough to reinforce a harmony of interests. However, the worldview that the interest of all can coincide with the interest of each must not neglect to factor in the variance of the perception of interests. After all, what is in one's interest, as is well known, is in the eye of the beholder. As a highly subjective exercise, interest determination transcends strictly "rational" considerations. The interests are not infrequently tinted by the passions. This makes for disparate perceptions of mutual benefits. In this sense, Raymond Vernon states with reference to TNCs: "The presence of a large, imperfectly controlled foreign element, associated with considerable strength and flexibility, constitutes a source of psychic pain that is so strong as to overwhelm and cancel out any perceived benefits."¹¹⁵ These

¹¹⁴Quoted in Edward Hallet Carr, The Twenty Years Crisis 1919-1939, (New York: Harper & Row, 1968), p.11.

conceptual differences in viewing the interests and the passions in turn influence the issue of how to divide benefits even when there is understanding that all parties do gain.

In framing mutual benefits, care must be taken not to gloss over the reality that it makes an important political difference if one party is continually benefiting more than the other. Slogans of "global interdependence" are purposely vague and are rarely intended to signify "equi-dependence", although they connote it. Recent United States concern over the uneven spread of economic benefits stemming from TNC activities crystalized only after the United States began to perceive that it was not receiving the lion's share of the benefits on its foreign investments. Bergsten concludes: "If host countries are achieving an increasing share of the benefits brought by multinational firms, someone else is receiving a decreasing share."¹¹⁶ This statement would seem to be an endorsement, albeit from an unlikely source, of the central thesis of dependencia literature that Third World academicians have been turning out prolifically, namely, that development and underdevelopment are simultaneous processes. While this proposition remains theoretically unsubstantiated there is little question that the two are

¹¹⁵Vernon, "Problems and Policies Regarding Multinational Enterprises" in United States International Economic Policy in an Interdependent World, (Washington, D.C.: United States Government Printing Office, 1971), p.126.

¹¹⁶Bergsten, "Coming Investment Wars", p.144.

related. And, indeed, the developing countries have been arguing for some time that world welfare does not improve uniformly. Given their underdevelopment, these same countries expect their share of mutual benefits to be disproportionately large. By the same token, the publics of the developed countries, accustomed to economic largesse and not yet affluent to the point of psychological satiation, are unlikely, from their track record, to take a voluntary reduction in their portion of the pie.

However, for the first time, developing countries, drawing on their strength as a union, enter into negotiations of mutual benefits shares with the developed world with a sense of parity. This Third World hubris stems from more than just security in numbers. It is due in no small measure to the growing recognition that southern economic vitality is a crucial engine of growth for the world economy. John W. Sewell has enunciated this twist in an exceedingly incisive paper. He concludes:

"A great deal more analytical work needs to be done before the full ramifications of the dependence of the industrial countries on the growth and progress of the developing countries can be understood and translated into concrete policy recommendations. Nevertheless, the implications are clear: the future growth and well-being of the industrial world will be dependent on what happens in the developing world; therefore working cooperatively with each other provides the only real promise of progress for either."¹¹⁷

¹¹⁷John W. Sewell, "Can the Rich Prosper Without Progress by the Poor?" to appear in United States and World Development Agenda 1978, Overseas Development Council, 1978.

The United States needs to come more fully to grips with the reality of an undormant Third World. Only then can the United States be a participant in shaping the nature of change and in constructing afresh a framework for it. The elasticity of the present international economic system is being tested with increasingly unfavorable results. The NIEO, as it turns out, is not as "epiphenomenal" as Henry Kissenger assumed. Bergsten states:

"It is clear that a NIEO, or at least significant change in the old order, is already emerging. Numerous economic concessions have already been made. New institutions have been created, and many more proposed. The underlying realities of economic and, hence, political power among the nations of the world assure that this evolution will continue to the point where a new equilibrium, and a method for further evolution to maintain that equilibrium are found."¹¹⁸

The "technology route" is an important component of this method. The critical interface between technology and development has become a key issue in the North-South debate. Orville Freeman goes further: "technology in the broadest sense--including material, managerial, marketing, organizational and other skills, as well as advanced technical information such as secret know-how--is at the heart of the difference between developed and developing countries."¹¹⁹ There can be no doubt that the technology issue is comfortably ensconced upon the international

¹¹⁸Bergsten, Panel Discussion, in Bhagwati: (ed.), The NIEO: The North-South Debate, p.352.

¹¹⁹Quoted in Brooks and Eugene B. Skolnikoff, "Science, Technology, and International Relations", a presentation made at NARO Science Committee Twentieth Anniversary Conference, April 12, 1978, (mimeo.), p.11.

agenda and is a bull that must be grappled by the horns. Properly addressed, this issue is the surest way of arriving at some kind of North-South entente.

On both sides of the "poverty curtain", it is often said, "political will" is the missing ingredient needed to make the breakthroughs that might reconcile basic North-South differences. This view is illustrated in opposing paradoxes bandied back and forth by discussants engaged in the Dialogue. The Richard Coopers cite the inequities within Third World national orders and they chide the elites who posit the claims for distributive justice for not doing more for their own people and for expecting the corporate actions of international actors to be more high-minded.¹²⁰ They criticize the practice of anthropomorphizing nation-states and they remind us that "the history of the international system is one of inequality 'par excellence'...states are, as it were, born unequal; so much so, indeed, that the natural inequalities among individuals appear almost marginal."¹²¹

The rebuttal is no less firmly held: Only with the reinforced economic expansion that can flow from the much longed for NIEO can the developing countries cope more effectively with their internal equity problems. The Ali Mazruis' spearhead the assault:

¹²⁰Cooper in Bhagwati.

¹²¹Robert W. Tucker, The Inequality of Nations, (New York: Basic Books, 1976), p.3.

"When Third World leaders are elitest and corrupt, we are told that no dockworker of Marseille should be forced to subsidize them. When Third World leaders are earnest and socialistic, and seek to end elitism and corruption, we are told that they are recklessly interfering with the market--and the dockworkers of Marseille must not subsidize them either." Hence, Third Worlders are left suspended "between the indignity of charity and the ambition of economic justice."¹²²

Mazrui correctly observes that the call for the NIEO incubated in the course of the consolidation of a new international moral order. This order is characterized, perhaps, not so much by its newness as its extension to global parameters in a backlash against moral exclusion in a technetronically sensitized world. Jimmy Carter has boosted this global morality and assured its self-sustained growth by affirming the indivisibility of human rights and basic human needs. The egalitarian tint of this moral code is singled out by Zbigniew Brezezinski, who is on record as saying that "equality is becoming the most powerful moral imperative of our time, thus paralleling the appeal of the concept of liberty during the Nineteenth Century."¹²³ Thus, the morality of some kind of international equality between men of all origins and persuasions, would make it unlikely that the United States would practice anything as reprehensible as "triage", should millions abroad face mass starvation.

¹²²Mazrui, p.374.

¹²³Zbigniew Brezezinski, "U.S. Foreign Policy: the Search for Focus", Foreign Affairs, Vol. 51, (July 1973), p.726.

Adherents to a nondiscriminatory moral code reap more than just the benefits of consciences salved. They gain the advantage of problems preempted. The net benefits of preventive as opposed to curative aid are far greater in human welfare terms and much cheaper in dollar terms. This rationale is axial to the mutual benefits ideology. It also highlights America's direct stake in reversing the deterioration of the human condition in the developing world.

One of the primary ways to assist the developing countries is to lay the groundwork for a new technological regime. In lowest terms, this numerately means greater research and development collaboration between developed and developing worlds. An indispensable condition for adequate development of new technologies for developing countries is a large build-up of their own organizational capabilities to assess, develop, adapt and use such technologies. The extent and effectiveness of research and development to fit technologies to local circumstances is likely to be meager without extensive participation by local research and development institutions. They are also essential to permit much use of outside scientific and technological talent, findings, and experience in developing solutions for local use. Local research and development institutions are among the most effective "gate-keepers" through which these external technological resources can flow to local users and through which local experience can flow out to other developing countries, to the United States and to other developed countries.

Experience has accumulated in recent years, primarily in agriculture but also in other fields, with systems for research and development collaboration among organizations all over the world that are doing research and related knowledge dissemination in a particular problem area. This experience suggests that such mechanisms can be productive in furthering technology transfer via joint problem-solving.

These research and development networks concentrate on problem-solving in a discrete and widely pervasive problem area. They are characterized by voluntary, self-selecting participation, by organizations that are private or public, national or international (but not by governments as such), in whatever collaborative activities they find useful. Essentially, they form a common pool of research and development results to which all participants contribute, based on the types of work that they want to do and are able to do for their own purposes, and from which all may draw for local adaptation, as needed to fit their own situations. The stimulus for the network's operations is provided by one or several of the more advanced participating organizations performing functions essential for this purpose, such as leadership in organizing collaborative programs or projects, logistical support, and information or materials management services. Although the research collaboration in such networks follows the traditional pattern of voluntary cooperation among scientists or organizations sharing common

interests, the collaboration in the newly-emerging agricultural research networks tends to be more extensive, systematic and sustained than the rather casual and intermittent international research collaboration that has long existed.

Such associations foster increased research specialization and divisions of labor that could increase the rate of progress of research and development on global problems. Appropriate divisions of labor permit economies of scale by concentrating much of the more expensive and difficult types of research at facilities that can serve international needs, particularly the needs of developing countries. The networks can provide both developed and developing worlds with access to worldwide scientific and technological capabilities far beyond anything that they could provide or organize for themselves on a country-by-country basis. In sum, the networks can have great flexibility in fostering contributions from and contributions to organizations and countries with diverse capabilities, needs and wants.

The present research and development networking in agriculture should be bolstered and replicated in many other key cluster areas including health, energy, industrialization, transportation, urbanization, etc. The United States should commit itself wholeheartedly to collaborative endeavors by relating them to United States and international development systems and by facilitating private tie-ins to the networks with publicly supported financial assistance. Bearing in mind the fact that over the past fourteen years the proportion

of United States gross national product devoted to research and development has fallen by one-third, increased funding for domestic collaboration with the networks may be a timely investment.

The second approach to the diffusion and exchange of technology that we advocate relates to the commercial transfer processes which largely take care of themselves but can be encouraged and promoted by government to the economic benefit of the United States. At present, the United States gives few incentives to domestic producers to enter the export market. Unlike most of its trading partners, the United States lacks a coordinated, aggressive export promotion program. Studies have shown that the rate of return on foreign sales activity is at least equal to that of domestic sales yet exports are dominated by only the largest United States firms. Small and medium sized firms shy away from the perceived and sometimes real complexities attendant to foreign export. They lack guidance as to the proper export procedures. Since the United States lacks a clearinghouse for export information, many firms fail to be aware of the foreign demand for their product. Export opportunities are lost. If these factors contribute significantly to the deterioration of the United States competitive position, policies which depreciate the dollar, create a comprehensive energy program, or advocate fiscal stimulus abroad will only slow the long run decline.

Continued United States support of the drive for a more healthy world economy requires increased government-business cooperation, based on mutual understanding at home

and abroad. Such an understanding cannot come about as long as United States firms continue to confront a governmental apparatus that is extraordinarily fractionated and diffused, as compared with most other countries. All three branches of the United States government have some power to legislate, adjudicate, and execute. That fact, coupled with the distribution of relevant powers between the states and the federal government, makes it difficult for the public and private sectors to collaborate on a very broad basis at a time when competition from the "incorporated state" and the "public corporation" abroad is very stiff. Hence the justification for a long-lacking focal point in government that could serve the functions of an agency for international trade and investment.

The much maligned transnational corporation is in fact the proud flagship of the free-enterprise system. It serves to anchor the private sector apex of the technology triangle. Its mere presence can offset the dichotomy articulated in some Third World circles to the effect that in the developed countries choice, development and transfer of technology is undertaken by the private sector whereas in the developing country the state must take primary responsibilities for these activities.¹²⁴ This overly ambitious view of

¹²⁴For a recent articulation of this dichotomy see Economic and Social Commission for the Atlantic and Pacific (ESCAP) Regional Paper in preparation for UNCSTD, (May 1, 1978).

governmental capabilities overlooks the role of educational institutions that produce research and development and a private sector structured to generate, receive and utilize technical advances. Indeed, there exists a fairly tight set of limits within which governments can commandeer and supply technology. John Lewis has remarked that in most areas the ballpark is very different from agriculture, where the technology is far more "socialized."¹²⁵

Recent domestic opposition to the TNC stems mainly from a domestic perception of benign neglect as capital, jobs, and technology are exported abroad. The complexity of the relationships is so great as to make it virtually impossible to determine the precise impacts on employment or trade from any given transfer of know-how. Support for such transfer may turn out to be an "act of faith" in the contribution that technology and technical skills make to the growth of the world economy and to all members within it. Were we in a position to design the world economy, and the location of the industrial activity more precisely, we would be able to focus the use and transfers of technology. As it stands today, not having such a "grand design" we are left with the alternative of spreading technology or attempting to contain it in the hope that it will retain for us a relative advantage compared with the rest of the world. This is a vain hope, given the multiple sources of technology and the readiness of others to use it to gain allies or preferential positions around the world.

¹²⁵Memorandum of Conversation, June 10, 1978, p.2.

As this paper should make abundantly clear, a large research agenda remains in the area of TNC-government and intergovernment interactions as related to TNC operations generally and, in particular, the performance of specific functions in the planning and execution of new forms of foreign corporate resource commitments, as well as the transformation of existing investments. Such research could shed light on the role TNCs might play in reconciling the economics of efficiency with the politics of distribution. Nye, for one, speculates that TNCs could evolve by the end of the century into a new and flexible form of functional international organization.¹²⁶

One must concede that too few such organizations exist at present, certainly too few to deal with the kinds of problems that beset world society. As Brooks says:

"One of the central issues of our time is how to deal with our pressing social problems, the problems brought about by the growth of population, urbanization, and the rapid application and diffusion of technology itself. These are public problems. They represent needs that cannot currently be expressed in terms of a market demand that can be satisfied for somebody's profit. There is no lack of ideas for dealing with many of these problems, but there is nothing analogous to the pull of the market to induce the development of the solutions, or to do the sorting out of alternative innovations that is achieved more or less automatically through the probing of the market in the private sector."

Brooks believes that more of our thinking and "innovative energy" should be aimed at inventing a market for these public sector problems: a "social mechanism that has some

¹²⁶Nye, "Multinational Corporations in World Politics", Vol. 53, No. 1, (October 1974), p.166.

built-in automatic selectivity that rejects unsuccessful ideas and rewards successful ones."¹²⁷

Although technology needs to be more strongly in the service of social goals, it should be remembered that many of the problems facing the world today are not scientific or technological. As Lance Taylor puts it: "The focal changes will have to be in the social relationships of people to technology and among themselves."¹²⁸ But the capacity for technological change within poor societies in particular matters very much in any attempt to eliminate the worst forms of poverty. In this task, social scientists can be valuable guides to their colleagues in the natural sciences who venture into the "seamless web" of social reality.

As Mark Kac noted at the Twentieth Anniversary Conference of the NATO Science Committee, we remain very much in the dark as to "the ways in which the cross-fertilization between knowledge and its application takes place, and we are in danger of undermanaging this delicate process."¹²⁹ A National Research Council study project on social research and development chaired by Donald Stokes sees the flow of knowledge into policy taking place via a transmission belt consisting of researchers, academic

¹²⁷See Brooks, "Future Needs for the Support of Basic Research", in Basic Research and National Goals, (Washington, D.C.: Government Printing Office, 1965).

¹²⁸Lance Taylor, "The Constraints are not in Technology", Technology Review, M.I.T. (January 1976), p.22.

¹²⁹Quoted in M. N. Ozdas, "Twenty Years of Scientific Cooperation", NATO Review, No. 4, (August 1978), p.19.

middlemen, research brokers, and policy makers. The projects findings suggests that research brokerage, i.e., the translation of social knowledge into policy advice, especially at the federal level, may constitute a new discipline, whose practitioners have "a sophisticated understanding of the importance of maintaining a flow of facts and interpretation from the world of research to the world of action and a flow of leadership and support back again...."¹³⁰ This recommendation reflects the significance of proper utilization of information in a world which has come to be practically organized around this basic and very sharable resource.

Information, i.e., organized knowledge, has transformed the United States economy to the point where by the mid-1970s only fourteen million out of eighty-seven million workers were "producing goods" in the traditional sense of those words. Indeed, at present half of the United States labor force is engaged in generating, processing, analysing, maintaining, communicating and distributing information. Of the information revolution, Harland Cleveland and Thomas W. Wilson, Jr. state:

"Since information is limited only by our imagination and our capacity to manage complexity, social processes based on information resources do not have to assume (as, by and large, our legal, administrative and judicial systems do assume) that if there are winners there must be losers. Adding information to other resources makes "positive-sum" games possible, inside nations and among nations."¹³¹

¹³⁰ See James L. Sundquist, "Research Brokerage: The Weak Link" in Laurence E. Lynn (ed.), Knowledge and Policy: The Uncertain Connection, Vol. 5, (Washington, D.C.: NRC 1978), pp.126-144.

While the research networks are important synapses of information transition they must be supplemented by institutions explicitly mandated to function as terminals for information systems and industries. An example is the National Technical Information Service of the Department of Commerce, which needs to intensify its efforts to assist developing countries identify and acquire information germane to their immediate problems. The proposed Foundation for International Technological Collaboration should possess a very up-to-date repository of information that could be readily tapped by developing and developed countries in a technology network.

In conclusion, there are times when, policy, rather than trying to deal with everything at once, must identify and tackle the jugular. Top policymakers in the central institutions of government at present need to devote more of their energies to questions of lasting importance rather than the day-to-day flaps which seem to monopolize their time. Shoring things up, putting out fires, untying jurisdictional knots drain their energy and their imagination, while important but longer-term problems go unattended. There is no way to insulate these officials from the distracting details of the moment's crisis--or, in the case of elected officials, from the things that need to be done to get reelected. But government--and the international organizations they spawn and supervise--do need to ensure continuous

¹³¹Farlan Cleveland and Thomas W. Wilson, Jr., "Growth for Whom? Growth for What?", a policy paper/Aspen Institute for Humanistic Studies, March /, 1978, (mimeo.), p.34.

attention to issues of fundamental importance--such as the complex, long-term problems of incremental enhancement of human welfare in an evenly technologized world.

Patterns of regularized policy coordination let alone formulation on a transnational basis are glaringly absent in the international system or, more precisely, the individual systems of disparate core areas. These systems transcend Northern and Southern affiliation and, without a critical mass of global cooperation, will be incapable of meeting the growing demands placed upon them. The time therefore seems overripe for more active explorations of how the institutional and human resources of both worlds, developed and developing, can be brought into closer and more informal working partnership. Without compromising the ultimate requirement for government to govern, without restricting non-official surveillance and criticism of what governments do or fail to do, easier and more continuous relationships need to bridge the Manichean distinction between "us" and "them".

Finally, we must not defocus our vision of a brighter future for mankind. True, the discordant sounds of ill-conceived ideas are too much with us--complicating efforts to orchestrate collaboration in tune with the times. How reassuring it would be if we could still afford to ignore the first murmurs of change and to attempt ever so quixotically to foil the inevitable. Albert Camus said it much better: "Great ideas come into the world on doves' feet. If we listen closely, we will distinguish amidst the empires and nations the gentle whisper of life and hope."