AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

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Batch 61

1. SUBJECT CLASSIFICATION
A. PRIMARY: TEMPORARY
B. SECONDARY:

2. TITLE AND SUBTITLE
Impact on the US economy of transfers of technology,pilot program in Korea

3. AUTHOR(S)
Mintzes,Joseph

4. DOCUMENT DATE: 1973
5. NUMBER OF PAGES: 34p.
6. ARC NUMBER: ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
AID/TA/OST

8. SUPPLEMENTARY NOTES (*Sponsoring Organization, Publishers, Availability*)
(In TA/OST 73-14)

9. ABSTRACT
(Science & Technology R&D)

10. CONTROL NUMBER
PN-AAD-690

11. PRICE OF DOCUMENT

12. DESCRIPTORS

13. PROJECT NUMBER

14. CONTRACT NUMBER
AID/TA/OST

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

TA/CST 73-14

IMPACT ON THE UNITED STATES ECONOMY OF TRANSFERS OF TECHNOLOGY

(Pilot Program in Korea)

JANUARY 1973

Office of Science and Technology
Agency for International Development
Washington, D. C.

PREFACE

This Report supplements the report of the Illinois Institute of Technology Research Institute on the pilot project "Application of Industrial Technology Developed under NASA Auspices to the Needs of a Developing Country" which was supported by the Office of Science and Technology. It has been issued as a separate report, however, since this type of analysis should have applicability to a broad range of technology transfer activities.

The Report was prepared for the Office by Joseph Mintzes, an economic consultant. Assistance given to him by the Department of Commerce, NASA, and the Illinois Institute of Technology Research Institute is gratefully acknowledged.

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*Korea Institute of Science and Technology

IMPACT ON THE UNITED STATES ECONOMY OF TRANSFERS OF TECHNOLOGY (Pilot Program in Korea)

Introduction

The purpose of this paper is to examine the potential impact on the United States economy of the transfer of technology under a pilot project supported by A.I.D.'s Office of Science and Technology [PASA TA (ZA)-70]. This project, which began in June 1970 and continued through 1972, provided for the transfer of American technology primarily from data banks containing aerospace and related technology to the Korea Institute of Science and Technology (KIST). Among other roles, KIST promotes the adaptation of technology from suitable foreign sources to the needs of Korean industry. Experience of KIST under this pilot project is being considered for possible application in other developing countries, particularly in Asia and Latin America. The objective of the pilot project is to demonstrate whether recently developed technology can be introduced into developing countries through a deliberately structured technology transfer program and thus enable them to "leap frog" some intermediate development steps.

This report has been prepared in light of a growing concern expressed by some branches of American industry and particularly trade union spokesmen that the accelerated transfer abroad of United States technology in recent years has reduced the competitive position of certain American industries in domestic and foreign markets. These spokesmen claim that the worsening international trade position of the United States in recent years and the unemployment problems of workers in affected industries are to a considerable degree attributable to the rapid international diffusion of American technology.1/ It should be noted that these concerns are raised primarily with

1/ For example, see the submission by Nathaniel Goldfinger, AFL-CIO economist, to the Commission on International Trade and Investment Policy, United States International Economic Policy in an Interdependent World, Papers, Vol. 1 (GPO) Washington, D. C., 1971, pp. 913 ff.

respect to the operations abroad of American-based multinational corporations. The debates and related proposals surrounding these issues have questioned a long-standing American policy favoring the unimpeded international flow of commercial technology.2/ Although transfers of the type envisaged in the aforementioned pilot project have not been questioned specifically in the public debates on the narrowing of the so-called "technological gap," it was nonetheless deemed desirable to air some of the possible issues involved, in view of the broad concerns raised in these discussions.

With these concerns in mind, this report attempts to assess the potential impact of technology transfers envisaged under the A.I.D.-financed pilot project, particularly on the electronics industry which has been emphasized in this project. A number of data problems make meaningful projections difficult with respect to the possible trade and related employment effects for the products that might be affected by the specific transfers envisaged in the projects. For one thing, it is still too early a stage in the transfer process to determine which technologies will be successfully adapted for Korean commercial application. Even when assuming successful completion of the transfers (i.e., actual commercial production of prototypes developed by KIST), Korean trade statistics and planning targets are not refined enough to provide needed data. For purposes of this study, trade trends for the electronics industry -- the sector of emphasis for KIST's activities under this project -- and related Korean planning targets are utilized to provide some indicative background. However, it should be noted that the transfers which may be brought about by the pilot project under even the most optimistic assumptions could only be a minor factor in such trends for the five-year period covered by this paper.

2/ The proposed Burke-Hartke Bill (S2592 and HR 10914) includes a broad provision (Title IX) that would authorize the President to withhold the transfer of United States technology abroad if it is judged that such prohibition would contribute to increased United States employment.

The study, nevertheless, reviews the relevance of broad patterns of international diffusion of technology to the industries that might eventually be affected by the transfers. The possible impact of the transfers on trade patterns affecting the United States is considered. It examines briefly the relative advantages and disadvantages to the United States of possible alternative sources of these or similar technologies for Korea.

KIST in the Korean Economic Setting

Korea, as one of the more technically advanced developing countries (together with such countries as Brazil, India, Taiwan and Mexico) has reached a point in its development where an up-grading of its industrial technology could be of considerable importance with respect to further progress toward self-sustained economic growth and ultimate entry into the ranks of the developed countries. Over the past five years, Korean GNP has risen at about 10 percent annually -- one of the highest growth rates in the world. Currently, domestic capital formation is about 18 percent of GNP annually, and foreign capital represents roughly 12 percent of GNP. Neverthless, against this background, Korea, with a $278 annual per capita GNP in 1971, is still a "poor" country -- only a little above the average level for the less developed countries as a group. It is not well endowed with natural resources and its indigenous business community tends to be conservative and disinclined toward innovation. In contrast to most developing countries, Korea is favored with a relatively low and declining population growth rate (now at about 2 percent per year). It has a relatively high literacy rate of 60 percent with a substantial number of post-secondary school trained professional and technical personnel.

Korea's exports have been increasing dramatically, rising at about 30 per cent annually during the past five years. About 80 per cent of its $1 billion in exports are in manufactures. Its chronic trade gap has been leveling off as recent growth trends in imports have been at only about half the annual export expansion rate. Government policy has favored supplies for export industries and capital equipment under selective administrative controls over imports. The Third

Five-Year Economic Development Plan calls for a quadrupling of exports, which stood at $882 million in 1970, to $3,510 million when this planning period ends in 1976. Exports in shipbuilding, chemical and electronic industries are expected to rise most rapidly.3/

The Plan emphasizes the up-grading of manpower and the conscious advancement of science and technology. KIST is identified as an element in Korea's planned research and development efforts during the planning period in which "...foreign technology will be adopted on a wider basis so as to increase the technical standards and international competitive power of local industries"4/ The Plan notes that Government R & D programs have been disappointing, universities and colleges have lacked funds for basic research, and private enterprise has done little because of small size and undue dependence upon foreign partners. Among major policy measures announced for this five-year period to improve the technical competitive capability of Korean industry are: tax incentives, increased international technical cooperation, further support of research institutions, and improved industry-education cooperation.

With this background in mind, it would be useful to examine briefly the history of KIST and its expected role in the Korean economy. The idea of KIST grew out of President Park's state visit to the United States in 1965 that led to a follow-up mission to Korea by Dr. Donald F. Hornig, then the President's Science Advisor. The purpose of the latter's mission was to advise on joint steps that could be taken by the two governments in drawing upon available United States science and technology to strengthen the Korean economy. A.I.D. subsequently carried out aspects of a proposed action program developed as a result of Dr. Hornig's mission. The pilot project is a small but

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3/ The Third Five-Year Plan for Economic Development (1972-1976), Government of the Republic of Korea, Seoul, 1971, p. 125.

4/ Ibid., p. 85.

unusual element in this program (i.e., it represents an American contribution of $150,000 plus a Korean outlay of about $200,000 for an 18-month program; KIST's operating budget amounted to $2.8 million in 1970).

KIST was formally established in 1966 by the Korean Government as an element in the national policy for upgrading the application of modern technology by Korean industry. Its role includes identifying appropriate foreign technology and interesting Korean industry in adapting it. KIST undertakes certain R & D activities for client enterprises that lack in-house capabilities. A sizable staff of over 500 professional, technical and scientific personnel are employed by KIST. Thus, the pilot project is only part of KIST's over-all efforts. While the pilot project was to be completed near the end of 1972, links with United States institutions were expected to continue and the United States experience and expertise to be available to provide needed guidance of KIST's efforts with respect to follow-up.

The Pilot Project with KIST

The A.I.D.-financed NASA pilot project provided Korea with some modest technological assistance in its industrialization program. Through the services of the Illinois Institute of Technology Research Institute (IITRI), under contract to NASA, aerospace-related technology was made available to KIST. To date, this project is the only international technology transfer activity undertaken directly by NASA with a developing country through its Technology Utilization Office. This office administers a broad program for making NASA-developed technology available to American firms and various governmental subdivisions. 5/ American

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5/ A separate NASA program, under the Assistant General Counsel of Patent Matters, promotes the licensing of NASA-owned inventions in various foreign countries "....to enhance the economic interest of the United States, and to advance the international relationships of the United States." Licenses are individually negotiated under this program with foreign applicants and cover the usual commercial terms of patent licensing.

firms are usually the intermediary in international transfers of NASA technology (for example, to Japanese firms) under normal commercial licensing arrangements.

The main elements in the pilot project were: (1) identification of problems or problem areas currently limiting growth of Korean industry; (2) training of Korean specialists of KIST to use available NASA services regarding technology utilization; (3) identification of suitable aerospace and related technology to match the identified problem -- drawing on NASA data banks and evaluating information obtained; (4) follow-up visits by Korean specialists to NASA facilities and United States industries where such technology is being utilized; (5) adaptation by KIST of identified technology to meet Korean industrial requirements better; and, (6) decision by Korean industry to apply the technologies in question commercially. A transfer of technology is considered achieved when stage (6) above has been completed.

In practice, KIST identified what it considered to be potentially commercially useful technology for Korean industry and, in turn,bought to bear its resources to produce an adaptation which can be commercialized. So far, KIST has identified all of the "problems" or industrial technological requirements to be examined by the pilot project. However, Korean industry is being encouraged to identify new problems that could be submitted to KIST. It is expected that KIST's experience in servicing Korean industry in this manner will stimulate additional transfers of technology after the completion of the pilot project per se.

To implement the pilot project, KIST identified a number of "problems" that might draw upon available NASA technology. Among these, the following received in-depth follow-up, including in some cases the production of prototypes: (1) miniature transceivers; (2) high sensitivity transceivers; (3) tantalum solid electrolytic capacitors; and, (4) the technology of inductorless circuits. More limited follow-up was given to: (5) the retort pouch (flexible can); (6) survival rations; (7) carbon monoxide elimination; and, (8) explosive metal forming.

In terms of possible commercial application much interest had centered on item (3) -- the tantalum solid electrolytic capacitor. Three Korean manufacturers of electronic components have been contacted by KIST and are interested. However, Korean authorities claim they want to wait until a domestic market estimated at $1 million annually is definitely assured.6/ This cautious approach may also reflect a concern over the eventual competitiveness of the product. At this time, no agreement has been reached for commercial production. The retort pouch (item (5) above) has also been discussed in some depth with prospective Korean commercial interests. KIST has adapted NASA transceiver technology for some military applications and has produced prototypes of possible civilian commercial versions. KIST R & D efforts have not yet produced commercially applicable results in inductorless circuitry. About $100,000 in R & D contract work has been performed by KIST for the Korean government and industry on commercial applications of these technologies. It estimated that, if successful, the resulting increase in industrial sales would amount to about $3 million annually over the next few years. Most of the new output would go to the domestic market to substitute for imported items or for the expanding internal market.

Early in the program, KIST decided to concentrate its efforts in the electronics industry and use this experience for demonstration purposes in other industries. This decision was based in part on the emphasis placed on the electronics industry (together with machinery and shipbuilding) by the Third Five-Year Plan with respect to export expansion possibilities for Korea. Applicable aerospace technology was located in the course of the early period of the program and KIST was of the opinion that the Korean electronics industry was adequately advanced to receive such technology.7/ In view of KIST's emphasis but still limited progress in actual transfers of technology, this report will draw mainly on background relative to the electronics industry in examining the potential impact of possible technology transfers on the United States economy.

6/ KIST memorandum, "Report on Potential Hard Transfer MM-4, Tantalum Solid Electrolytic Capacitors, Yoon and Lee,"

7/ IITRI Semi-Annual Report, June 23, 1971, to December 31, 1971, p. 8.

Transfers of Technology and Trade

A considerable body of literature has appeared on the impact of the transfer of technology on trade, covering theoretical concepts as well as some examination of empirical data.8/ Some of the conclusions, which appear most relevant to this study, are reviewed below.

Most observers agree that the international diffusion of technology has become increasingly more rapid since World War II than before. Thus the time in which monopoly benefits of an innovative advantage can be exploited has been significantly reduced.9/ However, the times required for innovation transfer vary considerably among countries, reflecting largely their relative levels of economic development. (The time factor, in effect, could be considered as a development indicator.) For example, Jack Baranson of the World Bank found in his study of diesel engine manufacturing in India that the transfer of manufacturing capabilities which took less than two years in the case of Japan will take at least 15 years in India.10/ The levels of advanced skills (including engineering, organizational and managerial capabilities)in the various countries are of critical importance with respect to the time required for effective commercial exploitation of new products. IITRI noted that the time scale from prototype to a manufacturing capability is longer in Korea than in more developed countries largely due to skill training requirements.

Some deficiencies in needed skills in developing countries can be filled by foreign personnel, either on a

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8/ See, in particular, items 5 and 8 in the Bibliography.

9/ Raymond Vernon uses a rough estimate that this time factor has been reduced in half since the pre-war period. See "U. S. International Economic Policy in an Interdependent World," Papers Vol. I, p. 941. Item 9 in the Bibliography

10/ Jack Baranson in "Technological Factor in International Trade," edited by Raymond Vernon, National Bureau of Economic Research, New York, 1970, p. 65.

commercial or government technical assistance basis, and thus accelerate transfers. With respect to electronics, American trade union economists claim that the multinational corporations have been the principal instrument for such facilitated transfers, citing examples of subsidiaries and licensing arrangements in Taiwan, Singapore and Hong Kong as important recipients of commercial assistance of this type.

Although times required for innovation are not available for LDC's, the period of adapting an innovation in the electronics industry has been reduced from 3.9 years to 1.2 years in Japan and from 2.6 to 1.6 years in the United Kingdom from 1951-1957 to 1958-1963.11/ Not only are transfers more rapid among developed countries than among the less developed, but as Almarin Phillips noted, in strictly economic terms technology transfer among the developed countries may have greater payoffs to them than transfers between them and the developing countries. He notes that economic and institutional forces mitigate the incentives for new production methods in the developing countries.12/ (This factor, of course, is one which KIST is trying to overcome in Korea).

These differences in innovative times, largely reflected in so-called "technological gaps," have been increasingly scrutinized by economists and government officials in explaining changing trade patterns among countries. This new technological factor has tended to modify the generally accepted comparative advantage concept in trade theory that assumed non-differentiated inputs of land, labor and capital in the production of countries. The technological factor helps to explain which among their products countries are best endowed and thus would export; or, conversely, least endowed, and import. The relative advantages of countries in the technological factor have been variously described in terms of a combination of the education, skills and

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11/ John Tilton, in National Academy of Engineering (NAE) Symposium, (Bibliography item 5), p. 13.

12/ Ibid., p. 85.

experience of the working population, R & D inputs, innovative attitudes and organizational and managerial capabilities. Nearly all develped countries and increasingly the developing countries have been focusing attention on this factor. 13/ In the Korean Five-Year Plan, as noted above, policy for science and technology and KIST's role therein were discussed largely in the context of the possible trade implications.

Raymond Vernon's product cycle theory could help explain the probable pattern of international technological transfers under this pilot project. The early monoply advantages in international trade to the innovative country (the United States in this case) have been largely realized for the types of technology involved. Imitators in Japanese and Western European electronic industries have entered the world market for these or similar products. United States firms have established subsidiaries or developed licensing arrangements with foreign producers to supply foreign markets as well as the domestic United States market with electronic products of this technological sophistication taking advantage of the relatively low wages and marketing opportunities abroad. The diffusion of technology in electronics has widened and extended to developing countries, notably Hong Kong, Taiwan, Singapore, Mexico and Korea. As a result, the comparative advantage enjoyed at one time by the United States and other developed countries for certain electronic components and products is passing down the line to newly developing countries. As this takes place, further innovation in this rapidly changing

13/ For example, the Organization for Economic Cooperation and Development (OECD) has devoted considerable attention to the technological gap and its activities in the science and related educational fields have dealt with various aspects of this subject, primarily from the viewpoint of the developed countries. The United Nations Institute for Training and Research (UNITAR) and the United Nations Conference on Trade and Development (UNCTAD) have considered aspects of the subject with respect to interests of the LDC's.

industry is introduced in the United States and other developed countries. The product cycle process begins all over again for the new products -- only, the time within which it is taking place is constantly shortening.

For Korea, Japan is likely to continue to be the st important intermediary in the transfer of technology, as well as the most immediate target for prodding in the competitive world market. According to a recent UNITAR study 14/ on the role of Japan in technology transfers to the developing countries, Japan's competitive trade position has declined for cotton textiles, tableware, wigs and leather products, as production know-how was acquired by various developing countries for these products. While not cited in the report, it has been evident that the Japanese trade position for electronic components and products are being similarly affected by LDC competition. This "chasing-up" effect of competition from the developing countries has encouraged Japan to move into more advanced technologies much in the same way that Japanese competition affected the United States and Western Europe.

Despite the entry of important Japanese and Western European competition, the United States has maintained technological leadership in the electronics industry throughout the post-World War II period, according to an OECD study on the technological gap.15/ American inventions revolutionized the industry -- first with the transistor in 1947 and subsequently with integrated circuits in 1960. The United States industry has been heavily oriented toward a large domestic market which served as its base for profitable expansion into an important export market. America's competitive position has been preeminent in the so-called "active" components industry that comprises transistors

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14/ "Japanese Role in the Transfer of Technology to Developing Countries," United Nations Institute for Training and Research, Research Report 7, United Nations, New York, 1971, pp. 25 ff.

15/ Gaps in Technology -- Electronic Components, part of a series of studies by the Organization for Economic Cooperation and Development, Paris, 1968.

and integrated circuits. Japanese production has been relatively more important for the "passive" components such as capacitors, resistors and relays. According to the OECD study cited above, American exports of active components led those of Japan by $109 million to $20 million in 1966; in the same year Japanese exported $123 million in passive components to $85 million for the United States.

If the Japanese pattern is followed, it is probable that Korean capabilities that will be most affected by the pilot project are in the passive group of components and in the production of electronics communications equipment such as transceivers. Increased Korean commercial capability in this sector would impinge more on Japanese markets (and possibly those of Hong Kong, Taiwan, etc.) in the United States and elsewhere rather than serve as a direct displacement of American output. Indirectly, the push of new entrants such as Korea into the world market for electronics will affect all the other producers that had heretofore enjoyed a technological advantage. The immediate impact might benefit the trade balance for the United States vis-a-vis Japan, since Korean trade would reduce Japanese dollar earnings. As a result of the pilot project's technology transfers, some displacement by the United States of Japanese capital equipment exports as well as components to Korea may also occur. In the long run, however, the impact of the Korean industry's entry as a possible supplier in markets for higher technology electronic components may be offset by the continued innovative leadership of the United States, Japan and other developed countries until Korea's stage of development is far enough advanced to sustain an innovative, rather than an imitative, industry. At that time, Korea will have reached the economic development status of a developed country.

Although most trade economists agree that an unimpeded international flow of technology is generally beneficial in the long run to all participants in a largely self-regulating international economic system, a number of industry and particularly trade union authorities have questioned this view. Besides challenging the assertion that the

system is self-regulating by pointing to the substantial portion of trade subject to national restrictions (particularly a wide range of non-tariff barriers, as well as foreign exchange controls), they note that assurances with respect to the long run do not provide much comfort to relatively immobile workers faced with serious hardships in those industries affected by foreign competition. These critics claim that the rapid transfer of technology unduly increases the competitive advantage of foreign countries with considerably lower wage standards than those of the United States. The concern of labor in affected industries, as noted earlier in this report, relates mostly to the transfers involving the multinational corporations. In particular, the latter's production and assembly plants for electronic consumer products (e.g., radios, television sets, etc.) in Taiwan, Hong Kong, Singapore, Mexico and Korea have been critized. Views of industry spokesmen are mixed, depending largely on the international production and marketing positions of their particular companies.

Korean Trade Patterns

Korean interest in improved technology is closely geared to planning goals that call for a marked improvement in trade balances which have been consistently in deficit. Since 1968, the Korean trade deficit has been running in excess of $1 billion annually. Although there has been some improvement in Korea's trade balances in the last few years, imports were still slightly more than twice the level of exports in 1971. Korea's major imports are food and raw materials; while her current exports are mainly in plywood, cotton fabrics, silk, and fish products. The United States has been Korea's principal customer, taking roughly 50 per cent of her exports in 1971. Japan, as Korea's principal supplier, provided over 40 per cent of the latter's imports the same year.

Korea's Principal Trading Partners

	1970	1971	1972 (4 months)
	(Millions of dollars)		
Exports to:			
United States	395	532	188
Japan	234	262	98
Hong Kong	28	42	17
Vietnam	13	15	4
Imports from:			
United States	585	678	205
Japan	809	954	266
Hong Kong	20	20	9
West Germany	67	74	25
Total Commodity Trade (including the above, as well as other trading partners):			
Exports:	835	1,068	392
Imports:	1,984	2,394	714
Trade Balance:	-1,149	-1,326	-322

Source: A.I.D. Data Book, Office of Statistics and Reports, Agency for International Development

Korean trade policy reflected in the Third Five-Year Plan calls for import restraint and a greater diversification of exports with respect to markets and products. (In 1971, for example, a substantial amount of textile exports were reportedly diverted away from the United States, which had applied increased restrictions, to Europe and elsewhere.) The plan emphasizes an expansion of manufactures which are expected to rise from 84 to 90 per cent of total exports. Chemicals, electronic components, shipbuilding and machinery industries are identified as the main contributors to this planned export expansion.

Korean Plans for Electronics Exports and Possible Impact on United States Industry

As part of the Economic Development Plan, Korean exports of electronic components are expected to grow at an annual rate of 39.4 per cent during the five-year period to reach a level of $452 million in 1976 which will then represent 12.2 per cent of total exports.16/ Electronic exports amounted to $55 million in 1970 and accounted for 51.8 per cent of the Korean electronics industry's output. By 1976, exports will represent 71 per cent of the industry's production.17/ Thus the rapid growth of the electronics industry will be heavily oriented to export expansion. Domestic demand is also to be encouraged through tax incentives in order to help make the industry more competitive internationally.

As an additional stimulus to exports, the industry is expected to widen its production capability -- presumably, developing a self-sufficiency in complete production (as opposed to assembling imported components). For example, mention is made in the plan of the development of complete production during the planning period of eight household appliances (including radio and TV sets) and 16 industrial items (including calculating machines). There is also reference in the plan to the development of 41 major components, including integrated circuits and transistors. Contrary to the pattern of other developing countries, cited above, Korea apparently is attempting to move into the production of active as well as passive electronic components. Other aspects of the plan for electronic export promotion include the stockpiling of raw materials, standardization and quality control and inducements for foreign capital and technology. A significant portion of KIST's resources are devoted to these export objectives. However,

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16/ The Third Five-Year Economic Plan (1972-1976), Government of Korea, Seoul, 1971, p. 24.

17/ Ibid., p. 56.

it is difficult to assess the importance of KIST's help in the overall export expansion efforts in the industry and the role of the pilot project in KIST's contribution.

Information on the specific Korean import requirements for the expansion of the electronics industry is not available. The categories of "Capital Goods" and "Raw Materials for Exports" are emphasized in the Korean import plans for the five-year period as contrasted with imports intended for domestic use. The sources for such imports and the commodity composition are not provided. If present patterns were employed to derive a rough estimate, imports from the United States would amount to about $1.1 billion, or approximately 28 per cent of the $4 billion total level of imports estimated for 1976 by the plan. The categories of "Capital Goods" would amount to 27 percent and "Raw Materials for Exports" would represent 33 percent of total imports in the plan. Information is not available on the proportions of the latter two categories that would be destined for the expanded electronics industry.

In view of the announced plans of the Korean authorities to diversify the output of their electronics industry and the foreign markets for its exports, along with other factors not related to this study that would affect trade patterns, it is not possible to project with any degree of precision the likely impact of Korean electronics exports on the United States industry. Taking what would probably be the most extreme possible general impact on the American market, the application of current Korean export flows would result in a United States import level of $225 million for electronic components and products in 1976. To determine the net impact, an unknown amount should be deducted from this level for the probable displacement of Japanese and other imports into the United States as well as possible resulting increases in American exports of capital equipment and component parts to Korea.

This maximum possible level of imports into the United States would appear to be relatively small against a

domestic output for electronics and related equipment that amounted to about $28 billion in 1971 and that is projected by the Commerce Department to reach about $37 billion in 1975.18/ Imports into the United States for electronic products amounted to about $2.1 billion and exports were roughly $2.7 billion in 1971. Comparable estimates are not provided for imports and exports in the Commerce Department projections for 1975. However, the following output estimates for the leading import and export sectors, respectively, could reflect trade trends. Domestic output of consumer electronic products is expected to decline to $3.7 billion in 1975 or almost 7 percent below the 1971 level and electronic computer output is expected to rise to $7.2 billion in 1975 or about 48 percent above the 1971 level. For 1971, United States imports in electronics were concentrated in the consumer products categories (about 75 percent of the total imports for the industry) and exports were concentrated in electronic computers (about 85 percent of the total electronic exports). In summary, trade patterns for electronic products will probably continue this marked trend during the period ahead with the United States industry's strength greatest in electronic computers and least in consumer products. In view of the magnitudes involved, the over-all Korean impact is not likely to be significant.

Although available data and information on planning targets cannot indicate the possible impact on specific sectors of the American electronics industry if technology transfers are eventually realized in connection with the pilot project, trade patterns for these sectors over the long run could be affected in varying degrees in the following ways: (1) the possible increased exports into the United States could displace or reduce the share of the domestic market served by American manufacturers, particularly if KIST's R & D efforts gave Korea a clear, technological advantage in trade for certain components (e.g., tantalum electrolytic capacitors, inductorless circuits, etc.); (2) similarly, possible Korean exports could cut into third markets formerly supplied by the American industry; and, (3) Korean exports could displace other

18/ Based on data in the U.S. Industrial Outlook 1972, Bureau of Domestic Commerce, Department of Commerce, Washington, D. C., 1972. Data for Electronic Computing Equipment (SIC 3573) were combined with that for Electronic Equipment and Components (SIC 3651, 3652, 3661, 3662, and 3671).

country suppliers (e.g., Japan, Taiwan, Hong Kong, Singapore, etc.) of the United States market and third country markets without a significant direct impact on the American industry. The overall impact on the industry would, of course, be muted by the displacement of other foreign competitors (3, above) and by possible resulting increases in United States exports of electronic equipment and components and earnings from licensing fees.

The significance of the possible impact of the technological transfers in question would also depend to a considerable degree on the competitive nature of the American electronics industry. This industry has been characterized as being one of the most innovative in the American economy. It is generally recognized that United States defense and space related R & D and procurement have been of major, if not critical, importance in the international technological preeminence of the industry. Besides the production experience in large Government procurement programs (representing about 45 percent of sales in 1971), much of the resultant technology found ready application in commercial markets -- notably in civil avaition, electronic computers, communications equipment, radio, television, and high fidelity sound reproduction. The industry with its advanced technological capability has directed its attention to the sizeable and rapidly expanding commercial market in the United States and abroad. As noted above, imports in recent years have been heaviest in the relatively less sophisticated consumer products while exports have been predominantly in the more complicated electronic computers.

Despite the past favorable competitive position of the American industry, particularly in its technologically advanced sectors, concerns have been expressed by American labor spokesmen over the employment impact of foreign competition. They note that imports tend to be concentrated in labor intensive products (such as consumer items -- notably radio and TV receivers) manufactured often in relatively isolated areas where alternative economic opportunities for workers are limited. These current

plant locations frequently reflect earlier moves from large urban centers by a competitive industry in search of lower labor costs. Trade union observers also believe that the competitive advantage of the United States is eroding rapidly by accelerated technology transfers in the more advanced sectors of the industry, particularly as a result of the expanding operations of multinational corporations.

To a considerable extent, recent declining employment trends in the industry can be attributed to the cyclical economic decline that affected United States employment generally. Total employment in the industry dropped from a peak of 1,253,700 in 1969 to 1,078,700 in 1971. Some of these employment losses are due to import competition as well as further mechanization of output of consumer items such as TV receivers in an effort to overcome labor cost advantages of foreign competitors. However, industry spokesmen expect employment to grow steadily with the resumption of economic expansion, especially for repair and maintenance personnel needed for complex electronic equipment and for engineers and scientists working on R & D. 19/ The net impact on employment of foreign trade is difficult to assess from available employment statistics. Apparently the loss of employment for consumer products has been only partially offset by increased employment in higher technology products in recent years.

The following table points up some employment problem areas in the American electronics industry:

19/ "Electronics Market Data Book 1972", Electronics Industries Association, Washington, D. C. 1972 pp. 95 ff.

Estimated United States Employment in Electronics-Related Industries, 1967-1971

(thousands of employees)

	1967	1969	1971	Percent change 1969 - 1971
Radio & TV Receivers (SIC 365)*	156.3	154.6	135.9	-12.0
Communications Equipment (SIC 366)	510.9	525.1	440.1	-16.2
Electronic Components & Accessories (SIC 367)	384.9	410.1	332.6	-18.9
Electronic Computing Machines (SIC 3573)	na	163.9	170.1	+ 3.8
** Total	1,052.1	1,253.7	1,078.7	-13.9

Source: Estimates based on data from U.S. Department of Labor in Electronics Market Data Book 1972, p. 95.

* Standard Industrial Classification categories employed in U. S. industrial statistics.

** Excluded from total are estimates for SIC codes 3611, 3622, 3643, 3693, 3699, 3811, 3821, 3822, and 3931 since these contain major non-electronic product categories.

During the recent cyclical peak year of 1969 for the electronics industry as a whole, employment in "radio and television receivers" had dropped somewhat from 1967 levels -- contrary to trends for all other branches for which data were available. As noted above, in addition to direct displacement by foreign competition in this sector, technological improvements in mass production methods designed to help meet foreign competition, have also contributed to lower employment requirements. Industry spokesmen claim that moving some production processes overseas has enabled American plants, which otherwise would be obliged to close completely because of foreign competition, to continue some operations. Employment for the entire industry was affected by the general economic recession in the period from 1969 to 1971 during which the average employment drop amounted to about 14 per cent. Employment for the other-

wise rapidly expanding electronic computer industry was also affected by this factor, showing only a modest increase of less than 4 percent over this period, and also to major consolidations in the industry in 1971 -- notably with RCA dropping out of electronic computer production. This sector of the industry had reached an employment peak of 190,000 workers in 1970 (not shown in the table).

Bureau of Labor Statistics employment data through September 1972 largely reflect recovery expectations. Small increases in employment, averaging about 4 percent, were recorded for radio and receivers (SIC 365) over comparable months in 1971. Employment for communications equipment (SIC 366) was still slightly below 1971 levels through September 1972. Employment for electronics components (SIC 367) had risen to about 7 percent above depressed 1971 levels in September. Electronic computers (SIC 3573) employment apparently reached a trough in May of 1972 and was at about 1971 levels by September.

While there is no assurance that these production and employment trends will continue over the next five years for these categories of industries, it seems very unlikely that the transfers of technology envisaged under the pilot project would have a significant impact on United States markets and employment in the industry as a whole. The still modest position of Korea in world electronics trade patterns at the end of the five-year period (assuming planning targets are met) would limit the impact even if, as seems improbable, the pilot project transfers were to make a major contribution to Korean electronic exports during this relatively short period.

For one thing, as noted above, the process of innovation in a developing country tends to move at a slower pace than in the developed countries. Relatively slow progress in the commercial adaptation of KIST-developed technology by Korean industry to date bears this out. Furthermore, if Korean industry follows the patterns of other countries which have become producers of electronic components, initial production costs will be high until experience is developed.

As a relatively late imitator, Korea might benefit to some extent from the experience of the United States, Japan and other producer countries. However, not all such experience is transferable. During similar periods in the learning process of other countries, a minimum level of a domestic market for output had to be assured to help cover learning costs. Government procurement advantages and various protectionist devices have been employed to provide such a base. As experience develops, lower costs enable the imitator to enter the world market profitably. 20/

In the case of one of the most hopeful of potential transfers of NASA-developed technology, the tantalum electrolytic capacitor, KIST reports that an assured domestic market remains a prequisite before firms will agree to move into production. Since the learning process is still ahead for the Korean firms that are likely to draw upon this and possibly other NASA-originated technology, there is little prospect that the pilot project transfers will result in significant inroads into the United States industry's domestic or third country markets in the period of the five-year plan. Nonetheless, KIST and the pilot project are likely to have a positive impact on the electronics industry and possibly Korean industry generally beyond the relatively short five-year period. For a longer range time framework, KIST's major contribution could very well be the stimulation of an innovative climate in Korean industry and thus help the country move more rapidly into the developed country category.

Beyond the five-year period covered by this study, possible transfers of technology envisaged under the pilot project could affect some individual United States firms.

20/ John E. Tilton, "International Diffusion of Technology: The Case of Semiconductors," Brookings Institution, Washington, D. C., 1971, pp. 38 ff.

This would be the case in situations where American enterprises are specializing in a few products and do not have the capability of diversifying their output or are generally not innovative. Such firms would also be affected by more innovative domestic competitors as well as by other foreign competition. It is beyond the scope of this paper to examine possible remedies for such firms and for workers who would be affected by possible foreign competition due to transfers of technology or other causes. 21/ An examination of one or more specific cases of the most promising prospective transfers (e.g., the tantalum electrolytic capacitor when its status is clearer) might help to determine the impact on American firms producing the same product. The characteristics of the particular firms affected and their respective labor forces would provide some additional insight into the possible impact and reactions in shared markets in which the Korean firms might compete. Among other factors, the likely process of adjustment and probable reactions of other foreign participants in the same markets would also be examined.

Despite the lack of evidence of possible injury to United States industry that would result from transfers envisaged under the pilot project, it is useful to consider briefly possible alternative sources open to KIST and the Korean industry for the same or similar technology. Much of the NASA technology in question could be obtained by them directly from NASA or through American firms under technical assistance and/or licensing arrangements. This would change little from the pilot project approach except for the promotional role of IITRI in ferreting out appropriate technology. In either case, KIST could provide needed R & D, if deemed desirable.

21/ Interested readers are referred to trade policy litature dealing with adjustment assistance and in particular to relevant sections of, "United States International Economic Policy in an Interdependent World," papers and report of the President's Commission on International Trade and Investment Policy, Washington, D. C. (GPO), July 1971.

The economic effects would not be much different except for fees to the private sector for services provided by the pilot project.

Alternatively, and what is more likely, the Korean industry would continue to look to Japan as the primary source for new technology and to Japanese industry for commercial relations. Japan now provides Korean industry with a substantial amount of technology as reflected by its relatively large share of total Korean royalty payments under licensing and technical assistance arrangements. According to information supplied by the American Embassy in Seoul, such payments to Japan amounted to $1,649,300 or over 60 per cent of total royalty remittance of $2,677,400 in 1971. Remittances to the United States amounted to $969,900 or slightly more than half of the Japanese level. Of the 285 technical assistance and licensing agreements entered into since 1962, Japan account for 199 and the United States for 64. Electronics and electrical equipment technical assistance agreements represent 61 of the total 285; the related communications field accounts for an additional 18 agreements. Japanese sources predominate among the licensors. Japan, of course, has important geographical advantages and its industry has generally developed more effective business relations in Korea -- particularly in servicing the market -- than have American firms. Under this likely alternative, possible follow-on sales of equipment and royalty fees, of course, would go to Japan instead of the United States.

Conclusions

Inasmuch as transfers of NASA-developed technology under the A.I.D. pilot project have not yet had much discernable impact on the Korean industry, this study drew mainly on the plans of the Republic of Korea with respect to the electronics industry in order to place in perspective the possible effects of the envisaged transfers on the United States economy. With this

important limitation in mind, the study concludes that the possible transfers of technology under the project could have only a marginal effect on the United States market and employment for electronics and related industries. This conclusion is borne out even when employing optimistic assumptions that the ambitious export plans for the electronics industry in the Third Five-Year Plan (1972-1976) would be achieved and implicitly that technology transfers under the pilot project would help significantly in reaching these goals within this relatively brief time period.

Most likely, any important new inroads into world and American markets for electronic products by Korea would be made mainly at the expense of Japan and other exporting countries. As experience with various developing countries exporting electronic products (e.g., Hong Kong, Taiwan, Singapore, as well as Korea) has already shown, Japan and other exporting countries will probably respond competitively by moving toward increased production and export of products requiring relatively more advanced technology. In turn, the United States, which has maintained technological leadership in the industry throughout the post-World Was II period, will be subjected to similar competitive pressure.

With respect to the time required to adapt new technologies commercially, it was noted that technology transfers -- even of less-sophisticated technology than those envisaged in the pilot project -- have historically taken longer in the developing than in the developed countries. The learning process for successfully commercializing results of such transfers is relatively more difficult in the developing countries because they lack adequately trained technical and managerial personnel, R & D facilities, and production and marketing experience. While foreign technical assistance and probably more importantly, foreign direct investment can help to shorten the time, it still remains very significant.

Although the general impact of the planned expansion of Korean electronics exports if achieved would not be significant for the United States industry as a whole, it is possible that for certain labor-intensive products some less-innovative and highly specialized American firms might be affected. Workers in these firms, particularly in relatively isolated areas where alternative employment opportunities are not readily available, would also be affected. Such firms and their workers are also likely to be or have been affected by relatively more dynamic domestic competitors as well as by other foreign imports. When the specific products that might be marketed as a result of the technological transfers under the pilot project are known, a case study approach could provide some useful information on the possible impact on American firms and workers that might be affected.

The report noted that the NASA-developed technology provided under the A.I.D. pilot project could also be obtained by KIST and the Korean industry directly or through the intermediary of American firms. The same or similar technology could also be obtained from other countries and particularly from Japan, which has been the major source for Korean technology imports under commercial technical assistance and licensing arrangements. If such an alternative were employed by Korea, the United States would be less likely to obtain possible follow-on capital equipment orders and possibly other advantageous commercial relations in Korea.

No attempt was made in the study to appraise the possible general impact of KIST's activities, including the pilot project's technology transfers, in stimulating the relatively conservative Korean industry into a dynamic and innovative pattern. This possible long-range impact is, of course, beyond the time framework of this study and, if realized, would help place Korea in the category of developed countries.

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(Note: Papers submitted by Nathaniel Goldfinger, James C. Abegglen and Raymond Vernon, and Chapter 11 of the Report, "Assisting the Developing Countries Through Trade and Investment," are particularly relevant to this study.)