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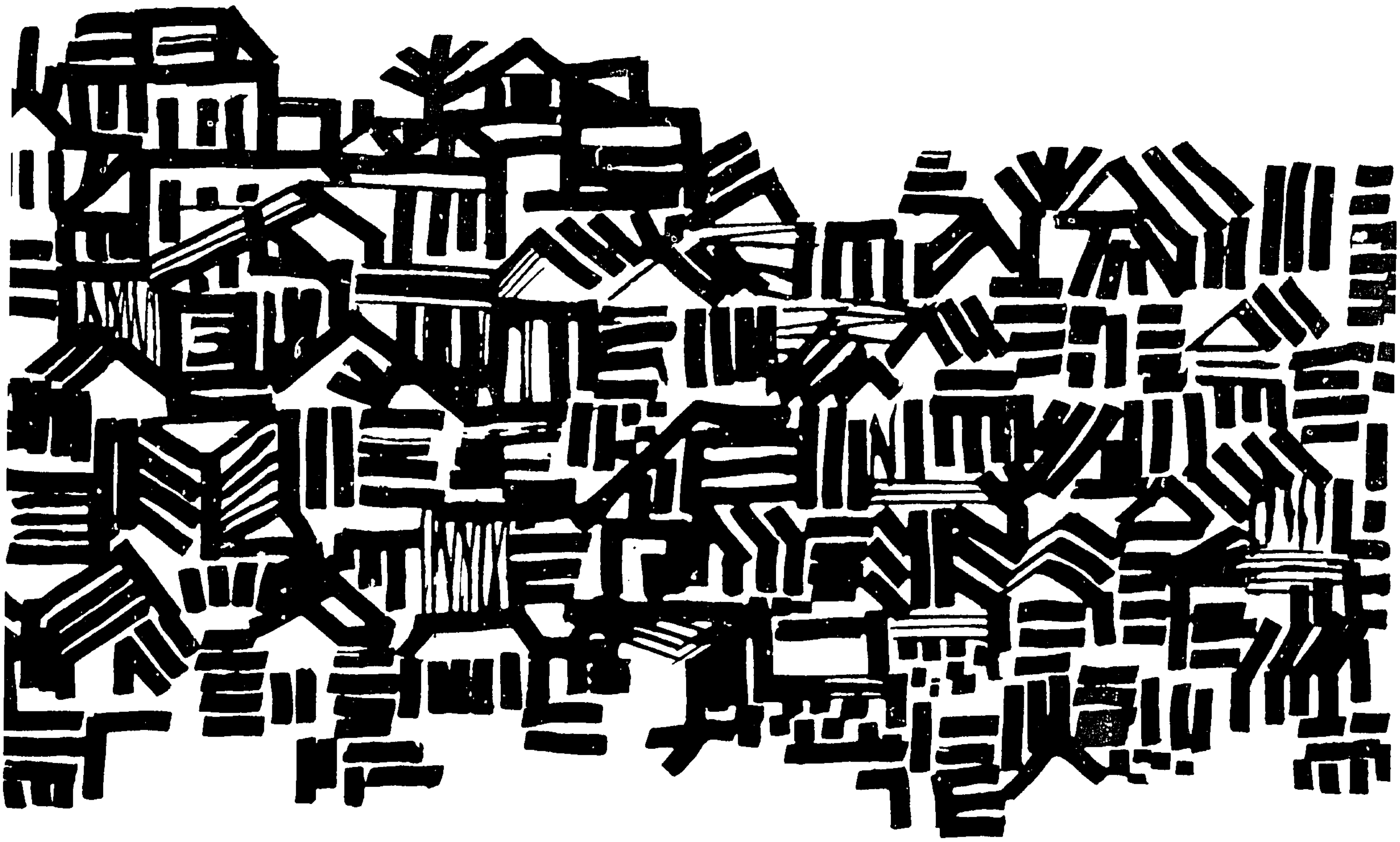

GRADUATE SCHOOL OF BUSINESS ADMINISTRATION • UNIVERSITY OF CALIFORNIA, LOS ANGELES

REPORT ON PRODUCTIVITY IN RELATION TO HOUSING CONDITIONS AND COMMUNITY FACILITIES IN HAMBAEK, KOREA

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PREFACE

This report, the first in a series of case studies constituting one phase of the International Housing Productivity Study, describes the social and economic benefits of rehousing mine workers in Hambaek, Korea. The study seeks to articulate an economic framework for analyzing the position of housing in development programs.

The Hambaek site was identified with the assistance of Agency for International Development personnel in Korea. Mr. Frank M. Landers and Mr. Pil Kyoon Kim of the USAID Mission in Korea were particularly helpful in this respect and assisted the author materially during his visit to Seoul and Hambaek during June 1965. Others in Korea who supplied valuable information for the study were Mr. Sang Yong Ha, Governor of the Dae Han Coal Corporation, Mr. Hyun K. Kim and Mr. Joo H. Kim and Mr. Seung M. Yang and other staff members of the Corporation, and Mr. Sang Ho Lee, manager of the Research Department, Bank of Korea. The data were processed by the Western Data Processing Center, UCLA. Drafts of the report were reviewed by Leland S. Burns, Marvin Hoffenberg, Frank G. Mittelbach, and E. H. Mulder. Roberta Campbell, Joyce Chamberlain and Ronald McDaniel provided valuable research assistance. Miss Jill Nichols typed the final report. The author is grateful to these persons and institutions, but naturally accepts responsibility for the accuracy of the analysis and results.

-B. Khing Tjioe
July 1966

1. RESUME

This report consists of estimates and an analysis of the benefits of qualitatively superior housing and community facilities based on experiences covering a recent three-year period in Hambaek, Korea. Benefits, measured in monetary units, are allocated among the "community-at-large," the sponsor-employer, and the rehoused employees.

Two major questions are addressed. First, does housing favorably affect the labor productivity and health of persons rehoused? Second, if so, how large are the effects?

Evidence supporting a positive answer to the first question is abundant and clear. Health and labor productivity improve with improved housing -- and the conclusion is statistically significant at a high level of confidence. The following results emerge:

1. After an initial adjustment period of roughly one year's duration, output per rehoused worker increased to a new level 31 percent higher than prior to rehousing.

2. Because occupancy priorities were based on productivity, the productivity of persons not rehoused also increased. This has been termed the "demonstration effect" and accounted for an average productivity increase of about 27 percent per worker.

3. Savings in medical costs for the rehoused were substantial with expenditures for this purpose declining an effective 67 percent per capita after relocation in the housing project.

4. These, plus other benefits to the corporation and community-at-large, totaled to an impressive sum. The investor netted a return of approximately 16 percent on total capital invested in the housing project and the returns to the community-at-large were slightly higher. The rate of return compared favorably with that of alternative investments in Korea.

Based on this tentative evidence, the investment in improved housing was favorable indeed. The returns promoted economic growth of this developing region, improved the profit position of the sponsor-employer, and raised the living standards of the rehoused workers.

2. INTRODUCTION

This report consists of estimates and an analysis of the benefits which may be ascribed to improved housing in a developing area of Southeast Asia. It represents one of the first attempts at such estimation and, to the best of our knowledge, the only effort undertaken in a less developed country.[1]

One approaches such research somewhat patronizingly, it has been stated,[2] because the favorable effects of better housing are intuitively apparent. Yet, the task of isolating the effects of housing, as separate from other changes in the home or work environment, is challenging and full of booby-traps. In a concrete, real-life situation such as the one we have chosen where estimates are based on historical evidence and on circumstances which are substantially less favorable than laboratory conditions, we are faced with the formidable chore of proving that the benefits spring from housing, and housing alone.

The task takes on added importance when the results seem unduly favorable. Our estimates of benefits tally to an impressive figure which, when related to costs, show that housing investment is highly productive, even in comparison with the "gilt-edged" projects customarily heading the priority lists of development programs.

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[1] For studies dealing with the economic benefits of housing for displaced slum dwellers in the U.S., see David A. Page, "Urban Renewal," a paper presented to the Bureau of the Budget, August 10, 1965, processed; and Jerome Rothenberg, "Urban Renewal Programs", in Robert Dorfman (ed.), Measuring Benefits of Government Investments (Washington, D. C.: The Brookings Institution, 1965); plus the work on which this report builds, Leland S. Burns and others, Report on a Pilot Study of Worker Productivity in Relation to Housing Conditions (Los Angeles: International Housing Productivity Study, University of California, 1965), processed.

[2] Alvin L. Schorr, Slums and Social Insecurity, Research Report No. 1, Division of Research and Statistics, Social Security Administration, U. S. Department of Health, Education, and Welfare (Washington, D. C.: U. S. Government Printing Office, 1963), p. 7.

These startling results double our anxiety when contrasted with other estimates which, as we have pointed out elsewhere,[3] show that the traditional measures, based on a narrow definition of output, place housing at or near the bottom of any list of investment projects. The estimates developed here, if reliable, advance housing many rungs up the priority ladder.

2.1. Some Caveats

Our results would offer substantial comfort for those dedicated to the cause of improved housing if the conditions of ceteris paribus were satisfied with certitude rather than simply assumed. We too would be more assured if we were fully convinced by the information obtained that housing was solely responsible for the substantial benefits we have traced in economic efficiency (or, less technically, in national income).

In order to test the ceteris paribus assumption, we shall first track down each conceivable influence on productivity other than housing and separately assessing its importance. As examples: Was it the reduction in overtime work rather than qualitative improvement in housing which accounted for increases in output? Did other investments, concurrently placed, increase labor's efficiency? Have changes in wage policy influenced production? These questions are addressed in Section 2. Our second test, to find statistical evidence that the ceteris paribus assumption is valid, is reported in Section 4.

As a corollary, a caveat on the quality and availability of data is also in order. Seldom, if ever, does the supply of data meet the demands of

[3] Leo H. Klaassen and Leland S. Burns, "The Position of Housing in National Economic and Social Policy," in James Gillies and Walter Harris (eds.), Capital Formation for Housing in Latin America (Washington, D. C.: Pan American Union, 1963); and Leo Grebler, "Housing and Community Facilities as Factors in Human Development," in "Social Problems of Development and Urbanization," Volume VII of Science, Technology, and Development, United States Papers Prepared for the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas (Washington, D. C.: U. S. Government Printing Office, 1962).

empirical research; the Hambaek case was no exception. Little hard information was available on the quality or type of investment in the coal mine, for example. While we have data on the division of investment between plant and equipment for a few years, we know pitifully little more about the nature of this investment. Was capital invested in equipment only for replacement of depreciated assets? If so, were the replacements technologically advanced? If not, did new capital displace labor?

At this juncture in our research, answers often must be based on reasonable assumptions. More positive statistical evidence would do much to resolve our present uncertainty. Hopefully, many of the facilitating assumptions in the beginning of the report could then be relaxed.

Secondly, the data supplied were not always in the form most amenable to our purposes. For example, the ideal measure of productivity would be stated in units of output per man. Because the miners performed a series of tasks related to digging and mined under diverse conditions, a standard unit of physical output was not available. The only common denominator homogenizing the various operations and outputs was wages. Consequently, earnings in constant won had to serve as a proxy for productivity. Moreover, because miners worked in teams, the average for the team, rather than for the individual, is the measure of productivity.

These difficulties -- and the unpleasant necessity for caveats -- will become more apparent as we describe the Hambaek Housing Project and mine, and proceed in subsequent sections to develop estimates of the benefits afforded by the project to relocated miners. Throughout this analysis, the generic term "productivity" will embrace all types of relevant outputs -- labor productivity, rents, budget savings in medical and health expenditures, or other real income increases -- traceable to a given investment. The adjective "relevant" will identify any effect identified exclusively with the housing project under consideration. "Relevant output," "relevant returns", "relevant earnings", or "relevant benefits," each refer to the net values of output, returns, earnings, or benefits attributable to the investment in qualitatively improved housing and community facilities.

Section 4 consists of a description of the process of estimating the impact of improved housing and community facilities on productivity for the short run and over the longer run. The relation between housing and health conditions is addressed in Section 5. In Section 6, the benefits in terms of productivity and health are recalculated in money terms and compared with other investment opportunities in Korea.

2.2. The Hambaek Coal Mine

The Hambaek Coal Mine, situated in the Taebek mountains of South Korea, is one of several mines owned by the South Korean Government and administered by the Dae Han Coal Corporation. The Corporation was established November 1, 1950, in accordance with the D. H. C. C. Organization Law wnich took over former Japanese coal interests in order to merge all coal industry development programs. The Hambaek Mine was opened prior to the Korean War, closed during the War, and reopened in July 1955 by the Dae Han Corporation.

Except for a negligible amount of employment in other industries, the mine constitutes the economic base of the rural village of Hambaek and, as such, is vital to the economic and social welfare of the region. Over 90 percent of the 1,400 employees at the mine are production workers. With an average family size of six persons, it is apparent that Hambaek's population of roughly 8,500 is primarily dependent for its livelihood on the mining operation (Table 1).

Without the mine, it is likely that there would be heavy migration to urban areas or substantial disguised unemployment in agriculture.[4]

TABLE 1. EMPLOYMENT, HAMBAEK MINE, 1963 AND 1964[a]

Year	Production Workers			Administrative Personnel	Grand Total
	Miners	Others	Total		
1963	1,151	148	1,299	125	1,424
1964	1,119	170	1,289	137	1,426

Source: Dae Han Coal Corporation

[a]Annual figures derived from monthly averages.

Anthracite reserves of the mine are currently estimated at about 30 million tons. Annual production of the past decade has averaged about 225,000 tons; however, current production is running at roughly 400,000 tons per annum (Table 2). At this level, existing reserves will last for approximately 75 years.

Increasing output and unit prices are responsible for the growth in the value of coal production over the past decade. The sharp increase in production during 1963 and 1964, compared to earlier years, is due mainly to overtime work necessitated by increased demand for coal. With a decline in demand during 1965, both the volume of production and the total number of hours worked decreased.

The pattern of net investment is less regular with fluctuations which fail to relate in any systematic fashion with changes in production. In constant

[4]Yong Sam Cho, Disguised Unemployment in Underdeveloped Areas (Berkeley and Los Angeles: University of California Press, 1963), with special reference to the chapter, "South Korean Agriculture".

TABLE 2. ANNUAL PRODUCTION, HAMBAEK MINE, 1955-1965

Year	Production (in tons)	Value of Production (in 1,000 won)	Average Price per Ton (in won)
1955[a]	33,978	17,329	510
1957	67,866	52,935	780
1958	75,307	58,739	780
1959	180,707	140,951	780
1960	155,611	121,376	780
1961	220,905	201,301	900
1962	279,463	276,701	985
1963	424,026	428,266	1,010
1964	436,362	474,652	1,087
1965[b]	372,268	503,679	1,353

Source: Dae Han Coal Corporation

[a]Adjusted to annual figures from 18 month data.
[b]Adjusted to annual figures from data for first nine months.

TABLE 3. ANNUAL NET INVESTMENT, HAMBAEK MINE, 1955-1965
(in thousands of won)

Year	Plant (current)	Equipment (current)	Total	
			(current)	(constant)[a]
1955[b]	n.a.	n.a.	39,123	86,266
1957	n.a.	n.a.	50,568	68,621
1958	n.a.	n.a.	39,019	54,236
1959	n.a.	n.a.	85,665	107,253
1960	n.a.	n.a.	38,217	43,529
1961	n.a.	n.a.	67,884	74,537
1962	n.a.	n.a.	83,036	90,675
1963	n.a.	n.a.	99,838[c]	99,838
1964	27,053	37,039	64,092	51,145
1965[d]	26,671	28,793	41,597	n.a.

Source: Current data from Dae Han Coal Corporation; deflater from The Bank of Korea, Monthly Statistical Review, November 1962, p. 39, and April 1965, p. 39.

[a]Current data deflated by index of wholesale prices for machinery (1963 = 100).
[b]Adjusted to annual figures from 18 month data.
[c]Excludes investment in housing project of 108.2 million won.
[d]Adjusted to annual figures from data for first nine months.

money units based on 1963 prices, annual investment over the past decade averaged 75 million won and ranged between 107 million in 1959 to 44 million in 1964 (Table 3).

2.3. The Hambaek Housing Project

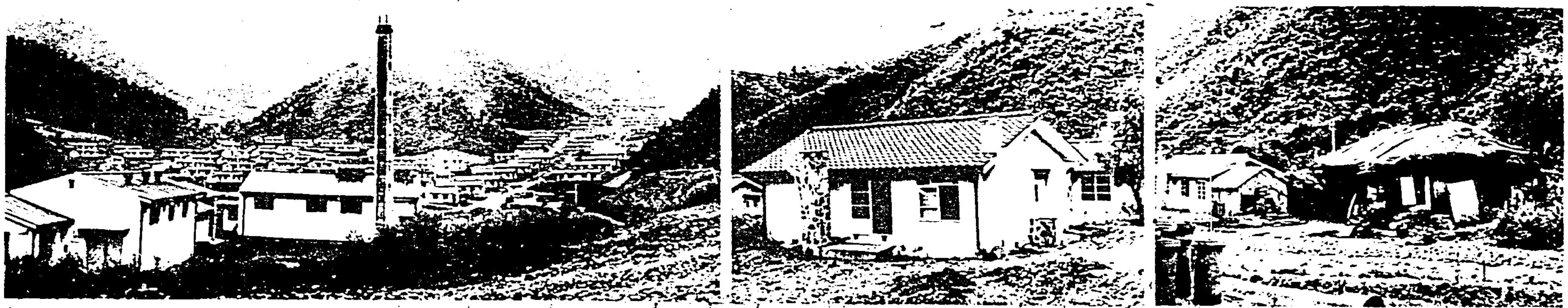
At the initiative of the United States Operation Mission to Korea (USOM), the planning and development of the Hambaek Housing Project was carried out by the Ministry of Construction and the Technical Staff of the Housing and Home Development Fund of the Korean Reconstruction Bank, in collaboration with USOM. The U. S. contribution consisted of technical assistance plus a counterpart loan to the Dae Han Coal Corporation, the owner-sponsor. The loan was repayable by the Corporation over a maximum period of ten years at four percent per annum of the unpaid balance. The project was completed and occupied September 23, 1963, 16 months after the start of site preparation and construction. The financing and costs of the project, totaling 108.2 million won ($832,300)[5], were distributed as in Table 4. Figure 1 shows examples of typical new and old units and locates the project on the Hambaek map.

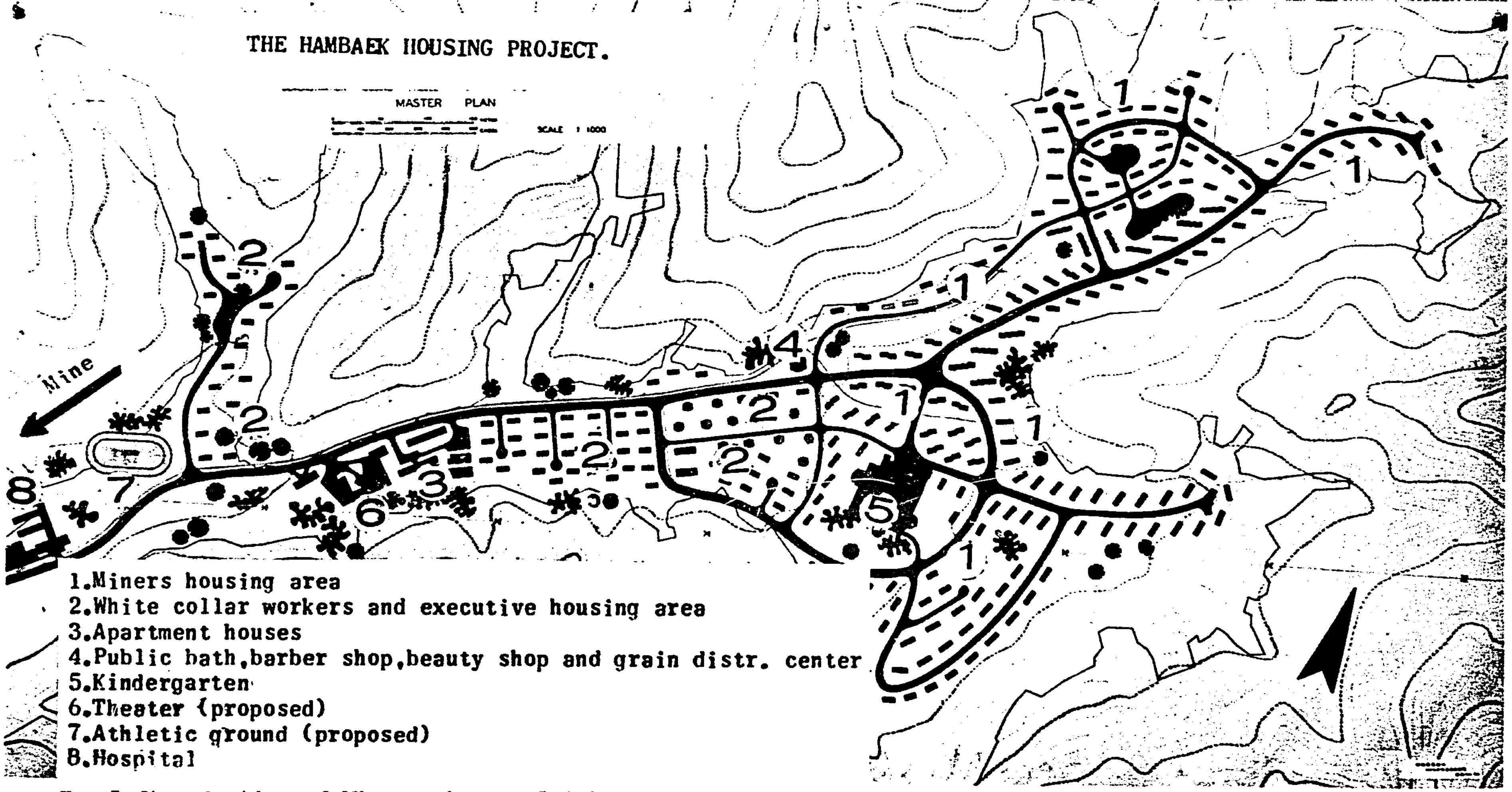
TABLE 4. SOURCES AND APPLICATIONS OF FUNDS, HAMBAEK HOUSING PROJECT
(in thousands of won)

Sources			Applications		
U. S. contribution	52,200	(48.2%)	Materials	61,104	(56.5%)
			Labor	24,893	(23.0%)
Project sponsor (Dae Han Coal Corporation)			Land and land development	17,440	(16.1%)
	56,000	(51.8%)	Other	4,763	(4.4%)
Total	108,200	(100.0%)	Total	108,200	(100.0%)

Source: Agency for International Development, "Airgram A-530," October 1, 1963.

[5]The official exchange rate in 1963 was 130 won = $1.00; it is currently 270 won = $1.00. Because it takes no account of purchasing power differentials, the won dollar comparisons should be regarded as only the crudest equivalents.





Top Left - Section of Mine workers pilot housing project in construction.
Top Right - Type housing being replaced by new homes shown adjacent.

Figure 1

The project consisted of 500 housing units distributed by size and cost as in Table 5. The three large units were built for top management at the cost of the Corporation. In addition to housing for the miners, the project included a public bathhouse, kindergarten with recreation facilities for children, a barber shop and beauty parlor, and a grain distribution center. These facilities are located about one mile from the existing project and are used almost exclusively by the rehoused families.

TABLE 5 DISTRIBUTION OF NEW HOUSING UNITS BY SIZE AND COST, HAMBAEK HOUSING PROJECT

Number of Housing Units	Area per Housing Unit		Cost per Unit Area		Cost per Housing Unit	
	In Square Feet	In Pyung[a]	Per Pyung (in won)	Per Sq. Ft. (in dollars)	in won	in dollars
410	324	9	14,500	$3.10	130,500	$1,004
34	540	15	15,200	$3.25	228,000	$1,754
17	720	20	15,600	$3.33	312,000	$2,400
36[b]	396	11	19,900	$4.25	218,900	$1,684
2[c]	900	25	n.a.	n.a.	n.a.	n.a.
1[c]	1,080	30	n.a.	n.a.	n.a.	n.a.
500						

Source: Agency for International Development, "Airgram A-530", October 1, 1963.

[a]One pyung equals 35.6 square feet.
[b]Apartment dwelling.
[c]Units for executive personnel; detailed cost information not available.

The weighted average area (exclusive of the three homes for executives) was ten pyung or 356 square feet per unit and the weighted average cost was 149,781 won or $1,152 at the then prevailing exchange rate of 130 won per U. S. dollar. Land accounted for 9,736 won ($75) per unit or 6.5 percent of this amount. It should be noted, however, that most of the units were constructed at a cost of approximately $1,000 including land.

The scheme for allocating the new dwellings among the mine workers gave preference to those employees (1) who worked in the tunnel, (2) with seniority, and (3) with higher productivities. No rent was charged for the houses but a nominal charge was levied for maintenance and electricity.

Workers living in the old houses not owned by the Corporation received rent compensation of 300 won per month. Because the market rent for comparable houses outside the Project was at least 500 won, monthly rent for the houses in the project can be conservatively estimated at the same amount.

The 500 houses in the demonstration project are far superior in quality to the existing stock of dwellings, particularly with respect to protection from the elements and the availability of utilities and sanitary facilities. The new houses are better insulated than the old and are equipped with chimneys. The lack of chimneys in most of the old structures meant that in order to generate sufficient heat, smoke from the cooking and heating fire was necessarily confined within the structure.

In contrast to the new dwelling units, most of the old had neither running water nor electricity. The best old houses had only running water and exterior sanitary facilities which served a block of houses. Traditionally, the river has supplied the residents of Hambaek with water for washing and toilet purposes.[6]

Occupancy density and intensity were also lower in the new units (Table 6). Density, a measure of space consumption, is calculated as the floor area per person. For the average new unit, the amount of habitable space per resident was double that of the old. The average densities in both the new and the old units, 143 and 61 square feet per person respectively,

[6] For comparative national data, see Appendix IV.

were within the bounds of 35 to 80 square feet established by the United Nations as space standards for "desirable type shelter accommodations." [7]

TABLE 6. OCCUPANCY INTENSITY AND DENSITY, HAMBAEK AND KOREA

Families	Persons Per Room	Area Per Person	
		In Pyung	In Sq. Ft.
Hambaek families rehoused[a]	2.5	4.0	142.6
Hambaek families not rehoused[a]	4.6	1.7	61.2
South Korea families (1960)[b]	2.5	0.6	21.4

[a]Besides both Hambaek groups there is a third group living in old company houses at an occupancy intensity of 3.5 persons per room; these families are excluded from our analysis.
[b]Estimates from 1960 Census data on the total number of rooms in Korean houses and total Korean population. See Appendix IV.

The second measure, occupancy intensity, is an indicator of relative privacy calculated as the number of persons per room. Standards set by the American Public Health Association recommend that the ratio not exceed one person per room in minimal housing. Neither the new nor the old units approximated this standard; however, the new dwellings, with a ratio of 2.5 persons per room, more closely approached the desirable standard for privacy than the old units with 4.6 persons per room.

The standards for minimum or desirable levels of shelter are relative, depending for instance on whether the units are built in rural or urban areas, on the size and age composition of families, on costs, on climate, and on a

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[7]United Nations, Goals and Standards for Housing and Environmental Development (Geneva: United Nations, January 15, 1964), p. 12. In contrast, standards set by the American Public Health Association some years ago are 400 square feet for one person, 750 for two, 1,000 for three, and so on. American Public Health Association, Planning the Home for Occupancy, Public Administration Service, Chicago, Illinois, 1950 and American Public Health Association, Committee on the Hygiene of Housing, Basic Principles of Healthful Housing, New York, Second Edition (1939).

host of other factors. The most relevant considerations for purposes of productivity measurement are the quality changes as reflected by differences between new and old.

While the new dwellings in the Hambaek project would be substandard by the norms set for developed countries, the differences with the former accommodations of the rehoused families are considerable. In sum, the new project satisfied the criterion of a sudden and substantial improvement in the quality of housing and community facilities. In the next section, we analyze the benefits of the investment in this improvement.

3. SITE SELECTION AND SAMPLE DESIGN

3. 1. Site Selection Criteria

The conduct of meaningful research into questions dealing with the productivity of investment requires conditions approaching those of a laboratory. This is particularly true for regions in the throes of early growth where, in the interests of balanced development, investment is spread concurrently among a number of sectors rather than concentrated in only one or a very few. The Hambaek project approached the ideal in certain important respects. The suitability of this site for our purposes was assessed against the following criteria:

a. The production process must be in operation before, during, and after a sudden qualitative improvement in housing.

The Hambaek mine has been in continuous operation since mid-1955. The housing project was occupied eight years later. The time period covered in our analysis extends from September 1962, one year before rehousing, to two years after. As noted in the previous section, the new units in the housing project are qualitatively superior by a broad margin over the former accommodations of rehoused workers.

b. The "income effect" must be absent or amenable to control.

A simple, positive association between housing conditions and productivity reveals little about the direction of causation. Increased labor productivity or efficiency implies higher income and, in turn, increased ability to pay for more expensive, better quality dwellings. If cause is primarily in this direction, then productivity is the determinant of housing quality rather than the effect. In the opposite case with better housing as the nexus, improved living accommodations would generate higher incomes via increased labor productivity. The "income effect" thus connotes the ability to pay for better quality housing through effective demand. To isolate the effects of housing transmitted through quality, the income effect must be eliminated if indeed it exists. The postulated sequence of events thus runs from a change in housing quality to a change in income. The sequence is traced by comparing labor productivity of rehoused workers before and after their relocation. As subsequently noted (Section 4.2), average income during the year prior to relocation remained constant and changed only during the year following. Hence, the "income effect" was inoperative.

c. The environment external to housing must remain unchanged over the measurement period.

Like the income effect, important changes in the non-housing environment would distort any analysis of the housing-productivity relationship. Because the real environment is rarely so static, however, appropriate adjustments must be made for any non-housing changes bearing on productivity. The "before-and-after" comparisons would be meaningless if, for example, a job training program had been instituted during the period of our analysis, or substantial investment had been made in new equipment which saved or replaced labor, or any other factor significantly affecting work performance had changed. Consequently, a second dimension -- "with-and-without" -- must be introduced into the "before-and-after" framework. The influence of non-housing factors on performance can be identified by observing the performance over a coterminous period of a sample composed of workers not rehoused (a control group). This exercise also provides the information necessary for "holding constant" the non-housing environment. Adjusting the before-after changes in performance of persons rehoused (a test group) by the performance of the control group during the same time period leaves the changes resulting from housing as a residual.

While this simple exercise for controlling for irrelevant changes is common to research methodology, its application in this case is confounded by occupancy policy which based priorities on performance at work. Consequently, it follows that the active bidding for a relatively short supply of new units would (and did) lead to vigorous competition among non-rehoused workers seeking units as they became available either through additions to stock or vacancies. Under these circumstances, the improvements in productivity of the control group may properly be credited to housing and community facilities, but the adjustments normally possible in the usual "with-and-without" framework are inappropriate.

This places the researcher in the somewhat uncomfortable position of defending the estimates he has imputed to housing and community facilities strictly on the basis of _ceteris paribus_. To assume "all else equal" may be convenient but meaningless in an instance where careful and correct estimation of particular benefits is requisite. The questions that must be addressed are: First, what changes in non-housing conditions may have affected productivity? Second, have these conditions had sizable effects on productivity and, if so, how can they be compensated? Our evidence, discussed in Section 4.4, indicates that the assumed _ceteris paribus_ is acceptable and, consequently, that observed changes may safely be attributed to housing improvements.

Of major concern is any non-housing investment made during the period under consideration which may, intentionally or not, have improved the quality of labor. Such investment takes many forms ranging from education and health programs for children with "pay-offs" delayed until entrance into the labor force, through on-the-job-training programs which generate quick returns in the form of increased efficiency at work, to technologically superior equipment which increases output without increasing inputs of labor.

Changes of this sort frequently can be identified from the composition of new investment. While our data reveal pitifully little about this structure, certain inferences, crude as they may be, can be drawn from changes in the total. If, for example, the level remains relatively constant over time and the life of assets is reasonably short on average, it seems likely that a substantial share of new investment is for the replacement of depreciating or depreciated assets. (This is not to deny, however, that replacement equipment may be superior technologically to the old and improve labor's efficiency.) Consequently, a fairly substantial share of new investment may have been allocated for the replacement of existing plant and equipment with like substitutes (Table 3).

If one can assume that new investment has maintained a reasonably standard composition since 1963, then the problem nearly disappears. The data analyzed later in this section indicates that labor productivity remained unchanged in the year before rehousing, yet during this same year, new investment amounted to nearly 99 million won, a fairly substantial increase exceeding 10 percent over the previous year. In the year following rehousing, this amount decreased to about 51 million won, a decline of about 49 percent over the level of the previous year (Table 3). If non-housing investment had an immediate bearing on productivity, one would expect the effects to become apparent during 1963 when, in fact, labor productivity remained stable. Hence, if the assumed constant distribution of new investment is tenable, one can dismiss non-housing investment from consideration as an exogenous influence of consequence.

The structure of investment reveals little about changes in work conditions which may bear importantly on productivity. Changes in incentive systems, in personnel policies, in plant lay-out, in work methods or flow, or in the availability of overtime each could influence the individual level of output. Knowleageable officials at the Hambaek operation assured us that the general conditions of work remained unchanged during the measurement period. Specifically, no changes had been made in plant layout, work methods or flow, or in other management techniques which might alter work efficiency. The amount of overtime work, however, declined during 1965. If efficiency runs inversely with length of work day, as one might suppose, it would follow that productivity would increase as overtime decreased. Investigation indicated that overtime hours accounted for a negligible share of total time on the job in 1964. With the lapse of overtime work, the total number of hours worked by the test group declined only 1.4 percent and remained unchanged for the control group. In sum, changes in the work environment, including the small decline in total working time, can be disregarded as a factor potentially distorting our measurements of labor productivity.

The community facilities associated with the housing project cannot be excluded from consideration however. Generally, such investment would favorably affect labor productivity, but from the nature of the facilities (Section 2.3), it seems unlikely that their effects would seriously bias the effects attributed to housing. However, because we are unable to separate the costs of these facilities and they constitute an integral part of the project, we will consider them with housing. In this sense, whatever benefits are attributed to housing are technically attributed to the package, housing and community facilities.

d. The worker must be able to control his level and rate of production.

In order to estimate the effect on labor productivity of environmental change, output level must be subject largely to the worker's own control. If output is machine-dictated, or if the employee is hired for a certain time period without regard for availability of work, then it cannot be assumed that the worker controls his rate of output. Since the individual's output was not machine-dictated, but related to personal effort and availability for work, the Hambaek mine met these requirements.

Related to this criterion is the requirement that workers have mastered their tasks and are past the initial learning stage. Productivity increases achieved by repetition of tasks must be excluded. Since the most rapid increases in learning normally occur in the earliest stages of employment, the measurement period should embrace the interval when the employees' productivity is nearly constant over time. The tenures of most Hambaek employees are extended and well past the initial learning stages.[1] The constant pre-rehousing production level estimated for both control and test groups (Section 4.2) further substantiates this fact.

e. Changes in labor productivity must be measurable in quantitative units of output.

The task of securing appropriate information on labor productivity at the Hambaek mine was complicated by two factors. First, lack of data on physical units of output per worker required using wages as a proxy. Second, the nature of the production process made it difficult to match specific workers with specific work tasks and, consequently, to measure the production of individuals in additive units of output. A digression describing the production process will illustrate these difficulties.

Although individual jobs are specialized to a degree, the miners are trained to perform several tasks. For example, each miner must be able and

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[1] See the hypothetical learning curve used as an example in the Pine Ridge Report; Leland S. Burns, Cecil B. Thompson, and B. Khing Tjioe, Report on a Pilot Study of Worker Productivity in Relation to Housing Conditions (Los Angeles: International Housing Productivity Study, 1965), Figure 1, p. 24. The Korean miners in both samples are producing in the time interval AB shown in the illustration. As we note in Section 4.2, regression of the before-rehousing time series on productivity yields no statistically significant trend for either the test or the control group. Technically, during the period prior to rehousing, wages fluctuated around the average for the year with a trend of zero. See Appendix I for details of the statistical analysis.

willing to perform repair and preparational work in addition to the principal tasks of drilling, digging, and loading. The amount of time and effort required for work preceding drilling and picking depends on circumstances such as type of rock formation. Due to the heterogeneity of tasks performed, it is difficult to distinguish pickers from repair workers. For these reasons, output cannot be measured in wholly comparable physical units nor can individual output records be strictly compared between time periods.

Comparability can be achieved, however, if labor productivity is measured in terms of work-group performance since shifts in individual tasks tend to cancel out and become "lost" in the group average. No bias is introduced into the comparative measurements between control and test groups if the composition of tasks is homogeneous and if each work-group is homogeneous in terms of housing status. The selection of the samples reflects these considerations (Section 3.3).

Although output cannot be measured in physical units, earnings represent a reasonable approximation of productivity since wages are paid on a piecework basis. The wage rate set for an individual job depends on the nature of the task and the performance level expected. The rate paid for picking, for instance, depends on the difficulty of the work. Because upward picking is easier than horizontal picking which, in turn, is easier than downward picking, less is paid per unit for coal mined by upward picking. Similarly, because a rock formation presents more problems than a sand formation, coal picked from rock commands a higher wage. Since the wage system compensates for the difficulty of the task, it is a good indicator of labor productivity and a workable proxy for output in physical units.

The wage proxy has the further advantage of stating output in commensurable units. The wage dollar earned for picking is comparable to the dollar earned for, say, repair work. Clearly, if units of physical output were the measure of productivity, rather than wages, a common denominator would have to be devised to reconcile the performance of diverse tasks.

f. Reliable data in sufficient detail must be available.

Several conditions at the Hambaek project indicated that ample information, covering a sufficiently long time period, and for a sample of reasonable size, was available for taking the types of measurements required for estimating housing-productivity relationships. First, completion of the housing project in September 1963 was sufficiently recent to insure that the necessary data would still exist. Second, the ten year history of continuous operation of the mine was long enough to yield ample information on output prior to rehousing. Finally, there was the additional presumption that most of the current labor force had work records covering an extended period and that they had passed the initial learning phase and were producing at a nearly constant level, at least prior to rehousing.

The Dae Han Coal Corporation, operator of the mine, willingly cooperated in the study by providing us with ready access to primary data sources. Considerable assistance was also given by the United States Operation Mission to Korea which had maintained a close involvement with the housing project since its inception. The Research Department of the Bank of Korea also cooperated in supplying information. The assistance of these three organizations was of inestimable value to this research effort. "Hard data" were supplemented by interviews and field notes reflecting personal observations obtained during the course of a field trip to the test site in June 1965.

3. 2. Site Selection Procedure

The choice of Hambaek followed the procedures established for selection of all test sites to be included in the second phase of research for the International Housing Productivity Study. First, the list of criteria just described was submitted through AID, Washington, to missions or U. S. Embassies in most developing countries. A tentative selection of potential test sites was made from the responses to these queries.

Next, answers to detailed questions were solicited from potential participants. Based on this set of responses, a list of promising test sites was drawn up for field visits by staff members in order to discuss in detail the availability and quality of needed information, to design samples if the test site satisfied the conditions for a productive research effort, and initiate data collection by reliable persons or agencies.

The importance of the first-hand conferences with persons at prospective test sites cannot be underestimated. They served two primary goals: (1) to eliminate or reduce to an allowable minimum the misinterpretation of information, and (2) to acquaint the research staff with local conditions in order to avoid inappropriate assumptions or incorrect inferences. In addition, the conferences served as a sounding board for ideas and assisted materially in explaining and enlisting support for the Study. As a consequence of these meetings, substantial interest in the nature and goals of the Study has been generated in Korea and the other developing nations visited. Very likely, private and public institutions in these countries will continue studies based on the same, or a similar, framework, hopefully with results useful to housing policy in particular and development policy in general.

3. 3. Sample Design

The samples were selected from the part of the population of 1,150 mine workers employed continuously over the period 1962-1965. The test group population consisted of 497 relocated miners and the control group population comprised the remaining 653. With the assistance of management personnel of the Dae Han Coal Corporation, samples of 50 miners were chosen from each population for the test group sample and the control group sample.[2]

The composition of each sample was representative of the composition of tasks performed by the population. Hence both samples were stratified identically except in terms of housing. Each sample was large enough to assure, with a high degree of probability, that any errors of classifying a job in terms of its appropriate wage would be cancelled by offsetting errors in the opposite direction.

The sample may be described schematically as follows:

	Before Rehousing	After Rehousing
Test Group	50 miners to be rehoused	Same 50 miners rehoused
Control Group	50 miners not rehoused	Same 50 non-rehoused miners

-1   0   Years   +2

↑ Moment of Rehousing

The work records of the control and test groups were <u>each</u> analyzed for a period extending from one year before (-1) to two years after (+2) rehousing.

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[2] Since each sample is representative of its respective population and due to the awkwardness of the terms, the "control group sample" and "test group sample" will henceforth be referred to simply as the control group and the test group.

The productivity data of each group of workers were provided for ten day intervals. The period of one year was satisfactory for estimating trends in productivity during the period before the test group was rehoused. Since the houses were completed and occupied on September 26, 1963, the maximum period available for analysis following rehousing covered about two years.

4. THE IMPACT OF IMPROVED HOUSING AND COMMUNITY FACILITIES ON LABOR PRODUCTIVITY

Changes in labor productivity attributable to better housing and community facilities are assessed in this section. Section five considers benefits in the form of improved health. Benefits of both types are re-estimated in monetary terms in the concluding sections.

4.1. The Measurement of Productivity.

Fluctuations in the total number of hours worked at the Hambaek mine are related to the availability of work and the conditions of work. Similarly, the number of hours worked by the individual miner fluctuates sharply. Over the long run, however, and taking samples of 50 workers in the aggregate, we can assume that hours on the job during normal work days fluctuate within rather narrow limits. But in the short run, individual productivity per time unit is volatile due to its substantial dependence on the number of hours worked, a number which, in turn, has fluctuated widely. For instance, it seems reasonable to assume that if the working hours for an individual paid piece rates are reduced, say, 25 percent, his incentive to work harder during fewer hours is greater for, in order to avoid a reduction in income, his productivity must increase. Moreover, it is likely that work efficiency declines as the number of hours worked per day increases. A high level of output can be sustained more easily during a four-hour day, for example, than throughout a normal work day of eight hours. In order to eliminate the influence of the number of hours worked on the level of productivity per short time-unit, the weekly wages earned (as adjusted from wage data for ten-day periods) were used as the measure of labor productivity.

The Dae Han Coal Corporation supplied wage data divided between earnings for work accomplished during normal working hours and for overtime work. These data have been analyzed separately and corrected for across-the-board wage increases.

Only earnings derived from normal working hours will be considered in the analysis to follow. Real earnings during normal working hours for the average test group and control group worker are graphed in Figure 2.

4.2. Short-term Relevant Changes in Labor Productivity.

Our first approximations of changes in labor productivity are initially obtained by contrasting productivity during the year preceding rehousing with the year following. More precise estimates, using two-year indexes for the post-rehousing period, are developed in Section 4.4.

During the period prior to rehousing, the average worker in both the test and control groups earned 1,690 won weekly,[1] and there was no significant change in this amount during the year.[2] The averages for test and control group after rehousing stood at 2,006 and 1,943 won respectively, or significant increases of 18.7 percent and 15.0 percent over the former levels. A regression of earnings after rehousing yielded positive and significant trends for both groups. The weekly earnings of both increased about 13.7 won each week throughout the year (Table 7). Comparison of performance during the periods before and after relocation revealed a significant improvement in average productivity for each group.[3] This finding is a strong indication that improved housing was indeed responsible for bettering the work performance of the miners (Figure 3). While the differences in performance for the average member of each group were significant, a detailed examination of the output records for each of the 100 workers in the two samples leads to the same conclusion. During the year prior to rehousing, production records showed increases for seven of the 50 control group workers and six of

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[1]Interestingly, although the Corporation assigned priority to the more productive workers, their productivity on average was equal to the average worker not rehoused.

[2]For the statistical analysis, see Appendix I.

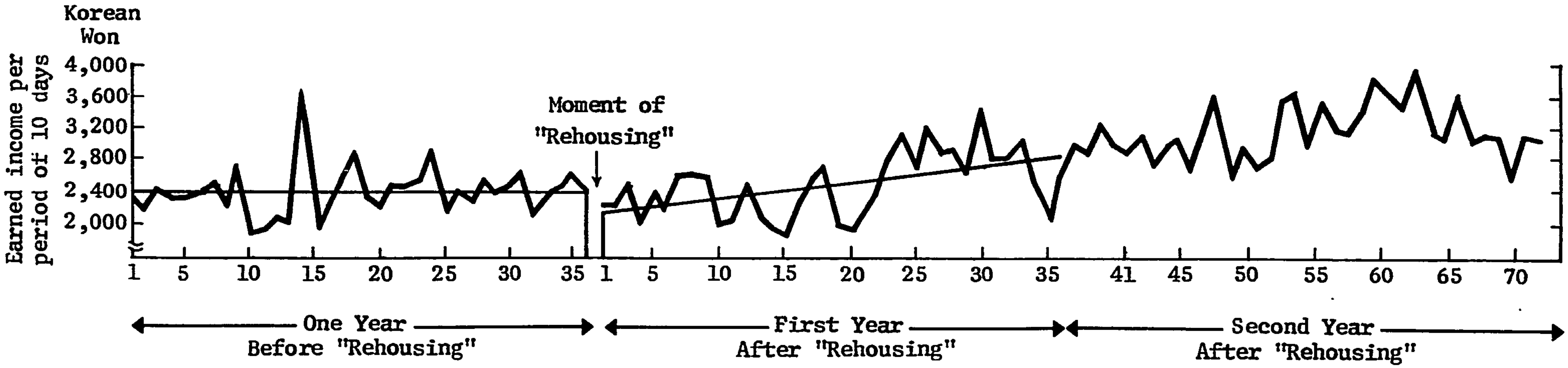
[3]See Appendix I.

ACTUAL EARNINGS OF AVERAGE TEST GROUP AND CONTROL GROUP WORKERS,

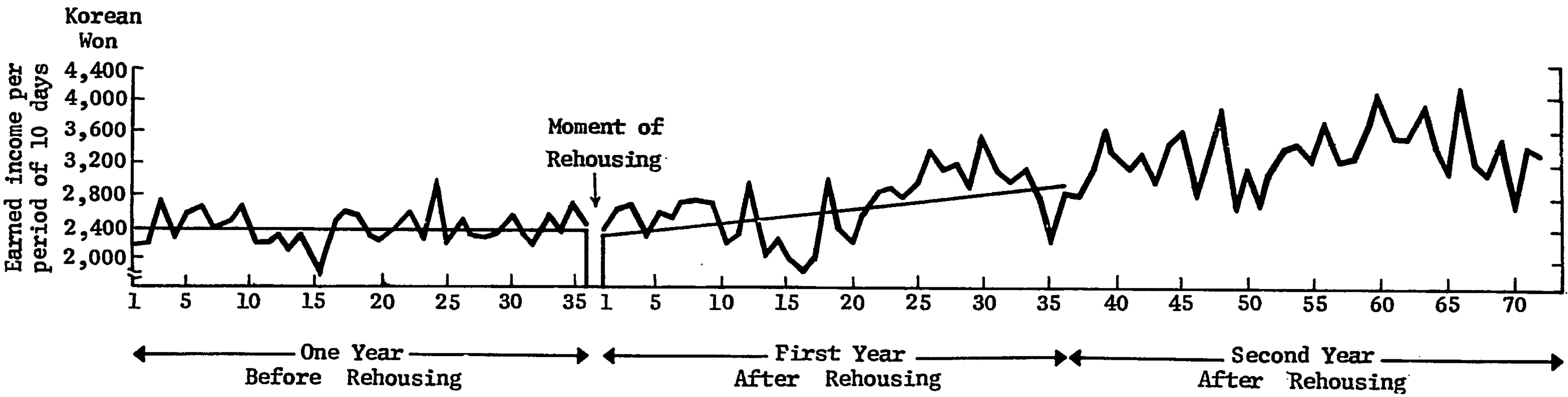
ONE YEAR BEFORE AND TWO YEARS AFTER REHOUSING,

FOR 10 DAY PERIODS

Control Group



Test Group



Source: Dai Han Coal Corporation

FIGURE 2

TRENDS OF WEEKLY EARNINGS, AVERAGE TEST GROUP AND CONTROL GROUP WORKERS,

ONE YEAR BEFORE AND AFTER 'REHOUSING' (IN KOREAN WON)

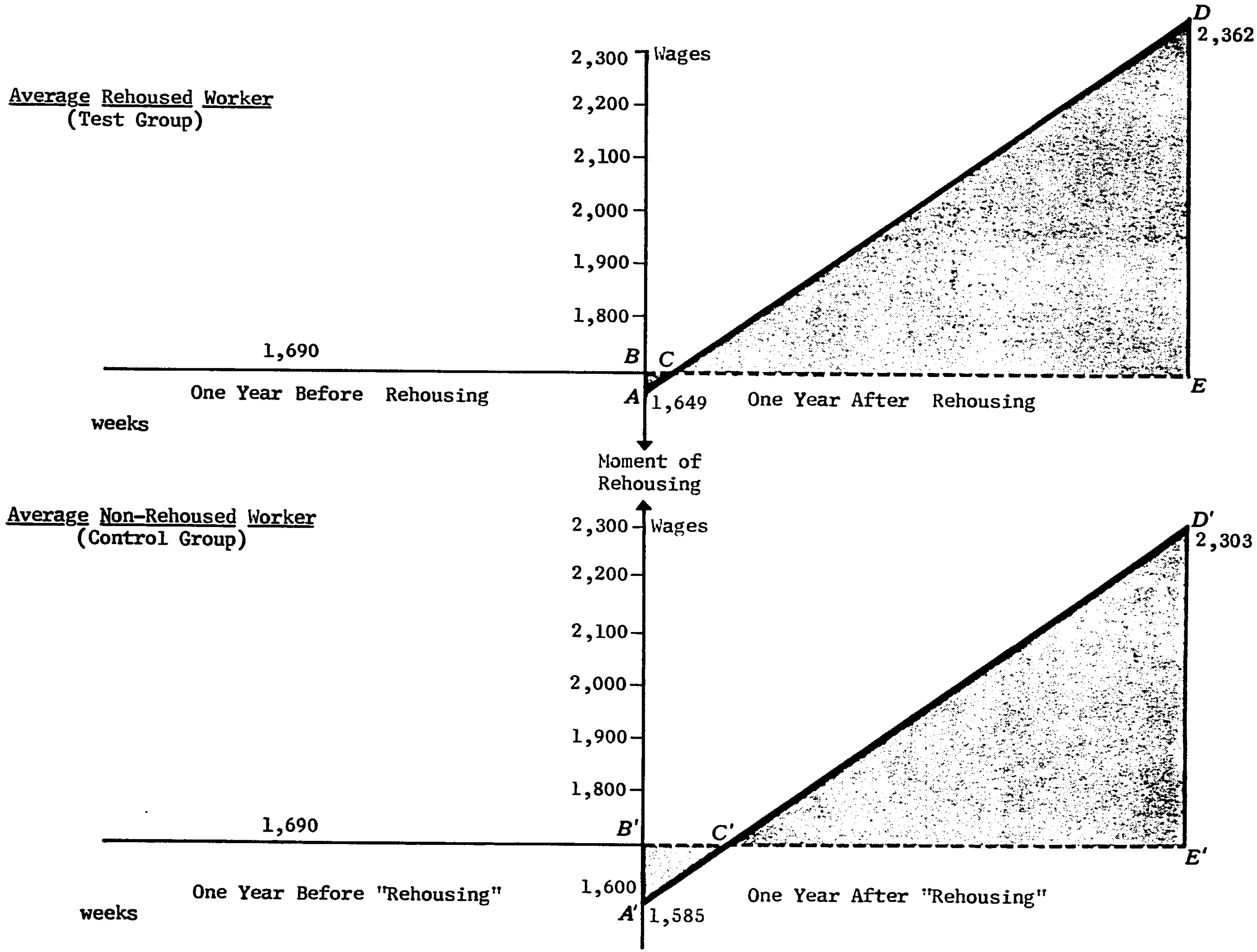


FIGURE 3

the 50 test group members. The picture in the following year changed substantially. After rehousing, the productivity of 31 of the test group workers increased by significant proportions while 26 of the control group members raised their productivity levels substantially. The before-after changes for each of the two groups were statistically significant.

TABLE 7. SHORT-TERM LEVELS AND CHANGES IN WEEKLY EARNINGS, YEAR BEFORE AND AFTER REHOUSING, AVERAGE TEST AND CONTROL GROUP WORKERS
(in won)

	Average Test Group Worker	Average Control Group Worker	Difference
Average levels:			
During year before rehousing	1,690	1,690	0
During first year after rehousing	2,006	1,943	63
Difference	+316	+253	63
Average weekly increases:			
During year before rehousing[a]	0	0	0
During first year after rehousing	13.7	13.7	0

[a]Regression of the time-series data for this period yielded average weekly increases of 1.93 won and 2.80 won for the test and control groups respectively with corresponding standard errors of 2.37 and 3.78. Because the increase was statistically insignificant at even the 68 percent level of confidence, the trend can be considered as zero.

Another approach to evaluating the quantitative differences in the before and after periods involves estimating, separately for test and control groups, the time trend in the differences in weekly earnings between the year before and the year after rehousing. In other words, the series regressed against time are made up of the earnings of the first week following relocation less the earnings of the first week in the preceding year as the first observation, the difference in earnings between the second week after rehousing and the second week of the prior year as the second observation, and so on until the series of 52 observations reflecting productivity changes spaced a year apart is complete. The analysis holds everything constant[4] -- the workers whose productivity is under consideration are the same -- except the differences in housing conditions. The results indicate a spread in wages of 11.8 won weekly per average test group worker and of 11 won per week for the average control group member.[5] Stated another way, the rehoused miner's production record improved, on average, 11.8 won more rapidly each week after rehousing than before and the typical non-rehoused miner's record showed a comparative improvement of 11 won. From this and the results of the two previous approaches to determining the significance of relative changes, it is apparent that improved housing bore favorably on labor productivity.

4.3. The "Demonstration Effect" of Housing and Community Facilities

Although we have shown earlier that in the year before relocation, productivity per average worker was identical for both the test and control groups, occupancy priority was presumably assigned the most productive miners. If good housing was regarded as desirable, it would follow that the possibility of being housed in the new project would act as a powerful incentive toward greater output. A host of reasons could be, and have been, advanced for the desirability of the new, qualitatively superior units, not the least of which is the estimated rent value of 500 won per month[6] compared to the rent subsidy of 300 won foregone, or a net bonus raising each family's effective living standard by 200 won monthly. That productivity levels apparently were ignored in the realities of assigning preference for

[4] As will be demonstrated in Section 4.4.

[5] Both estimates are significant at the five percent level of confidence; that is, the chance is at least 95 percent that the increasing spread is significantly different from zero.

[6] A "shadow-priced" rent equivalent as explained in Section 2.2.

rehousing is irrelevant so long as the fact was not revealed to the employees. One would expect the impetus, or the "demonstration effect" to remain.

What form might the demonstration effect take? First, assume the possibility exists for rehousing in improved accommodations and, second, that the probability of relocation improves with increases in productivity. Given these assumptions, it would be expected that the non-rehoused would stimulate their own efforts toward greater output, hence improving their chance of securing a new housing unit. If true, the productivity trend of the control group would be likely to approximate the pattern of the test group.

The estimates developed in the previous sub-section generally confirm these assumptions. Starting from identical levels of output at the moment of rehousing, both groups substantially improved output during the first year following, although the test group's record on this count was marginally superior. The benefits of housing are clearly not restricted to the rehoused.

The demonstration effect multiplier is a product of two measures, (1) the ratio of non-rehoused to rehoused workers, which depends on the number of housing units available for occupancy, and (2) the perceived probability of rehousing, which is equivalent to the relative increases in income or productivity of the non-rehoused compared to the rehoused. An example drawing on data from this case will illustrate.

For the sake of simplification, suppose that each worker seeking a better house perceives absolute probability of rehousing if his work record is competitive with the average worker currently occupying a house in the project. Next, 497 superior units are currently occupied leaving 638[7] workers as potential candidates, or 1.28 unrehoused per rehoused family. The 638 succeed in increasing their average

[7]Based on the average number of miners during 1963 and 1964 (Table 1).

weekly productivity 253 won per week compared to the year before the housing project was available for occupancy, but still short of the increase of 316 attained by those rehoused. The probability of rehousing, or the "income ratio", is .8. The product of the two ratios is the demonstration effect multiplier; that is, 1.28 x .8 = 1.02. Hence, each won increase in earnings of the currently rehoused generates 1.02 won in the form of additional earnings for the non-rehoused workers.

Disturbing conclusions result if all of the above assumptions are maintained as constants, but the proportion rehoused (or its complement, the proportion still unrehoused) is allowed to vary. The size of the multiplier is inversely related to the proportion rehoused or positive with respect to the ratio of unrehoused to rehoused. Suppose that instead of 497 dwellings available for 1,135 workers, there are, as a first example, only 200 and, as a second illustration, 1,000. The respective multipliers are calculated as follows:

	Income ratio or probability factor	x	Proportion unrehoused	=	Demonstration effect multiplier
1)	253/316	x	$\frac{1,135 - 200}{200}$	=	3.74
2)	253/316	x	$\frac{1,135 - 1,000}{1,000}$	=	1.08

Consequently, the multiplier tends to disappear as the proportion remaining unrehoused declines. When all are rehoused, the multiplier is zero or inoperative. Similarly, if any term were zero -- for example, if the control group had maintained its former output level after the new housing was occupied by the rehoused, or if no hope of rehousing were perceived (hence, zero probability) -- the multiplier effect would also be nil. Conversely, the smaller the proportion rehoused, the larger the multiplier. To illustrate with an extreme, if only one house was available and the other components of the multiplier remained unchanged, the multiplier would be a fantastic 771! Clearly, the assumption of holding constant the probability of housing and the income ratio is inappropriate. To return to the extreme, if only a single unit was built, the probability of housing would be perceived as zero or nearly zero and, due to the interdependence between probability and the "income ratio", it is likely that the latter would disappear. Since only a single estimate of the "income ratio" is available, it is impossible to estimate with any degree of accuracy the changes in the multiplier deriving from changes in the proportion of workers to be accommodated or the optimal number of housing units to be constructed. However, the existence of the demonstration effect is sufficiently unique in housing research to argue for more detailed investigation.

Finally, the scope as well as the size of the demonstration effect multiplier cannot be fully measured. The demonstration effect likely extends to the indirect workers, the 125-137 administrative workers, particularly if they share the opportunity for rehousing.

4.4. Longer-term Relevant Changes in Labor Productivity

How persistent over time are the relevant labor productivity changes? What are the limits to change both in terms of time and the worker's capacity to produce? These are the principal questions addressed next. The analysis of this subsection extends to a two-year period the earlier examination covering one year of post-rehousing performance.

Earnings of both the test and control groups increased slightly during the first half-year following rehousing and sharply during the next four months. During the second year, earnings leveled off to repeat the pattern of the year prior to rehousing. In other words, the productivity trend for the second post-housing year was roughly horizontal (or, with zero increase per unit time), but at a substantially higher level than before rehousing. The year between, the period of rapid development in output, bridged the two levels with growth closely approximating the logistic curve described in Figure 4. In answer to the first question, after an initial rapid increase, productivity leveled off at a higher plateau or capacity limit.

This limit is estimated at 2,216 won per week for the average test group worker and 2,145 for the average control group member.[8] Based on statistical fits to a logistic curve, wages remained constant after the limit was attained with no indications of subsequent decline.

After the productivity of the test group attained and stabilized at its new limit, earnings per week were 2,216 won compared to 1,690 won during the pre-rehousing period, or a relevant increase of 31 percent. The productivity record of the average control group worker developed similarly, increasing to a stabilized level of 2,147 won, 27 percent greater than the earlier level. This pattern was consistent with the assumed parallel behavior of the control and test group in their competition for housing in the project. The estimates are summarized in Table 8 and graphed in Figure 5.

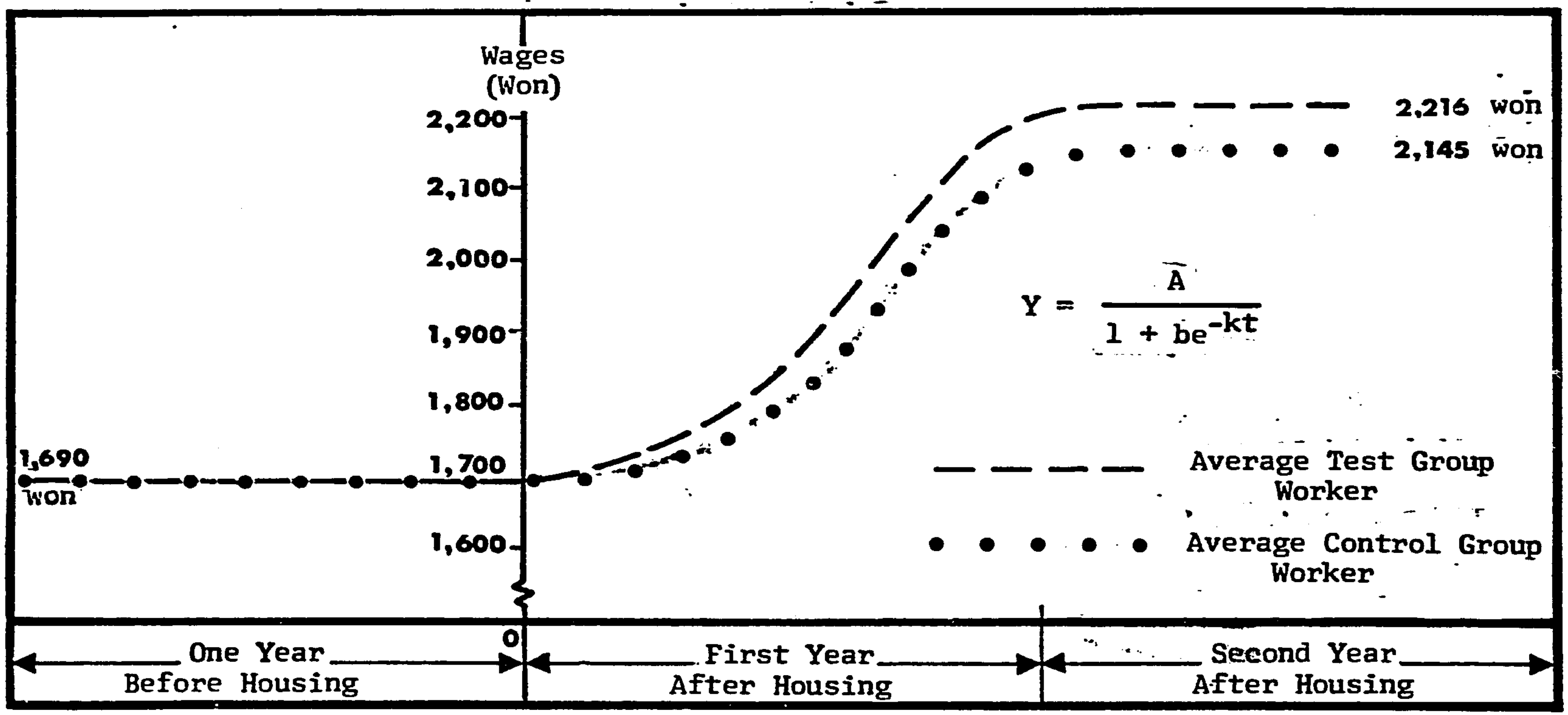
TABLE 8. LONG-TERM AVERAGE ACTUAL AND EXPECTED WEEKLY EARNINGS AFTER REHOUSING, TEST AND CONTROL GROUP WORKERS

Weekly Earnings During Second Year After Rehousing	Average Test Group Worker	Average Control Group Worker
Estimated earnings	2,216	2,145
Expected earnings[a]	1,690	1,690
Relevant earnings	526	455
Percent increase	31.1	26.9

[a]Defined as the level expected if rehousing had not occurred. In the absence of the new project, it would be assumed that past levels of output would persist in the future, consequently the expected value is the before-rehousing level.

[8]Estimates are developed in Appendix I.

FIGURE 4: TRENDS OF WEEKLY EARNINGS, AVERAGE TEST GROUP AND CONTROL GROUP WORKERS, ONE YEAR BEFORE AND TWO YEARS AFTER REHOUSING



AVERAGE WEEKLY EARNINGS, TEST GROUP AND CONTROL GROUP WORKERS,

YEAR BEFORE AND SECOND YEAR AFTER REHOUSING (IN WON)

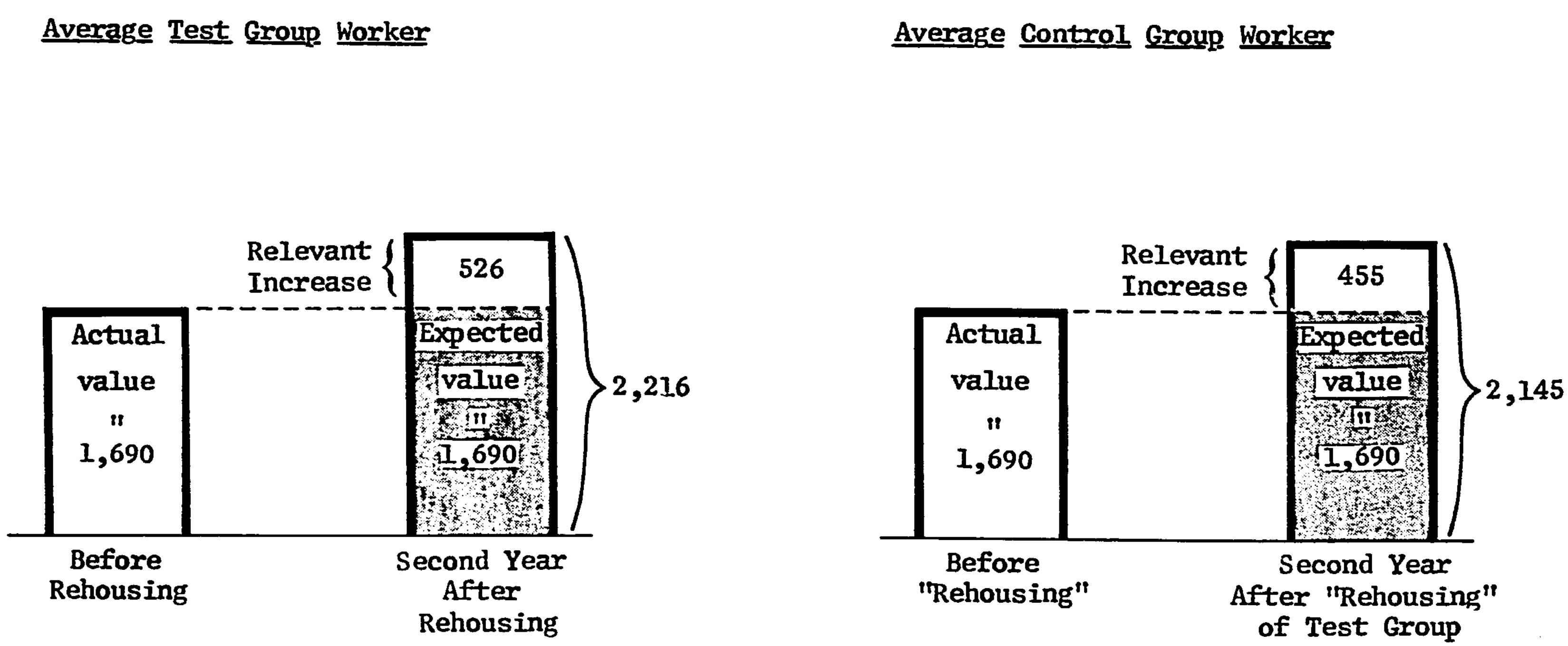


FIGURE 5

The earnings differences are truly relevant to housing and the community facilities complement only if the <u>ceteris paribus</u> assumption holds. In addition to information on the constancy of work conditions noted earlier, additional evidence supporting the assumption may be gleaned from an analysis of performance during overtime. Due to changes over time in the total amount of overtime work for both groups, the proper measure is output per overtime hour worked. Comparing the second year following housing -- the interval in which productivity during normal work hours stabilized -- with the year before rehousing yields the following:

Average Worker	Mean Output per Overtime Hour: Year Before Rehousing	Mean Output per Overtime Hour: Second Year After Rehousing	Difference in Mean Output	Standard Error of Difference
Test group	49.321	72.233	22.912	10.391
Control group	48.932	60.466	11.534	13.765

Because of the high standard error, the difference for the average control group worker is insignificant. In contrast, the average test group worker's 23 won increase is significant. If exogenous factors, i.e., any change other than housing affecting productivity, had been operative, the effect should show up in the behavior of both groups. That it did not, leads us to accept the assumption as realistic and, further, indicates that the earnings differences are properly attributed to housing.

As a final piece of evidence, we have estimated that during normal work hours, the productivity of the average test group worker exceeded that of his control group counterpart by a statistically significant margin during 80 percent of the two-year post-rehousing period.[9]

The estimates of increases in earnings and productivity take on added meaning when compared to benchmarks. Total output of coal in Korea increased 8.6 percent in 1964 over the previous year and, simultaneously, output per

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[9]See Appendix I.d.

man-hour increased six percent, or a magnitude about one-fifth the Hambaek increase.[10] Yet, if our estimates seem astonishingly high, they become relatively modest by comparison with some of the more spectacular productivity gains registered elsewhere. In one extreme instance, a new incentive scheme instituted by Bethlehem Steel Company yielded a 40 percent increase in efficiency.[11]

Comparison of each group's relevant earnings (Table 8), suggests that the psychological response to better housing and community facilities accounted for the substantial share of the improvement in productivity and earnings (455 of the 526 won increase) while the remaining 71 won increase may be attributed to the material or physical housing improvement per se. The distinction between material and immaterial transmissions of labor productivity change is cloudy. In an earlier report,[12] we differentiated between physiological and psychological responses to changed housing circumstances as related to changes in mental attitude toward work compared to the ability to work more time and more efficiently per unit of time due to improved physical health. Similarly, material effects reflect reduced incidences of illness or accidents in response to better hygenic conditions of newer, safer, more sanitary homes. The immaterial effects refer to improved morale and incentive resulting from superior housing.

As a digression, it is interesting to note that the immaterial or psychological effect played a minor role in influencing productivity increases in the Pilot Study at the Pine Ridge Indian Reservation,[13] and the material effects dominated. The situation was the reverse at Hambaek due perhaps to two factors. First, competition for a relatively smaller supply of good housing was keener at Hambaek. Second, the Dae Han management appeared to assume a more benevolent

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[10]The Bank of Korea, Monthly Statistical Review, Vol. XIX, No. 4 (April 1965), p. 87.

[11]Fenninger, Lawrence, Jr., "The Establishment of Norms Under Incentive Systems in the Basic Steel Industry in the United States," in John T. Dunlop and V. P. Diatchencho, Labor Productivity (New York: McGraw-Hill Book Co., 1964), pp. 271-72.

[12]Burns, et al., op. cit., pp. 21, 22.

[13]Ibid.

posture toward its employees. If the material factor can be separated from the immaterial, it would seem that this manifestation of interest may have been as powerful an incentive toward greater efficiency as the housing improvement itself. Conceivably too, other steps taken by management to raise living standards could yield results of no less consequence.

5. THE IMPACT OF IMPROVED HOUSING AND COMMUNITY FACILITIES ON HEALTH

The positive relation between housing quality and health quality has been subjected to careful study but, to our knowledge, little is known about the relation in monetary terms.[1] This section examines the relationship between housing and health, with the latter referring to circumstances requiring preventive or curative medical attention. In Section 6, the benefits of housing to health are calculated in monetary terms compatible with units used to measure other benefits.

5. 1. The Measurement of Health Effects

While labor productivity changes were measured using employed persons as units for observation, samples for measuring health effects were drawn from a population consisting of all persons rehoused with a control group sample consisting of nonrehoused persons. The Dae Han Coal Corporation supplied data on health conditions for a test group of 197 rehoused persons and a control group consisting of 287 covering one year before and a year after rehousing. Except that the time period is shorter by a year, the larger random samples for health measurements, compared to the samples for labor productivity measurements, mean that any conclusions are more firmly grounded with smaller probabilities that purely incidental factors govern.

Our information was obtained from records of the only hospital in Hambaek offering health and medical care. The distinction is drawn between outpatient and inpatient admissions with the former referring to clinical treatment and the latter to more extended care requiring hospitalization. However, the data exclude illnesses and accidents for which medical care was not sought at the hospital.

[1] For a comprehensive review and bibliography of such studies, see e.g., Schorr, *op. cit.*

5. 2. Relevant Changes in Health

The hypothesis under consideration is that better quality housing is positively associated with improvements in health. Acceptance of the hypothesis is based on two conditions. First, the improvement in health must be positive with respect to the improvement in housing quality. Second, the improvement must be of statistically significant dimensions. A relative improvement in health conditions after rehousing is not sufficient proof that the change in housing conditions is responsible. The improvement may result from other factors such as a concerted health education program. Only comparison with a control group which differs strictly in terms of housing conditions provides convincing evidence that housing, not other factors, was responsible for health improvements.

TABLE 9. ACTUAL NUMBER OF HOSPITAL ADMISSIONS BEFORE AND AFTER REHOUSING, TEST AND CONTROL GROUPS

Type of Admission	Test Group	Control Group	Total
Outpatient:			
Before Rehousing	527	589	1,116
After Rehousing	442	602	1,044
Change (after less before)	-85	+13	-72
Inpatient: (days of hospitalization)			
Before Rehousing	25	51	76
After Rehousing	11	73	84
Change (after less before)	-14	+22	+8
Number in Sample	197	287	484

If the control group sample is truly representative of all persons not in the housing project, their admissions records will reveal the importance of non-housing factors influencing the use of health and medical services. The data in Table 9 show that these services are utilized to an increasing extent, either because of increasing need, greater recognition of their worth, increased availability, or any combination of these or other reasons. Over the two year period, outpatient admissions among the control group of 287 persons increased from 589 to 602. In ratios, the per capita number of outpatient admissions rose from 2.05 (or 589/287) to 2.10 (or 602/287), an increase of 2.4 percent. In contrast, outpatient admissions for the 197 test group members declined from an annual level of 527 to 442, or the number per person dropped 16.4 percent from 2.68 to 2.24. If the test group's behavior had paralleled that of the control group, the number of outpatient admissions would have increased by 11 visits rather than declining by 85. More precisely, the expected number of outpatient admissions, or the number expected had rehousing not taken place, would have climbed to 540 rather than dropping to 442. If the difference is significant, that is, not determined by random change, housing can be credited with the change.

The statistical significance of the difference was measured using a chi-square test.[2] The results confirm the significance of the differences and affirm the hypothesis; that is, for the test group, the difference between the actual and expected number of outpatient admissions was statistically significant. Consequently, the probability is high that the improvements were explained by qualitative improvements in housing.

Generally similar results were obtained from the analysis of comparative before-after data on inpatient admissions. Again, the autonomous trend in admissions was upward. Over the two-year period, inpatient admissions climbed

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[2]See Appendix II for the calculations.

from 51 to 73 for the control group or .18 per capita during the year before rehousing to .25 the year after. Among the test group, however, the annual number of inpatient admissions declined from 25 to 11, or .13 and .06 per capita before and after rehousing, respectively. The number of inpatient admissions for the test group after rehousing would have been 36 rather than 11 if the trend had run parallel with the control group. Again, a chi-square test indicated that the difference was of statistically significant proportions.[3]

Actual and expected values for the number of outpatient visits and the number of days of hospitalization are summarized in Table 10 and Figure 6. The number of outpatient visits was reduced about 18 percent as the result of housing. Stated another way, had the new project not been built, the test groups' need for clinical care would have been 18 percent greater. The relative changes in the need for hospitalization are an even more dramatic improvement of 69 percent. In other words, the actual number of days of required hospitalization was 69 percent less than the number expected if better housing were not available.

TABLE 10. ACTUAL AND EXPECTED NUMBER OF HOSPITAL ADMISSIONS, TEST GROUP

Type of Admission	Before Rehousing		After Rehousing		Percent Change
	Per Person	Total	Per Person	Total	
Outpatient Visits:					
Expected number of visits[a]	-	-	2.73	538	+2.1
Actual number of visits	2.68	527	2.24	442	-16.1
Difference: actual less expected	-	-	-0.49	-96	-
Inpatient Days:					
Expected number of days[a]	-	-	0.183	36	-44.0
Actual number of days	0.13	25	0.056	11	-56.0
Difference: actual less expected	-	-	-0.127	-25	-

[a]The expected number, or the number expected if rehousing had not occurred, was calculated as the "before" level of the test group multiplied by the rate of change of the control group after housing relative to before.

[3]See Appendix II for the calculations.

ANNUAL NUMBER OF HOSPITAL VISITS, TEST GROUP, BEFORE AND AFTER REHOUSING

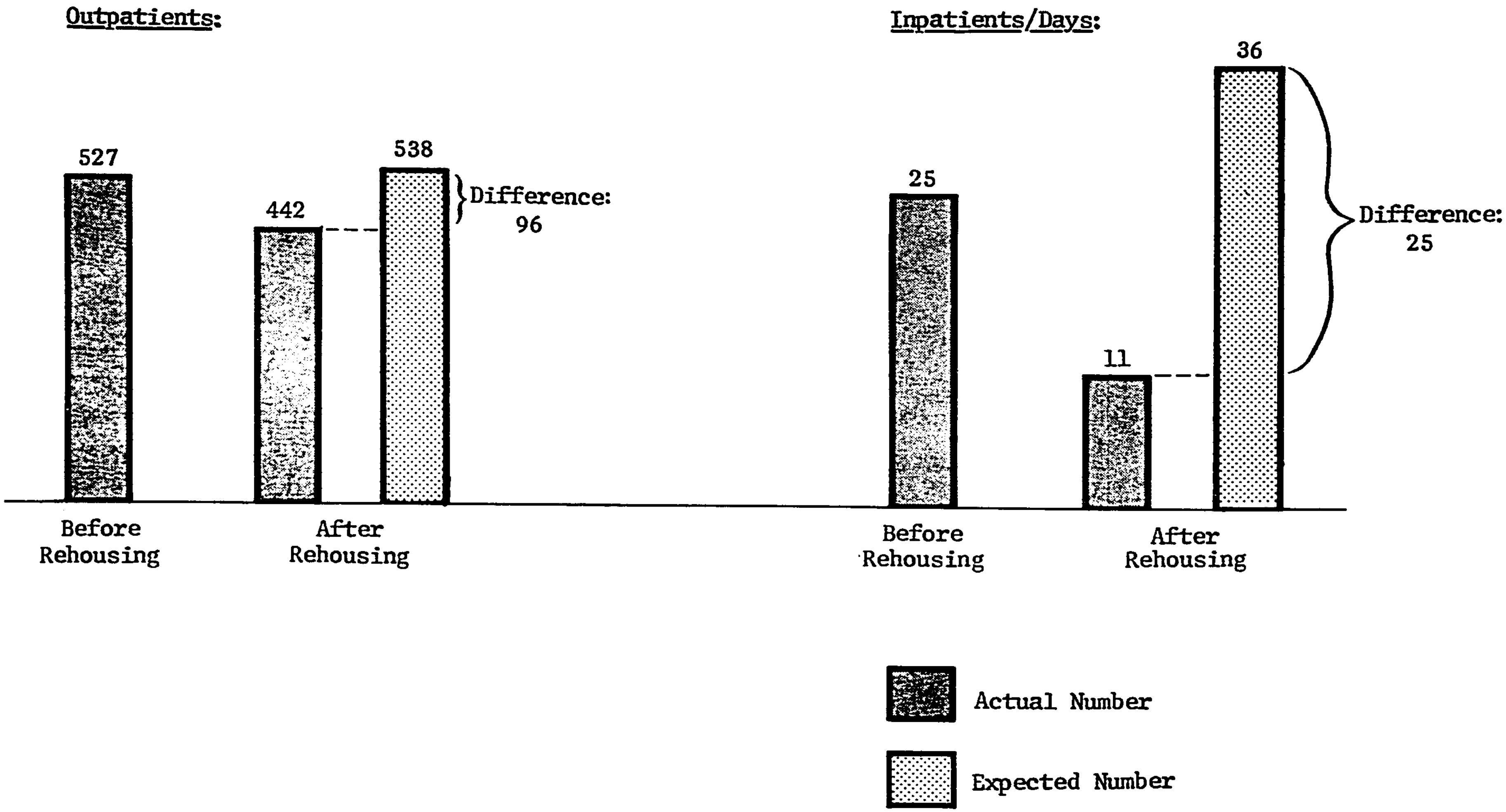

FIGURE 6

Clearly, improved housing favorably affected the health conditions of the rehoused families. Monetary values for the benefits are estimated in the next section.

6. THE BENEFITS OF IMPROVED HOUSING AND COMMUNITY FACILITIES

The benefits accruing from better housing have been estimated in units which are neither additive nor commensurate with costs. Increases in earnings cannot be added to reductions in hospital admissions to arrive at a sum for comparison with the costs of securing these benefits. While index numbers have been used experimentally to reconcile differences in unit measures,[1] one of the most useful common denominators for structuring benefit-cost relationships is price. In this section, benefits are estimated in monetary values and classified in terms of their importance to the Dae Han Coal Corporation as investor, and to the persons rehoused.

The classification of benefits into three categories is useful for purposes of investment planning since returns on housing investment, perhaps the criterion an investor ranks highest, may depend on the worker's own evaluation of the personal benefits related to the personal costs of relocation. For example, the potential candidate for rehousing may evaluate the costs of giving up his present home in excess of the anticipated benefits of a new one. If the improvement in quality is not worth a rent higher than he would pay for inferior accommodations, he may reject new housing. Conceivably too, the higher earnings resulting from reduced absenteeism and greater efficiency at work may not be sufficient to turn his decision. Consequently, if costs outweigh the benefits in the calculus of the worker considering relocation, his decision would likely favor maintaining the status quo. Under these circumstances, pessimistic and unrealistic as they

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[1]United Nations Research Institute for Social Development, The Level of Living Index, Programme C, UNRISD/65/c.28/Rev. 1 (Geneva: The author, 1965), processed.

are, no rents would be generated and the other benefits would never materialize for the investor.

As the example illustrates, housing is a good with both consumption and production properties. Consumption properties are measured by living standards. If rents paid are a valid indicator of housing utility, the consumption value of a new house compared to an old one would roughly be the difference in rents between the two. In the Hambaek case, the renters forsook a rent subsidy in favor of gaining rent-free accommodations. The benefit to the relocated of the superior accommodations clearly exceeded the foregone subsidy, an annual "cost" of 3600 won. As noted, comparable units rented for at least 6000 won. While the rehoused family may not have realized the full value of their new homes, they valued the superior accommodations at something in excess of the lost subsidy.

The production properties refer to the returns generated by the investment. In the convention of capital-output analysis such returns are measured solely as rents. But, as our estimates show, the returns also included improvements in labor productivity which translate into added income for the family, the employer, and the community. The size of these returns is the focus of this section.

6.1. Benefits From Changes in Labor Productivity

Estimates of the benefits in the form of additional income deriving from increased labor productivity are calculated for the rehoused workers and those not rehoused. The latter estimates are based on the "demonstration effect" (Section 4.3). Since the size of this effect and the consequent benefits are partly determined by the ratio of rehoused to non-rehoused, it is likely (though far from certain), that the effect's magnitude diminishes with increases in the number of dwelling units built. Because the nature of this function is beyond the scope of this report and impossible to estimate, the effect must be calculated from a single known point: the ratio of families not rehoused to rehoused, 638/497 or 1.28/1. Stated another way, each new dwelling unit generated benefits for 1.28 nonrehoused workers in addition to the rehoused family or 2.28 families in total.

The money value of labor productivity benefits excludes the adjustment period of the first year after rehousing. Except for this year, the increase in annual income from improved labor productivity of the test and control groups was 526 won and 455 won respectively (Table 7). Relevant benefits from this source attributable to a single dwelling unit are the weighted sum obtained as:

Annual income increase of one rehoused worker:	526 won
Annual income increase of 455 won for 1.28 non-rehoused workers:	582 won
Total annual income increase attributable to one new dwelling:	1108 won

Unless the advantages of these increases are transferred completely to labor in the form of higher wages, the mine corporation also benefits from the increase in labor productivity. Profits increase from scale economies deriving from more effective utilization of existing capital with less than proportional increases in costs. Within certain limits, the size of fixed capital investment, e.g., mining equipment, and fixed costs, e.g., operating costs of the administration, are independent of the level of output. When output increases, the size of both fixed items in the corporate budget may remain unchanged but, by definition, surely do not change in equivalent proportions to the change in production and earnings. In this particular case we will consider those costs as fixed, which remain unchanged with an increase in output of 28.8 percent, the average productivity increase per miner.

The increase in the net value of final product added by the mine workers is equivalent to the gross increase in value added less all variable non-labor inputs required for the increase. The following steps lead to the estimate of value added traceable to a single new dwelling unit:

First, output per mine worker in 1963 and 1964 was 372,082 and 424,175 won respectively.[2] Since the 1964 figure reflected the productivity increase resulting from rehousing and the previous year did not,[3] 1963 is the base for calculating values for relevant changes. We have estimated that improved housing was responsible for increasing the labor productivity of the rehoused and non-rehoused 31 and 27 percent respectively (Table 8). The average productivity increase for all miners, weighted by the relative numbers of rehoused and non-rehoused, is 28.8 percent. The value of production per miner increased 107,160 won or 28.8 percent over 372,082. This amount includes variable costs which must be deducted to determine the net relevant benefit.

Second, in the absence of precise accounting figures for the Dae Han Corporation's Hambaek operation, variable costs are estimated from averages for the Korean coal industry (Table 11). Sales costs are largely variable. Because the data source fails to reveal whether the sales costs item contains any fixed elements, it is assumed to be composed entirely of variable elements. This assumption, if false, leads to an underestimate of value added and, consequently, of the size of the relevant benefit. Other operating costs, consist of general administrative charges such as salaries and expenses of administrative personnel, office equipment, and general expenses. Within limits, these costs are unaffected by changes

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[2]Ratio of total production to total number of production workers (Tables 1 and 2).

[3]Changes in labor productivity during the brief period from the relocation date (September 26, 1963) through the balance of the calendar year were negligible.

TABLE 11. SELECTED OPERATING RATIOS, THE KOREAN COAL INDUSTRY[a]

Year	Sales Costs to Net Sales	Other Operating Costs to Net Sales	Operating Profit to Net Sales
1961	74.11%	14.10%	11.79%
1962	90.18%	5.77%	4.05%
Mean	82.14%	9.94%	7.92%

a Each row sums to 100 percent. Sales and other operating costs equal total operating costs.

Source: Research Department, Bank of Korea. Economic Statistics Yearbook, 1964 (Seoul: The author, 1964), pp. 172-177.

in the level of production. The same applies to the profit margin (7.92%) which is largely independent of output level within reasonable limits. Since the increase in production of the Hambaek mine resulting from the productivity increase would affect total Korean coal production by a spare 1.5 percent, the affect on coal prices and, therefore, on profits would be of negligible importance.

Third, deducting variable costs of 88,021 won (.8214 x 107,160) from the increase in gross value added per worker (107,160 won) yields a net increase in value added of 19,139 won per miner. Fourth, since there were 1.28 nonrehoused workers per rehoused worker, and one rehoused worker in each new house, the relevant benefit per dwelling is 2.28 times the increase in net value added per miner, or 43,632 won.

In sum, the derivation of relevant increases in value added per new dwelling unit is as follows:

1. Increase in gross value added (total production) per miner. . .107,160won

   Obtained as the product of (a) the weighted average increase in production per miner, 1963-1964 (28.8 percent), and (b) production per miner, 1963 (372,082 won)

2. Less variable costs . . . . 88,021 won

Obtained as the product of (a) the mean ratio of sales costs to net sales (82.14 percent), and (b) the increase in gross value added per miner (107,160 won)

3. Equals the increase in net value added per miner. . . . . . 19,139 won

4. Increase in net value added per dwelling unit . . . . 43,632 won

Obtained as the product of (a) the increase in net value added per miner (19,139 won), and (b) the ratio of the number of miners to the number of new dwelling units (2.28)

If the estimates of the share of increased labor productivity attributable to better quality housing during 1963 were extrapolated to 1965, total output would be 739 million won rather than 504 million won, the actual level (Table 2). The difference can be explained by reduced demand for Hambaek coal during the latter year. The decrease could be accommodated either by reducing overtime work (which occurred) or by lay-offs. Either alternative would be reasonable even with labor productivity increases. While the benefits to employees would still accrue in the form of increased earnings, income for the region would decline as a result of the decrease in sales. However, an already high unemployment rate would be further aggravated in the short-run by lay-offs. Over the longer period, capital would be used more intensively with new investments adjusted to reflect anticipated (reduced) demands for final product. Consequently, in the short run, the relevant increases in value added can be realized only if demand expands sufficiently to accommodate productivity increases. Otherwise, the advantages accrue only in the long run.

6.2. Benefits From Changes in Health

Imputing money values to the benefits of better health deriving from improved housing is not an easy task. Merely noting that the number of outpatient admissions dropped .49 per annum and the number of days of hospitalization was .127 fewer than if rehousing had not occurred, is insufficient. The full money value of these improvements in health attributable to better housing can be measured only partially by the direct cost savings from reduced need for clinical and hospital care. Yet a reduction to money units is required for comparison with other benefits and the most indicative proxy is savings in the cost of medical and health care.

The Hambaek case is somewhat unique since the principal burden of medical costs is borne by the Corporation. Medical care is provided at no charge to employees and families are required to pay only the costs of medicines, a negligible share of the total medical bill. Costs per outpatient visit and inpatient day are 448 and 647 won respectively.[4] To arrive at an estimate of the changes per household, the per capita changes developed in Table 10 must be multiplied by six, the number of persons in the average Hambaek family. Per household, the changes are reductions of 2.94 outpatient visits (6 x 0.49) and 0.762 days of hospitalization (6 x 0.127). In monetary terms, relevant annual savings in the need for clinical care and hospitalization total to 1,810 won per family. In sum, the total is derived as follows:

For outpatients . . . . 1,317 won

Obtained as the product of (a) the relevant change in annual number of clinical admissions per person (0.49), the number of persons per family (6), and (b) the cost per clinical visit (448 won)

[4]For details, see Appendix III.

For inpatients . . . . 493 won

Obtained as the product of (a) the relevant change in number of days hospitalized per person (0.127), (b) the number of persons per family (6), and (c) the cost per hospital day (647 won)

Total money value of reduction in medical costs. . . . . 1,810 won

These estimates assume that all costs of providing medical care are variable and consequently that capacity of the hospital and clinic can be adjusted with changes in the need for medical and health services. Alternatively, it must be assumed that the capacity of the hospital and medical services is insufficient to satisfy need. Otherwise, reductions in the demand for services would generate excess capacity and the relevant benefits would fail to materialize.

The assumptions are invalid and the benefits would be overestimated, only in the very short run. Over the long run, all costs become variable since capacity can be adjusted to the required level. Hence, if the need for medical services declines as the result of improvements in housing or in other facilities improving environmental health, the budget for hospital and clinical services can be reduced correspondingly.

When medical and health costs are charged directly to the patient, the benefits from cost reductions are reflected in his personal budget. Reductions in costs for care provided at public expense or by the corporate employer, as in the Hambaek case, accrue to the public or corporate treasury. Except for costs of medicine, the benefactor in this instance is the Corporation.

6.3. Allocation of Benefits

In this section, we have imputed monetary values to a series of benefits attributable to improved housing. For certain benefits, such as the increase in value added and the reduction in the need for medical care, it can be argued that true values are not fully realized in the short run; this however, is no reason for disregarding such benefits. The same would hold for technological developments where short run adjustments militate against full realization of returns until the distant future.

The values for benefits, measured in 1963 prices and with corrections for across-the-board wage increases are listed in Table 12. The list of benefits assessed here is not comprehensive and include only those that could be measured without launching a substantially more ambitious data collection effort. Among the benefits excluded are those generated by increased exposure to education, an omission necessitated by the lack of data on school performance or attendance of the rehoused children.[5]

TABLE 12. SUMMARY OF ANNUAL RELEVANT BENEFITS PER DWELLING UNIT ALLOCATED BETWEEN CORPORATION AND WORKERS (in won of 1963)

Type of Benefit	Corporation		Workers	
	Income Increase	Income Decrease	Income Increase	Income Decrease
House rents:				
Elimination of subsidy	3,600			3,600
Rent paid	0		6,000	
Earnings		1,108	1,108	
Value added	43,632			
Medical costs	1,810			
Total net increase	47,934		3,508	

[5]For measurements of these benefits related to improved housing, see Leland S. Burns, "Case Study of a Cost-Benefit Analysis of Improved Housing", paper prepared for the Meeting of Experts on Cost-Benefit Analysis of Social Projects, United Nations Research Institute for Social Development, Rennes, France, September 26-October 2, 1965, processed.

7. AN EVALUATION OF INVESTMENT IN HOUSING AND COMMUNITY FACILITIES

Investment in housing is customarily justified on social grounds with little relevance to economic growth. Benefits of the type we have estimated in the previous sections are traditionally ignored in evaluating returns to housing. In this section, we compare the economic feasibility of investment in housing and community facilities with alternative investment possibilities in Korea.

An important and frequently used investment criterion is the comparison of benefits to costs. More often than not, benefit-cost analyses are limited to considering the rationality of an investment in isolation. Because it is difficult to take account of the full range of benefits, indirect returns, or macro-economic returns, are frequently ignored. Moreover, the costs of the project under consideration may be benefits to another project, yet the costs decrease the subject project's attractiveness to the investor but contribute to the welfare of the community-at-large.

Capital-output analysis, which ignores non-capital costs and interest, is often a preferable criterion for evaluating profitability in terms of the macro-, as well as the micro-, economy. The ratio measures the number of units of capital required to generate one unit of output per annum or the number of years required to recapture capital.

Although an appropriate interest rate is difficult to establish due to large fluctuations over time and among investment alternatives, rough approximations will be made for discounting streams of future returns in order to compare the present value of benefits with costs. Because the estimates are necessarily crude, a second set of calculations will be made using capital-output ratios. Each set of calculations will yield certain unique insights of use to investment planning and permit comparisons between housing and other investment possibilities.

7. 1. Cost-Benefit Analysis of the Investment in Housing and Community Facilities

Relevant benefits of an investment in one housing unit have been estimated at 51,442 won per annum following an adjustment period of one year. Of this amount, 47,934 won accrued to the Corporation and were largely due to a substantial increase in value added (43,632 won) deriving from increases in labor productivity. The balance of 3,508 accrued to the worker in the form of a higher living standard deriving, in turn, from increased earnings and improved housing (Table 12).

Costs were of two types, capital and operating. Operating costs, or items recurring over the useful life of the project, consist of depreciation, interest charges, and costs of administration. Average capital cost per unit was 149,781 won (Section 2.2). Based on the quality of the structure, the average lifetime of these dwellings can be conservatively estimated at 40 years. Using straight-line depreciation, the value of the structure 140,045 won, (exclusive of land value of 9,736 won), would decline an average of 2.5 percent annually, or 3,501 won.

As noted earlier (Section 2.2), the housing project included related community facilities. The costs of these facilities, together with the costs of land, roads, and electrical and water distribution systems, represented about 43 percent of the investment per dwelling. The costs of community facilities must be included as a part of the capital costs of housing since both investments occurred simultaneously, and both improved housing and community facilities may have reacted favorably on labor productivity. However, since the improvement in community facilities was moderate compared to the improvement in housing, it seems likely that housing had a substantially greater impact on productivity.

Further, as Figure 1 indicates, the new community facilities together with the new residential community were completely separate and located at some distance from the original community of Hambaek. For this reason, they were relatively inaccessible to the non-rehoused population and can therefore hardly be considered to have any material effect on the productivity level of the non-rehoused population.

Due to lack of more detailed data, we shall arbitrarily assume that community facilities accounted for a conservative 20 percent in addition to the construction costs per dwelling with land (149,781 won). We assume further that depreciation of these facilities can be neglected since the bulk of costs are for land. Thus, the total investment per dwelling, and the proportional share of community facilities, is 179,737 won (120 percent of 149,781 won).

The average interest paid on capital was 4 percent (Section 2.2). However, the rate reflects a substantial element of subsidy in the counterpart loan rather than the market rate. Though there is considerable controversy over the proper rate to apply to investment projects in less developed countries, the weight of evidence suggests about ten percent.[1] The rate we have chosen, 15 percent, is conservative by these standards and represents a rough average of 1963 interest rates in Korea which fluctuated between eight and twenty percent (Table 13). Over the term of the loan for a dwelling plus its share in community facilities of 179,737 won, average unpaid principal outstanding represents half the capital cost of the new asset yearly or 89,869 won. At the shadow price rate of 15 percent, the yearly interest charges for this investment is 13,480 won.

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[1] Cf. Jan Tinbergen, Cost-Benefit Analysis of Social Projects (Geneva: United Nations Research Institute for Social Development, 1966), and Jack Hirschleifer, James C. DeHaven and Jerome D. Milliman, Water Supply: Economics, Technology, and Policy (Chicago: University of Chicago Press, 1960), Chapter VII.

TABLE 13. PREVAILING INTEREST RATES FOR SELECTED TYPES OF CREDIT, KOREA, MAY 1963

Type	Rate (percent)
Loans for the purchase of aid goods	13.87
Loans for foreign trade	8.03
Loans on bills	15.70
Discounts on bills	13.87
Overdrafts	18.25
Loans overdue	20.00

Source: Bank of Korea, Monthly Statistical Review, May 17, 1963.

Because data on administrative and related costs are unavailable, this amount is arbitrarily estimated at ten percent of depreciation and interest. The estimate is likely conservative since costs of maintenance, which include administrative costs, are paid by tenants.

Annual operating costs of 18,679 won per dwelling unit are itemized as follows:

Depreciation (.025 x 140,045 won)	3,501 won
Interest costs (.15 x 179,737/2)	13,480 won
Administrative and related costs (.10 x (13,480 + 3,501))	1,698 won
Total	18,679 won

Relevant annual benefits related to total capital invested are 16.3 percent for the Corporation and 18.2 percent for the community-at-large.[2] The derivation is as follows:

	For the Corporation	For the Community-at-Large
Total annual relevant benefits	47,934 won	51,442 won
Total annual operating costs	18,679 won	18,679 won
Relevant benefits less operating costs	29,255 won	32,763 won
As a percent of total capital invested (179,737 won)	16.3	18.2

[2]The sum of relevant benefits accruing to the Corporation and the worker (Table 12).

The return of 16.3 percent is doubly impressive when contrasted to average profit rates for industrial investments in Korea. For example, the average rates for mining and manufacturing were, respectively, 10.2 and 7.2 in 1961 and 1962. Ratios listed by detailed sectors in Table 14, and ranging from 3.33 to 16.55 percent, are based only on direct returns exclusive of indirect benefits accruing to other investors. The comparison indicates clearly and dramatically the profitability of the housing project to the Dae Han Corporation.

Several factors account for the marked difference between the rate of return from the Hambaek project and the averages for alternative investments. Scale economies, or the more efficient utilization of existing investment, are one important reason. The externalities to the Dae Han Corporation, principally in the form of substantial increases in value added, are generated without additional direct investment in plant and equipment, and with less than proportional increases in operating costs principally due to the fixed cost component. This advantage is inherent in capital-deepening investment, or investment made expressly for improving labor productivity.

Another reason accounting for the substantially higher rates of return from the housing investment derives from the mine's high operating ratio, or production level relative to plant capacity.[3] This can be contrasted with estimates for manufacturing ranging between two and 124 percent of capacity, depending on time and type of manufacture (Table 15). If the ratio is low, existing capital is inefficiently utilized. According to the Bank of Korea, insufficient supplies of raw materials caused by foreign exchange scarcities

[3]Although data for calculating the mine's operating ratio were not available, the use of overtime to meet increased demands would suggest the ratio is high.

TABLE 14. RATIOS OF NET PROFIT TO GROSS CAPITAL, PRINCIPAL MINING AND MANUFACTURING SECTORS, KOREA, 1961 and 1962

Classification	Ratio
Coal	9.63
Metals	16.55
Stone quarrying	7.64
Non-metal	4.83
Food	8.22
Beverage	9.66
Textile	7.03
Footwear, apparel, etc.	7.14
Wood and cork	11.14
Furniture and fixtures	11.57
Paper and paper products	3.33
Printing and publishing	7.05
Leather and leather products	5.39
Rubber products	8.00
Chemical and chemical products	6.67
Petroleum and coal products	11.84
Clay, glass, and stone products	6.26
Basic metal	5.22
Metal products	6.04
Machinery	8.35
Electrical machinery and appliances	5.93
Transport equipment	5.34

Source: Research Department, Bank of Korea, Economic Statistics Yearbook 1964, p. 176.

TABLE 15. OPERATING RATIOS, PRINCIPAL MANUFACTURING SECTORS, KOREA, 1961-1965 (in percents)

	1961	1962	1963	1964	1965[a]
Refined sugar	26.1	21.8	16.2	7.0	9.4
Wheat flour	23.3	36.4	56.8	27.5	21.9
Ethyl alcohol	35.2	22.0	21.9	17.6	23.8
Cotton cloth	49.8	56.4	56.5	60.8	68.7
Cotton yarn	66.0	78.2	76.3	77.7	71.4
Rayon cloth	84.7	93.2	66.8	73.0	93.2
Nylon	n.a.	n.a.	8.9	7.7	101.5
Newsprint	90.8	98.9	78.6	80.8	82.7
Wood free paper	n.a.	n.a.	87.4	94.2	98.9
Rubber shoes	58.4	73.3	74.3	80.3	50.1
Tires	53.4	59.7	49.9	52.8	46.4
Oxygen	66.8	91.5	114.6	119.2	100.3
Industrial explosives	52.1	75.0	43.3	30.8	33.3
Fertilizer	76.1	95.6	57.5	83.0	96.0
Soap	35.1	50.0	59.9	52.4	40.6
Paint	19.4	27.8	14.6	18.7	19.0
Refined oil	n.a.	n.a.	n.a.	43.7	80.4
Flat Glass	123.9	51.8	97.6	92.6	99.4
Cement	72.6	109.7	108.1	72.2	47.4
Pig iron	9.1	n.a.	8.4	2.0	18.1
Steel ingots	67.7	104.5	86.4	43.7	15.2
Steel bar	n.a.	n.a.	53.3	22.3	16.8
Electrolytic copper	59.1	100.0	100.0	107.7	66.7
Uninsulated electric wire	20.0	45.7	45.7	73.3	53.3
Bicycles	26.6	41.0	21.0	25.8	28.2
Fire bricks	29.8	45.1	48.5	62.2	59.0
Plywood	n.a.	n.a.	83.8	91.2	95.5
Nails	27.0	23.0	58.1	47.3	27.0

[a]January - March only.

Source: Research Department, Bank of Korea, Economic Statistics Yearbook 1964, p. 176.

was a major cause contributing to generally low rates of utilization. Industries using capacity at a low rate due to input shortages would be poor choices for housing projects or for other investments of the capital-deepening type if improvements in labor productivity were expected. The ideal industry is one where production bottle-necks are created only by a qualitatively or quantitatively short supply of labor. Except that the demand for Hambaek coal is unstable and mainly domestic and, as a consequence, the demand for labor may be uneven, the Hambaek mine was close to ideal in this respect.

7. 2. Capital-Output Analysis of the Investment in Housing and Community Facilities

Defining housing output as the sum of relevant benefits accruing to the community-at-large (51,442 won), rather than in the narrower sense as exclusively rents, and capital as the amount of investment in a housing unit plus its share in community facilities required to generate these benefits (179,737 won), yields a capital-output ratio of 3.49. Stated two ways, the amount of won required for producing one won output each year is 3.49, or the capital invested will be recaptured by the community-at-large in 3.49 years. Because the output side includes returns earned by the workers in addition to the investing Corporation, the ratio will be somewhat higher for the Corporation, hence the capital recapture period is somewhat longer (about four years). Since the project is viewed as an instrument for development of the macro-economy, rather than for the sole profit of the investor, this allocation problem disappears.

The ratio of 3.49 compares favorably with alternative investments. Chenery and Strout have estimated the incremental capital-output ratio for Korea at an average of 3.74 for the period 1960-1964.[9] The average estimated

[9]Hollis B. Chenery and Alan M. Strout, "Foreign Assistance and Economic Development," A.I.D. Discussion Paper Number 7, Office of Program Coordination, A.I.D., June, 1965, processed, Table A-1.

by Ki Choon Han for the same period was 3.42.[10] His estimates, listed in Table 16, show rather sharp annual fluctuations between 1954 and 1964. The annual ratio ranged over the decade from a low of 1.64 in 1964 to a high of nearly 8.00 in 1956, an extreme attributed to the bad harvest of that year.

The average ratio also varied by industry, as would be expected (Table 17). The variations, like those in the net profit ratios (Table 14), are in part explained by different operating ratios. Other things equal, a low operating ratio and, consequently, under-utilization of plant and equipment would produce a high ratio of capital to output.

The comparatively high capital-output ratio for "ownership of dwellings" (6.98) closely approximates the early ratio developed by Leontief for the American economy (7.1).[11] Both measures define output only as rents earned by the investor. Applying this rule to the Hambaek project would yield estimates of 25 (or 149,781/6,000)[12] if the rents were shadow-priced, or 41.6 (149,781/3,600) if returns were defined in terms of savings in rent subsidy. In either case, a narrow construction which considers housing as investment only for consumption purposes, is singularly myopic and of course places housing in a most unattractive position. Defining output more broadly, and more properly, as indirect as well as direct returns, not only puts housing in a decidedly more favorable competitive position for investment resources

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[10] Ki Choon Han, "Capital-Output Ratio in Korea -- A Trial," Quarterly Economic Research, June 1964, Economic Planning Board, Republic of Korea.

[11] Wassily Leontief and others, Studies in the Structure of the American Economy (New York: Oxford University Press, 1955), pp. 220-221.

[12] The estimates are of course somewhat exaggerated by comparing the capital required for a new, undepreciated dwelling with the monthly rent assumed at 500 won for a comparable older house.

TABLE 16. MARGINAL CAPITAL-OUTPUT RATIOS, KOREA, 1954-1964

Year	Ratio
1954	1.69
1955	1.80
1956	7.91[a]
1957	1.84
1958	1.91
1959	2.59
1960	7.32[a]
1961	2.36
1962	4.00
1963	1.80
1964	1.64
Average	3.17

[a]These figures are due mainly to bad harvests.

Source: Ki Choon Han, "Capital-Output Ratio in Korea -- A Trial," Quarterly Economic Research, Economic Planning Board, Republic of Korea, June 1964.

TABLE 17. AVERAGE CAPITAL-OUTPUT RATIOS, BY INDUSTRY, KOREA, 1962

Industry	Ratio
Agriculture, forestry, and fishing	1.54
Mining and quarrying	.42
Manufacturing	1.07
Construction	3.95
Electricity, water, and sanitary services	12.03
Transportation, storage, and communications	7.09
Ownership of dwellings	6.98
Average	2.41

Source: Ki Choon Han, "Capital-Output Ratio in Korea -- A Trial," Quarterly Economic Research, Economic Planning Board, Republic of Korea, June 1964.

but is more realistic in terms of its contribution to economic growth.

Another related sector is construction which, with other sectors, also benefits from investment in new housing. Due to the linkages or inter-dependencies among industries an increase in the demand for housing generates derived demands for the output of many industries, but most particularly for construction. The benefits to the building industry will be larger, the lower its operating ratio, since the increase in output can be accommodated with a less than proportional increase in investment. Unfortunately, no data are available on the operating ratio of the construction industry to support such a conclusion, however annual construction volume in square meters is a crude proxy (Table 18). Unless the industry can contract and expand rapidly, the wide fluctuations in output revealed by the time-series, strongly suggest a low level of production relative to capacity. With output of 1.74 million square meters in 1959, it is likely that the industry operated with excess capacity during earlier years when output averaged only about 1.1 million square meters and between 1960 and 1962 when the figure averaged approximately 1.4 million. If true, then the derived demands for output from the construction industry are likely to yield sizable returns by more effectively using existing capacity.

TABLE 18. BUILDING PERMITS IN FLOOR AREA, KOREA, 1956-1964
(In Thousands of Square Meters)

Year	Dwellings	Total
1956	328.9	1,114.8
1957	263.9	1,055.6
1958	443.2	1,251.8
1959	734.8	1,741.6
1960	650.1	1,402.7
1961	370.5	1,161.4
1962	390.6	1,699.6
1963	747.6	2,152.8
1964	829.6	2,509.7

Source: The Bank of Korea, "Review of Korean Economy in 1964" (Seoul: The Author, 1965), p. 133.

The evidence presented in this section supports the economic feasibility of housing as a tool for the economic development of the Hambaek region. Although housing ranks as a particularly attractive investment in comparison to alternative uses of capital, more definitive conclusions can only be drawn after considering side-effects on the Korean economy: the influences on the balance of payments, on prices, and on linked industries.

APPENDIX I. REGRESSIONS FOR LABOR PRODUCTIVITY ESTIMATES

a. Linear Trend of Earnings Over Time.

The data for wages earned by each group of 50 rehoused and 50 non-rehoused miners were provided for pay periods each of ten days length and exclude overtime. We define the following variables:

W_r = wages (in won) earned by the rehoused (test) group,

W_n = wages (in won) earned by the non-rehoused (control) group, and

T = trend factor (the first ten-day period for each interval before and after rehousing = 1).

From the development of earnings graphed in Figure 2, it seems likely that the shape of the trend for the year before rehousing is linear. Regressing earnings against time for each group of workers during this period yields the following:

$$W_r^b = \underset{(169.2569)}{137.8484}\,T^b + 118{,}183.2764, \tag{1}$$

$$W_n^b = \underset{(270.0861)}{199.6432}\,T^b + 117{,}032.8213, \tag{2}$$

where superscript b identifies the year before rehousing and superscript a will denote the period following, as in equations (3) and (4). The trend factors are insignificant since the corresponding standard errors (indicated in brackets) are substantially larger than the trend coefficients. In other words, the trend of earnings before rehousing is statistically insignificant, hence zero.

The earnings data for the first year after rehousing show the following relationships to time:

$$W_r^a = \underset{(306.7678)}{979.7725}\,T^a + 116{,}838.6250, \tag{3}$$

$$W_n^a = \underset{(284.5618)}{982.2448}\,T^a + 112{,}265.4434, \tag{4}$$

The trend of earnings for both groups of miners was highly significant over this period since the computed t-value, the ratio between the regression coefficient and the corresponding standard error, was larger than two while the number of observations was 36. Based on these regressions, the increase in weekly earnings in each group of 50 was 13.72 won per week for the average test group member and 13.75 won for the average control group member. The derivation of the latter estimate from regression equation (4) will illustrate the adjustment. From the equation, total wages for the sample of 50 increased 982.24 won each ten days, or 19.645 (equivalent to 982.24/50) per worker on average. Adjusting to a week from the ten-day pay period requires multiplying by seven-tenths to yield 13.75.

b. Linear Trend of Differences in Earnings Over Time.

The positive trend of earnings after rehousing, in contrast to lack of any trend prior to rehousing, is not conclusive evidence that better housing is responsible for the increases. Such a conclusion requires an analysis of the differences between wages earned for each time interval during the period after rehousing and the corresponding time interval during the period before; that is, the wages earned in the first ten-day period after rehousing minus the wages earned in the first ten-day period of the interval before rehousing, and so on. If these differences are significantly larger than zero, then earnings after rehousing are significantly larger than prior to rehousing.

The previous set of regressions suggest an increasing trend in wage differences between the two years. Regressions of these differences yield the following:

$$W_r^* = \underset{(317.3599)}{841.9241}\, T^* - 1{,}344.6508, \qquad (5)$$

$$W_n^* = \underset{(362.4476)}{782.5902}\, T^* - 4{,}767.0857, \qquad (6)$$

where W^* is the difference between wages earned after rehousing during each ten-day period and the earnings of the corresponding periods prior to rehousing. The estimates show that earnings are indeed significantly larger than zero at the 95 percent level of confidence with a significantly increasing trend. Hence, the earnings after relocation are significantly larger than before relocation.

c. Non-linear Trend of Earnings Over Time.

As indicated in Section 4.4, the wage pattern of each group of workers, control and test group, follows a learning or logistic curve (Figure 4). The curve is described algebraically as:

$$Y = \frac{A}{1 + be^{-kt}} \tag{7}$$

As Figure 4 suggests, the increases in earnings had dropped nearly to zero at about the tenth month following rehousing. Output had reached its maximum at the new high and further increases in labor productivity could not be attributed to improved housing. The maximum level in earnings, hence output, can be described by rewriting equation (7) and differentiating:

$$be^{-kt} = \frac{A - Y}{Y}, \tag{8}$$

$$\frac{dY}{dt} = \frac{kAbe^{-kt}}{(1 + be^{-kt})^2}. \tag{9}$$

Substituting (8) in (9) gives

$$\frac{dY}{dt} = \frac{Ak\,\frac{A - Y}{Y}}{\frac{A^2}{Y^2}}, \text{ or } \frac{dY}{dt} = \frac{k}{A}(A - Y) \cdot Y. \tag{10}$$

This leads to

$$\frac{1}{Y} \cdot \frac{dY}{dt} = k - \frac{k}{A} Y. \tag{11}$$

From this, it follows that the relative or percent increase in Y ($= \frac{1}{Y} \cdot \frac{dY}{dt}$) is linearly dependent on the absolute level of Y. Both the relative increase in earnings and the absolute earnings for the two-year period following rehousing can be determined in order to estimate the parameters of (11). For each group,

$$\frac{1}{Y^r}\frac{dY^r}{dt} = \underset{(0.00624)}{-0.02649}\, Y^r + 41.9258, \tag{12}$$

$$\frac{1}{Y^n}\frac{dY^n}{dt} = \underset{(0.00594)}{-0.02252}\, Y^n + 34.5051. \tag{13}$$

From equation (11), the regression coefficient of Y is $-\frac{k}{A}$. Since A is the earnings maximum on the logistic curve (7), this level can be calculated by dividing the intercept values, 41.9258 and 34.5051 (= k) for the equations describing test and control group samples respectively, by the corresponding regression coefficients. The earnings maxima derived from these calculations are 2,216 won per week for the average rehoused worker and 2,145 won per week for the average non-rehoused worker.

d. Significance of Differences in Productivity between Test and Control Groups

During the year prior to rehousing, the productivity of the average test group worker exceeded that of the average control group worker 23 of the 36 ten-day pay-periods. If this difference is statistically significant, then its occurrence is not the result of chance. If not, we would expect an even chance, that is, productivity of the average rehoused worker would be greater 18 (half) of the 36 observations and conversely for the remaining half of the total period. Hence, the expected value for each group would be 18. Chi square (X^2) is estimated as follows[1]

$$X^2 = \frac{(23 - 18)^2}{18} + \frac{(18 - 13)^2}{18} = 2.778.$$

Since $X^2_{.01(1)} = 6.635$, the observed difference is insignificant. Hence, the differences may be regarded as negligible.

The differences after rehousing are, however, highly significant. During this two-year period, productivity of the average test group member exceeded that of the average control group member during 58 pay-periods with the reverse holding

[1]For a description of the test see, for example, Ronald A. Fisher, Statistical Methods for Research Workers (London: Oliver & Boyd, 1958).

for the remaining 14 pay-periods. Based on these data, the chi-square is

$$X^2 = \frac{(56 - 36)^2}{36} + \frac{(36 - 14)^2}{36} = 26.889$$

which exceeds $X^2_{.01(1)} = 6.635$ by a substantial margin.

APPENDIX II.

SIGNIFICANCE OF DIFFERENCES IN THE NEED FOR HEALTH AND MEDICAL CARE

Two steps were followed in determining whether changes in the number of in-patient admissions and out-patient visits were statistically significant after rehousing compared to before rehousing.

First, the expected numbers of admissions and visits were calculated for the test group before and after relocation. Verbally, these numbers indicate an expected change in the level if rehousing had not occurred. Calculation of the expected number involves projecting the control group changes, or before/after ratio, on the test group's record. The numbers for before and after relocation were obtained by dividing the sum of the test group's before and after rehousing averages by the before-after ratio of the control group. The expected and actual levels for the test group were as follows:

	Before Rehousing	After Rehousing	Total
Out-patient visits:			
Actual	527	442	969
Expected	480	489	969
In-patient days:			
Actual	25	11	36
Expected	15	21	36

Second, the significance of the differences between expected and actual was calculated using the chi-square (X^2) test. At $X^2_{.01(1)} = 6.635$, the probability is at least 99 percent that the differences between actual and expected values are statistically significant, hence that better housing has significantly affected health and medical conditions, provided that the calculated values for X^2 exceed

6.635. These values are calculated for out-patient visits and in-patient days as follows:

$$X_o^2 = \frac{(527 - 480)^2}{480} + \frac{(489 - 442)^2}{489} = 9.119,$$

$$X_i^2 = \frac{(25 - 15)^2}{15} + \frac{(21 - 11)^2}{21} = 11.429,$$

where subscripts o and i refer to out-patients and in-patients respectively. Since both values of X^2 are greater than 6.635, it follows that the differences are significant and not simply the result of chance.

APPENDIX III. ESTIMATES OF HEALTH AND MEDICAL CARE COSTS

Annual costs of medical care consist of two components, capital amortization (or depreciation) and operating costs. The annual capital element is derived by estimating the depreciation of buildings and equipment from data supplied by the Dae Han Coal Corporation:

	Hospital Building	Medical Equipment
Initial cost	7,425,069 won	2,334,984 won
Annual depreciation:		
Amount given	366,193 won	467,000 won
Price level change	24%	49%
Amount adjusted for price change	454,000 won	695,830 won

The depreciation data supplied (amount given) ignore changes in the price level. Our correction of these data is based on the change in the cost of building materials and general prices in Korea. Between 1960 and 1963, the general price level rose from 100 to 149 while the prices of building materials increased from 100 to 124.[1] To account for these changes, depreciation of the hospital building is increased 24 percent and the depreciation for medical equipment is increased 49 percent to yield adjusted values of 454,000 and 695,830 won respectively.[2]

For purposes of calculating operating costs and differences in costs for out- and in-patients, the following facts are relevant. Hospital rooms and medical

[1] United Nations Economic and Social Council, Review of Housing Situation in the ECAFE Countries, Economic Commission for Asia and the Far East, Committee on Industry and Natural Resources, Working Party on Housing and Building Materials, Eighth Session, Bangkok, Thailand (Bangkok: The author, 1965), p. 51.

[2] This assumes that the hospital and the equipment are about five years old on average.

equipment are used rarely by out-patients. Medical equipment is used extensively for in-patients only for the first examination and seldom during routine examinations. We shall assume first, that, on the average, cost of the use of medical equipment for one out-patient visit is equal to the medical equipment cost of one in-patient hospitalization day and, second, that the use of the hospital room by one in-patient is comparable with the space required for four out-patients.

Since costs of interest for capital were unavailable, two interest rate assumptions are employed. One reflects the cost of subsidized capital, the other, a market rate for capital. The low alternative, four percent, is the rate charged for loans made by the U. S. government for the housing project. The high alternative is an approximation of market rates. Given the structure of interest rates prevailing in May 1963 (Table 14), we have assumed that a rate of about 15 percent is appropriate. The annual interest charges in won are based on one-half the initial costs of the hospital building and its equipment:

	Hospital Building	Medical Equipment
4% alternative	148,501	46,700
15% alternative	556,880	175,124

The costs per patient for depreciation and interest are obtained by dividing yearly costs by the estimated capacity separately for in- and out-patient care. These costs, together with supplementary data provided by the medical staff of the Hambaek hospital, provide costs per in-patient or per hospitalization day.

Hospital capacity is estimated from information on the number of out-patient visits and days of hospitalization. Before rehousing, the average person visited the hospital as an out-patient 2.31 times per year and was hospitalized .157 days per annum (Section 5.2). The services of the medical facility were available to 8,550 persons (1,425 employees times six persons per family). Hence capacity must be sufficient to accommodate 1,342 in-patient hospital days (8,550 x .157) and 19,751 out-patient visits (8,550 x 2.31) each year.

Costs are estimated as follows:

Cost item	Per out-patient visit		Per in-patient day	
	4% Alternative	15% Alternative	4% Alternative	15% Alternative
Depreciation:	51.0	51.0	105.0	105.0
For the hospital building[a]	(18.0)	(18.0)	(72.0)	(72.0)
For the medical equipment[b]	(33.0)	(33.0)	(33.0)	(33.0)
Interest charges	8.1	30.5	25.8	97.1
Doctors' costs[c]	250.0	250.0	250.0	250.0
Medicine and other costs[c]	128.0	128.0	231.0	231.0
Total for one visit or day	437.1	459.5	611.8	683.1
Average for one visit or day	448		647	

[a]Total annual depreciation is divided by 19,751 plus 4 x 1,342 in-patients to arrive at depreciation for one day hospitalization as an out-patient.

[b]Since in- and out-patients are comparable, the figure was derived as depreciation divided by 21,093 patients.

[c]Given.

Hospitals in the vicinity of Hambaek charged an average of 440 won for an out-patient visit or for one day hospitalization. However, it is questionable whether these facilities are fully self-supporting. For instance, their depreciation costs fail to take price changes into account and it is likely that the hospital costs are subsidized or supported externally to some extent.

Since the four percent and 15 percent alternatives hardly differ in total, the estimates in the text are based on the average of both alternatives.

APPENDIX IV. SELECTED CENSUS OF POPULATION AND HOUSING DATA, KOREA, 1960

(all figures in thousands)

	Urban	Rural	Total Number	Total Percent
Population characteristics				
Population, total	6,851	17,593	24,444	100.0
Male	3,349	8,644	11,993	49.1
Female	3,502	8,949	12,451	50.9
Households, total	1,263	3,120	4,383	100.0
Private	1,250	3,095	4,345	99.1
Collective	13	25	38	0.9
Housing characteristics				
Dwelling units, total	1,300	3,170	4,470	100.0
By occupancy status				
Occupied	1,263	3,120	4,383	98.1
Vacant	37	50	87	1.9
By number of rooms				
1	608	652	1,260	28.2
2	397	1,395	1,792	40.1
3	178	750	928	20.8
4	70	256	326	7.3
5	24	62	87	1.9
6	7	28	34	0.8
7	3	5	8	0.2
8	3	3	6	0.1
9	--	1	1	0.0
10+	3	3	6	0.1
Unknown	7	15	22	0.5
Median*	1.1	1.7	1.5	
Mean*	1.9	2.3	2.2	
Dwelling units, total	1,300	3,170	4,470	100.0
By room area (in Pyong)				
Less than 2	432	498	930	20.8
2-3	482	1,304	1,785	39.9
4-5	196	834	1,030	23.0
6-7	86	319	405	9.1
8-9	40	109	149	3.3
10+	45	57	102	2.3
Unknown	19	49	69	1.6
Median*	2.4	2.8	2.7	
Mean*	3.3	3.7	3.5	
Dwelling units, total	1,300	3,170	4,470	100.0
By various types of facilities				
With kitchen	1,155	3,054	4,209	94.2
With bathroom	54	28	82	1.8
With storeroom	119	763	882	19.7
With electricity	889	347	1,235	27.6
With radio	401	249	651	14.6
With barn for cattle	63	1,225	1,288	28.8

*Estimates

(Table continued on next page)

	Urban	Rural	Total Number	Total Percent
By type of toilet				
Earth pit	115	615	731	16.4
Concrete pit	317	517	835	18.7
Flush	4	1	4	0.1
Other	428	1,798	2,226	49.8
None	429	223	652	14.6
Unknown	7	15	23	0.5
Dwelling units, total	1,300	3,170	4,470	100.0
By source of drinking water				
Public well	548	2,538	3,086	69.0
Private well with pump	38	35	72	1.6
Private well without pump	73	318	391	8.7
Public piped water system	392	6	398	8.9
Private piped water system	211	2	213	4.7
Other	29	254	283	6.3
Unknown	9	17	26	0.6

Source: Korea Economic Planning Board, "Sample Tabulation, Advance Report for the 1960 Population and Housing Census of Korea." Tables 1, 19, 20, 22-25.