PRODUCTIVITY CHANGE FOR CARPENTERS AND OTHER OCCUPATIONS IN THE BUILDING OF SINGLE-FAMILY DWELLINGS AND RELATED POLICY ISSUES

by

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Max DeGialluly, Erwin Dreessen, and Clyde Johnson

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PREFACE

The purpose of this study was to develop, for the first time to my knowledge, average physical labor productivity estimates for as many building trades occupations as our financial resources would permit. The result was the derivation of these data for carpenters and a group of related occupations involved in the on-site building of single-family dwellings in 1930 and 1965. Although the analysis is restricted to Alameda County, California, I believe the results are applicable to other areas where wood is a major building material and where merchant builders dominate the market.

Having derived the physical labor productivity estimates, it was possible to compute the rate of change in productivity for the individual occupations and to use the results to examine three issues that originally motivated the undertaking of this research, i.e.,

1. How and to what extent have new building techniques influenced the employment of carpenters over the 35 years?

2. What is the impact of productivity change on forecasting labor requirements in the selected building occupations?

3. What, if any, has been the inflationary bias of wage rate increases in these occupations?

This study received its initial impetus from the late C. R. Bartalini, former Secretary of the Bay Counties District Council of Carpenters and former President of the California

State Council of Carpenters, who sought answers to the above questions, "No matter what the answers are."

In order to accomplish the goals of this research, I designed the project in such a way that the results would emerge from an intensive examination of actual building practices in the two periods. This meant that typical houses of each period were designed, specified in detail, and then estimated with respect to the use of labor and material.

The raw data needed to complete the research design were developed under my supervision by three assistants, Max DeGialluly, Erwin Dreessen, and Clyde Johnson. Mr. DeGialluly, a graduate student, conducted the extensive building permit survey required, derived the characteristics of the typical houses, reviewed the trade literature from 1930 forward, conducted interviews, and photographed the houses selected for study. Clyde Johnson, former Business Agent of Local 550 in Oakland and a journeyman carpenter, assisted in the building permit survey. Most of his time, however, was devoted to developing detailed specifications of the typical houses, searching for data sources and finding needed estimators' handbooks and price lists (which was especially difficult for 1930), and preparing cost estimates of the detailed typical houses. The grant supporting Mr. Johnson's services expired before this tedious assignment was completed. Erwin Dreessen, a graduate student, was trained by Mr. Johnson, and he completed the final cost estimates of all the houses. His final estimates appear in Tables 2-13, Table 16 and the Appendix A Tables.

(It should be mentioned that the tables in Appendix A as well as those in Appendix B represent but a summary of far more detailed work.) In addition, Mr. Dreessen is responsible for the detailed descriptions that appear in Chapter II, Sections 2-5, and in Chapter III, pages 74 to 80. I am indebted to Mr. Dreessen for his meticulous reading of an earlier draft of this study.

I prepared the original working outline of this research in January 1966. Following that time, I supervised the work of the staff in the preparation of the basic data on the sample houses. In addition, I determined the scope of other research, conducted interviews with a host of persons knowledgeable in the field, and periodically spoke to carpenter and contractor groups where I learned a great deal from the "give and take" involved.

The final detailed estimates of the houses were completed by Mr. Dreessen in August 1969. The length of time between the first research proposal and the final cost and manhours' estimates was a function of three constraints: (1) the graduate students worked only part-time; (2) the time-consuming nature of the work involved in estimating costs for the detailed house specifications; and, (3) the enormous number of manhours required to conduct the building permit survey and to analyze the resultant data. In fact, the body of data collected from the building survey would by itself have provided the basis for a fascinating report.

After August 1969, I was able to start work on the monograph. If any major research appeared on this subject after the fall of 1969,

it will thus not appear in the bibliography. The first reading copy of this study was completed in January 1970. Unfortunately, the time between the first reading copy and this final manuscript was interrupted by circumstances beyond my control. To the many persons who awaited these results I am deeply appreciative of the patience they showed. In particular, I owe a debt of thanks to Joan Lewis, Senior Administrative Assistant of the Institute of Industrial Relations, who bore the brunt of carrying out the administrative detail related to the project.

I wish to thank the following persons for assistance during various stages of this project or for reading an earlier draft. They are

Al Figone, Secretary-Treasurer, Bay Counties District Council of Carpenters,

Clive Knowles, Research Director, California State Council of Carpenters,

William T. Leonard, Executive Vice President, Associated Home Builders of the Greater East Bay Inc.,

Junius Porter, member of Local 36 and a student in the Labor Center's Minority Trade Union Leadership Training Program, and

Anthony Ramos, Executive Secretary-Treasurer of the California State Council of Carpenters.

I am especially grateful to Don Vial, Chairman of the Center for Labor Research and Education, for his interest in this project, for the many discussions we had which assisted me in sharpening the issues, and for his critical reading of an earlier draft.

The financial support for this project was pieced together from a variety of sources.

1. The material in this project was prepared under Grant No. 91-05-67-61 from the Manpower Administration, U.S. Department of Labor, under the authority of Title I of the Manpower Development and Training Act of 1962, as amended. Researchers undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment. Therefore points of view or opinions stated in this document do not necessarily represent the official position or policy of the Department of Labor. In the grant proposal, the project was entitled "A Study of Changing Skill Requirements in the Building Trades."

2. The Associated Home Builders of the Greater East Bay Inc. gave a gift to the Institute of Industrial Relations for use on this project.

3. Other funds given to the Institute of Industrial Relations for this project were contributed by the:

a. Bay Counties Carpenters Apprenticeship and Training Program;

b. Carpenters Joint Apprenticeship Committee Fund for Southern California;

c. 42 Counties Carpenters Joint Apprenticeship and Training Committee; and,

d. San Diego County District Council of Carpenters.

I am especially grateful for the interest shown by the Apprenticeship Directors, respectively, Gordon A. Littman, Charles M. Sanford, E. A. Brown, and Fred B. Gough.

4. Financial help was provided by the Work-Study Program.

5. Last, but not least, the balance of the financial assistance was provided by the Institute of Industrial Relations. We are particularly grateful for the interest and support received from the Director, Lloyd Ulman. Further, I wish to thank George Strauss, Associate Director of the Institute, who kept me apprised of new references dealing with aspects of this subject matter.

As the above list implies, this project existed on a financial shoestring.

I wish to thank Linda Dayton and Barbara Porter for typing the text of the final draft, Jeanette Podvin for typing all of the tables except those in Appendix A, and Christine Lira for typing the Appendix A tables. Further, I am indebted to Linda Dayton for preparing the Table of Contents and to Jeanette Podvin for preparing the List of Tables. In addition, I am grateful to Hazel Grove who made needed corrections to the manuscript. These members of the Institute staff made the final stages of this project almost enjoyable.

Sara Behman

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SUMMARY AND CONCLUSIONS

1. General Comments

Has physical labor productivity of carpenters and other building occupations increased in the construction of single-family dwellings between 1930 and 1965 -- the former a year when cut-and-fit methods and small builders predominated, the latter a year when prefabricated components and merchant builders predominated? Based on original research in this paper, the answer to this question is, "Yes." Specifically, for a crew of carpenters and allied occupations working on the construction site, average physical labor productivity grew at a rate of 3.2 per cent per annum over these 35 years.

This finding is applied to three policy issues: unemployment, manpower forecasting, and the effect of money wage rate increases on the price of single-family dwellings.

Unemployment. The research findings suggest that although total output produced, in terms of square feet of living area, increased more than sixfold between 1930 and 1965, the number of carpenters needed for the larger volume of output in 1965 was 55 per cent of the number that would have been needed if building methods and the organization of the industry had not changed. A hypothesis suggested is that supply adjustments to changing labor requirements are sufficiently sticky so that unemployment in this trade is augmented above the level that results from the seasonal and casual characteristics of the on-site building industry.

Manpower forecasting. The rising productivity suggests that manpower forecasts that do not take this fact into account will overestimate projected labor requirements.

Effect of money wage rate increases on house prices. The rising productivity did not offset entirely the growth in money wage rates over the 35 years, so that unit labor cost grew at an annual rate of 1.5 per cent. However, when the composite of inputs is considered, rising unit labor cost was responsible for seven per cent of the constant annual compounded rate of change in the unit price of the house which was almost 3.0 per cent per annum.

The major results sketched above appear in Chapters III and IV.

This monograph is really a collection of four essays because each Chapter can stand alone.

Chapter I develops the rationale underlying the study and describes prior research.

Chapter II is a technical one that describes the research methodology and details the dollar cost of labor and material as well as manhours required per 1000 square feet (MSF) of living area for typical sample houses. The reader will quickly observe the complexity of the detail that was required in order to develop the productivity estimates in this paper.

Chapter III provides detail on changing methods in building and their impact on skills in the building trades. In particular, productivity changes by craft or labor group are given. This Chapter should be helpful to persons responsible for establishing training programs in the occupations studied.

Chapter IV carries the report into the area of costs and their impact on the pricing of single-family dwellings. This Chapter should provide insights into the forces that have affected the rising price of single-family dwellings.

In Chapters III and IV, the aggregated data developed are evaluated against evidence that could be found. In various sections, therefore, the reader will find the flow of the argument slowed down because of the evaluation of the derived estimates. These sections can be readily omitted by those readers interested only in the major arguments of the paper.

2. Specific detailed findings and remarks.

Average physical labor productivity increased between 1930 and 1965 for carpenters and other building trades occupations involved in the on-site construction of single-family dwellings in Alameda County, California. For the integrated on-site crew, the group of occupations studied -- i.e., carpenter, cement finisher, lather, plasterer, linoleum layer, hard-tile setter, general building laborer, hod carrier, tile helper -- average physical productivity increased at a rate of 3.2 per cent per annum over the 35-year period. Among the dominant occupations with respect to hours worked per MSF of living area, growth rates[1] varied, with the lowest rate that for carpenters, 1.7 per cent per annum, and the highest rate that for hod carriers, 7.4 per cent per annum. These average annual compounded rates of change in productivity compare with 6.3 for plasterers, 5.5 for lathers, and 5.2 for general building laborers. For the skilled group as a whole, productivity grew at a rate of 2.5 per cent per annum; that for the unskilled group, at a rate of 6.2 per cent per annum.

The carpenter's productivity growth rate was less than that for the other occupations studied because (1) carpenters broadened their jurisdiction, for example, installing drywall in 1965 whereas in 1930 the plasterer and lather dominated labor time in interior-wall finishing, and (2) although changes in building methods reduced labor hours per 1000 square feet (MSF) of living area in the various operations carpenters performed, the reductions in relative terms were not as large as those for the several other occupations where tasks in some cases were even actually eliminated.

Historically, carpenters have adjusted their jurisdiction to account for changes in building methods. This finding by Robert A. Christie in his classic history of the United Brotherhood of Carpenters and Joiners of America, Empire in Wood, continues to apply to this Union in the Bay Area.

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[1]The growth rate is the same as a compound interest rate which would be derived as follows. An individual deposits some amount in a bank and leaves it there. At the end of each time period, say one year, interest is added to the principal. In succeeding periods, interest is computed on the compounded principal. Hence, interest is called "compound" for that period.

The various activities in which carpenters worked show differential rates of productivity change. Over the 35-year period, the largest rate of growth in productivity was in window installation, at 6.81 per cent per annum. In contrast, average productivity declined at a rate of 1.11 per cent per annum in tasks involved in interior walls and ceilings because the union widened its jurisdiction as mentioned above. Rates of productivity gain per annum for the other operations were 0.10 for footings, 1.12 for framing, 6.00 for exterior walls, 4.73 for doors, 3.09 for interior trim, 0.63 for floors, 1.28 for roof covering, and 5.43 for stairs.

The advance in average physical labor productivity occurred in large part from the substitution of material for on-site labor. For the integrated crew, the labor-cost--material-cost ratio was .802 in 1930 but .575 in 1965. Interestingly, the most significant trade off between material (or off-site labor) and on-site labor occurred in the two most labor intensive activities in 1930, i.e., interior walls and ceilings and stairs.

What effect did the rising productivity have on the utilization of carpenters in the on-site construction of single-family dwellings? Total output in terms of square feet of living area in Alameda County increased by a factor of 6.4 between 1930 and 1965, from 1,320,232 to 8,469,037. However, the number of carpenters needed to produce this larger output in 1965 was 55 per cent of the number that would have been required if 1930 techniques had been used. This estimate, it should be noted, is based on the theoretical concept of full-time equivalents, or the assumption that all carpenters would have worked full time, in this case 1800 hours a year.

These results have implications for any study of unemployment not only for carpenters but I would suggest for any of the building trades. It is well known that on-site construction is subject to seasonal fluctuations that affect employment continuity. Further, on-site building, represented by discrete projects, means that building tradesmen are also subject to casual unemployment. However, the above finding regarding the labor saving that occurred with new building techniques over the 35-year period suggests that the trade may also be subject to what may be termed technological underemployment. The line of reasoning is as follows. As is suggested in several places in this study, new methods are introduced slowly and a logical inference is that supply adjustment to changing methods is slow. Meanwhile high wage rates per hour relative to other occupations that require similar educational requirements, for example those in some manufacturing industries, are sufficiently attractive to keep a basic labor supply attached to the trade, even though the number of opportunities may be gradually diminishing. The result is that opportunities available, especially in slack labor markets, must be spread over more workers so that average hours worked per annum are lower in these trades than in the steady industries where the relative hourly wage is lower. This hypothesis is consistent with evidence showing that average hours worked per annum in the building trades are lower than those in most other industries. The implication of this hypothesis is, of course, that the building trades would consistently have a larger excess supply of labor than other industries because the technological underemployment is superimposed upon the seasonal and casual types of unemployment.

The rising productivity estimates found for each occupation mentioned above have implications for manpower forecasting. The historical data derived here show that labor requirements grew at a lesser rate than total output produced because of the impact of rising productivity. In fact, for three dominant 1930 occupations, plasterer, hod carrier, and lather, labor requirements declined between 1930 and 1965.

Using the assumption that building technology in single-family residential construction did not change from 1930 to 1940, the rate of change in labor productivity for the integrated crew is also estimated for the 25-year period 1940-1965. The result is that average physical labor productivity over the 25 years grew at a rate of 4.4 per cent per annum for the integrated on-site crew. This rate of increase compares with a growth rate of 3.0 per cent for output per manhour in the entire private economy over the same period.

The above results suggest that manpower forecasting in the building trades, at least for the craft and labor groups studied here, should not be based on the assumption of a zero rate of growth in labor productivity because such an assumption would consistently overestimate manpower requirements. Further, to assume a constant rate of physical labor productivity growth for the various occupations is also a hazardous assumption, for as shown here the productivity growth rates have varied among the occupations and there is no reason to believe such would not be the case in the future. Indeed, to have validity, manpower forecasting in the building trades must be based on a thorough knowledge of building methods and materials. Inasmuch as training programs, which are costly, may be geared to occupational forecasts, the need for considering trends in labor productivity is absolutely essential. The evidence in this study suggests that labor requirement projections based simply on an extrapolation of product demand may have a wide margin of error.

The average physical labor productivity estimates provide basic information for assessing the influence of rising money wage rates in the several construction crafts on housing prices. As shown above, over the 35-year period, labor productivity of the integrated crew grew at a rate of 3.2 per cent per annum. For this group, however, hourly money wage rates including fringes increased by 4.7 per cent per annum. Consequently, unit labor cost in the building of single-family dwellings grew at a rate of 1.5 per cent per annum. The labor factor thus did exert an inflationary bias. The question then is: What was the ultimate impact of this factor on housing prices as compared with other inputs such as land, material, financing, and marketing costs as well as quality variation that has added amenities to single-family dwellings? The finding shown in Chapter IV is that the price of the house per unit, i.e., the price per square foot of living area, grew at a rate of 2.98 per cent per annum between 1930 and 1965. When this annual rate of growth in the unit price is allocated among the different inputs, the labor cost component accounts for seven per cent of the annual price increase. In fact, this is the smallest share of the annual percentage rise in the price. This result suggests that policy efforts directed towards producing low-cost, single-family housing will probably not be successful if efforts are not directed at the totality of inputs. For example, although the house price per unit grew at a rate of 2.98 per cent per annum, the site value per square foot increased at the fastest rate among the inputs, 3.90 per cent per annum, to account for 23 per cent of the rate of growth in the unit price.

PRODUCTIVITY CHANGE FOR CARPENTERS AND OTHER OCCUPATIONS IN THE BUILDING OF SINGLE-FAMILY DWELLINGS AND RELATED POLICY ISSUES

Chapter I

INTRODUCTION

1. Policy Issues

This research, which deals primarily with the impact of changing methods in the building of single-family dwellings on carpentry labor and some related crafts, was motivated by three policy issues -- high unemployment rates among carpenters, forecasting of labor requirements for carpenters, and the possible inflationary bias deriving from wage increases in excess of productivity gains in the building trades.

In the Bay Area, unemployment rates of carpenters, the largest group of the building trades' craftsmen, reached high levels in the mid-sixties according to local business agents. An obvious reason for the high unemployment rates according to union officials was the substantial drop in new housing units authorized, especially in 1966. For several years before the onset of the house-building slump, however, the sentiment was growing that more than a cyclical decline in building was affecting the use of carpentry labor. Casual observation suggested that new techniques in building were both reducing the need for on-site carpentry labor and changing the skill requirements of carpenters on the job site. The first task was to provide decision makers with a quantitative estimate of the extent to which new production methods were affecting both the volume of employment for carpenters and the skill mix used in the trade in order to provide insights into appraising whether or not the carpentry trade in the Bay Area was burdened by an excess supply of labor that did not originate from either cyclical or seasonal factors.

If new techniques have been affecting manhours required on on-site carpentry labor, then this effect should be made explicit so that the magnitude of future labor requirements in the trade can be determined. In particular, with the enactment of the Manpower Development and Training Act in 1962, Congress declared that an effective full employment policy requires a major effort to improve the functioning of the labor market and the quality and adaptability of the labor force. To carry out this policy, a major effort has gone into providing employment projections by occupations. To provide meaningful employment projections, however, requires productivity data by occupation, because by definition, changes in total manhour requirements can be decomposed into two parts, (1) changes in output (however measured) and (2) changes in the reciprocal of labor productivity. This relationship is shown in the underlying identity, i.e.,

$$MH \equiv O\ [MH/O],$$

where MH represents total manhour requirements, O represents an output measure, and MH/O is the reciprocal of labor productivity, or unit labor requirements. The identity can be rearranged as

$$O \equiv MH\ [O/MH].$$

Shown this way, it is a matter of simple manipulation to show that the annual rate of growth in output (by the compound interest formulation) equals the sum of the annual rates of growth in total manhour requirements and in labor productivity, or,

$$g_0 = g_{MH} + g_{0/MH},$$

where g is the annual rate of growth. It can easily be seen that if $g_{0/MH}$ is zero, then and only then can the annual rate of growth in manhours required, g_{MH}, equal the rate of growth of output, g_0. To my knowledge no published employment projections have included explicit estimates of both total manhour requirements and labor productivity, except those recently prepared by Dunlop and Mills.[1]

To make the projections by craft to 1975, however, Dunlop and Mills use a range of estimates for real productivity increases for the construction industry because, as they point out, "There are little or no data to allow estimates of past changes in productivity by craft in construction."[2] The importance of accounting for productivity change in manpower projections can be clearly shown in the work of these authors. They show that "...man-hour requirements on standardized operations would tend to be about 30 per cent less in 1975 than currently, if the annual rate of productivity growth were 3.5 per cent rather than 0.0 per cent."[3]

In this research report, we have derived labor productivity

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[1] See J. T. Dunlop and D. Q. Mills, "Manpower in Construction: A Profile of the Industry and Projections to 1975," in The Report of the President's Committee on Urban Housing, Technical Studies, Vol. II (Washington, D.C.: U.S. Government Printing Office, 1968), pp. 263-273.

[2] Ibid., p. 265.

[3] Ibid., p. 265.

growth rates for several construction craftsmen, in particular, for the following categories: (a) carpenters; (b) plasterers, (c) unskilled on-site labor (including general building laborers, hod carriers, and tile helpers); (d) skilled on-site labor (including carpenters, cement finishers, lathers, plasterers, carpet and linoleum layers, and tile setters); and (e) all occupations dealt with in this analysis. (The all occupations category includes all of the aforementioned specific occupations.)

Besides being important for forecasting labor requirements, labor productivity growth rates are important as evidence relating the influence of annual wage rate changes to the changes in the final product price. Without productivity estimates of all the crafts involved in building a house, however, this aspect of the study is not fully satisfied in this research. In particular, for this aspect of the study to be fully satisfied, we should have the rate of labor productivity growth in the construction of single-family dwellings. In this case, productivity growth is related to unit labor costs via the following identity,

$$ULC \equiv \frac{w}{O/MH},$$

where ULC is unit labor cost, or labor cost per unit of output, required for on-site building, w is the average wage rate per hour for all occupations involved, and O/MH is output per manhour, or productivity. From this definition, it is clear that if output per manhour (labor productivity) rises by the same percentage as the wage rate per hour, then unit labor cost remains constant. Hence, the labor factor should not induce a rise in the final price of the product, in this case, a square foot of living area in a house. If, however, the wage rate rises by a larger percentage than output per manhour, then unit labor cost would rise, and unless some offset were made in other cost factors, the final price of the house per square foot would rise. But what must be brought into the discussion when dealing with a commodity such as a house is that the price to the consumer in this instance includes not only the construction cost of the structure but also a large proportion for a scarce natural resource, land, and another not minor proportion for financing charges. These latter two costs, on one estimate,[4] can account for almost 43 per cent of the final sales price. Even if labor cost per unit of output, say per 1,000 square feet of living area constructed, can remain unchanged, the impact of land and financing costs on the final house price is of such magnitude that increases in these two factors could appear to be difficult to offset and so would be reflected in rising house prices.

For this aspect of the productivity issue, however, the productivity change of all labor needed to build a house is required, or, to say it another way, the productivity change for the residential construction industry is required because houses are built by integrated crews whose wages form a wage structure. Because of the inter-relatedness of the wage structure, it does not seem reasonable to believe that one trade could get a wage increase without triggering demands for increases

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[4]Lawrence Weinberg, Statement in Hearings Before the National Commission on Urban Problems, Los Angeles and San Francisco, June-July, 1967, National Commission on Urban Problems (Washington, D.C.: U.S. Government Printing Office, February 1968), p. 45.

in the other occupations involved in on-site house building.

In this report, we cannot give a definitive answer regarding productivity change in the building of single-family dwellings. However, by combining the craft and laborer groups mentioned above, our estimate for all occupations shows the productivity change for about one-half to two-thirds of the on-site construction involved in single-family dwellings.

2. Prior Research

Each motivation underlying this research undertaking presented a challenge because data required to quantify the issues posed were non-existent. A survey of the literature indicated that no scholar has quantified the impact of changing building techniques on carpentry man-hours. Assertions are plentiful that techniques changed considerably in the building of houses following World War II. Especially cited are the increasing utilization of pre-assembled components which has induced specialization in carpentry and has shifted traditional relationships between on-site and off-site labor requirements. However, we found no comprehensive study of long-term changes in the employment of carpenters in single-house construction at the micro-economic level. What literature is available deals with the construction industry per se. For example, Maisel, Kelly, Grebler, and Colean and Newcomb wrote of the industry generally but did not emphasize the impact of changing construction methods on labor requirements.[5]

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[5] See Sherman J. Maisel, Housebuilding in Transition (Berkeley and Los Angeles: University of California Press, 1953); Kelly, Burnham, and Others, Design and Production of Houses (New York: McGraw-Hill, 1959); Leo Grebler, Production of New Housing (New York: Social Science Research Council, 1950) ; and Miles L. Colean and Robinson Newcomb, Stabilizing Construction (New York: McGraw-Hill, 1952).

Several other studies deal with labor in the construction industry, those by Haber and Levinson, Daily and Kaplan, but they do not examine changing labor requirements through time nor do they provide the type of information we believe to be a necessary first step to answer the issues posed above.[6]

As this research neared completion, new studies appeared on manpower in residential construction, in particular, the Dunlop and Mills study cited above. In this same report, Burns and Mittelbach survey the prior literature in an article entitled "Efficiency in the Housing Industry,"[7] and point out that no consistent answer has been given regarding the existence or nonexistence of productivity growth in housebuilding. "Many of the arguments shaping public opinion state unequivocally that the housebuilding industry is backward and inefficient. Evidence to the contrary is often buried in technical reports which do not receive the same attention."[8]

A major problem encountered in resolving the controversy regarding whether or not efficiency, in terms of rising productivity, has characterized housebuilding, is that productivity estimates that have been made are for the contract construction industry, of which housebuilding is

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[6] See William Haber and Harold Levinson, Labor Relations and Productivity in the Building Trades (Ann Arbor: University of Michigan Press, 1956); James Merle Daily, "Skill Utilization and Its Impact upon Apprenticeship Programs in the Home Building Industry" (unpublished Ph.D. dissertation, University of Colorado, 1964); and Lawrence Jay Kaplan, "Factors Affecting Productivity in the Homebuilding Industry" (unpublished Ph.D. dissertation, Columbia University, 1958).

[7] See The Report of the President's Committee on Urban Housing, Technical Studies, Vol. II, pp. 75-144. This article includes a comprehensive bibliography on the subject.

[8] Ibid., p. 80.

only a part. Sims correctly observes that "Generalizations about productivity changes in construction as a whole should clearly be applied with caution to the residential construction subsector."[9] In particular, residential construction represents about 40 per cent of total construction.[10] Construction products other than houses include bridges, industrial buildings, office buildings, and other types of nonresidential structures. Because available statistics do not show manhours by activity, it is not possible to obtain accurate productivity estimates for the residential sector. The necessity to obtain separate productivity estimates for residential construction (in fact, even for single-family dwellings) is supported by data published in surveys by the Bureau of Labor Statistics.[11]

According to the B.L.S. surveys, manhour requirements of carpenters per $1,000 of construction contract cost vary considerably by activity. The differences in requirements for the United States are:

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[9]Christopher A. Sims, "Efficiency in the Construction Industry," in The Report of the President's Committee on Urban Housing, Technical Studies, Vol. II, p. 157. In this paper Sims examines various productivity estimates that are extant and enumerates the deficiencies that exist in published data for the construction industry.

[10]Burns and Mittelbach, op. cit., p. 81.

[11]U.S. Department of Labor, Bureau of Labor Statistics, has published the following bulletins that show manhour requirements in various types of activities per $1,000 of construction contract cost. See B.L.S. Report 299 and B.L.S. Bulletins 1299, 1331, 1340, 1390, 1402, 1404, 1441, 1490, and 1586. Bulletin 1586 is the second survey prepared for schools for the 1964-1965 reference period. In the text, therefore, two figures are shown for schools. In addition, Bulletin 1691, issued in 1971, is the second report on hospitals. Two figures are thus also shown for hospitals.

Activity	On-site Carpenter Manhours Required Per $1,000 of Contract Construction Cost	Survey Period
1. One-family residences	24.9	1962
2. Public housing	21.8	1959-60
3. College dormitories	15.8	1960-61
4. Schools	15.7 & 11.9	1959 & 1964-65
5. Federal office buildings	12.2	1959
6. Hospitals	11.7 & 9.9	1959-60 & 1965-66
7. Sewer works	6.5	1962-63
8. Highways	6.0	1961
9. Civil works	5.4	1957-60

From the above tabulation it is obvious that, of all types of construction, single-family residences consume more carpenter labor than any other type of building. (Within the single-family residence category, carpentry is also the major craft used.[12]) These data support Sim's statement that productivity estimates for all contract construction should be used with caution as a proxy for productivity estimates in residential construction. Ideally, data that could yield productivity estimates for single-family dwellings would be desirable. In this way, residential construction related to high-rise apartments would be excluded. According to interviews conducted during the progress of this research, the exclusion of high-rise apartment buildings would be desirable because the use of manpower in this activity resembles manpower used in commercial construction.

3. General Scope of This Research

The research in this report attempts to fill some of the data

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[12] See Bureau of Labor Statistics, Labor and Material Requirements for Private One-Family House Construction, Bulletin No. 1404 (Washington, D.C.: U.S. Government Printing Office, June 1964).

gaps in the construction literature, although certain limitations had to be imposed in order to make the project manageable within the constraint of our financial resources. The key question around which this entire research project focused was: How have new techniques in housebuilding affected both the demand for carpenter manhours on the construction site and the skill requirements of carpenters? If the new building technology was increasing specialization in this craft, as has been alleged, then over a sufficiently long enough time period, the resulting efficiency should be observed by rising labor productivity in this craft. This study attempts to answer this question within the limits outlined below not only for carpenters but also for several other labor classifications used on the construction site.

1. The data are restricted geographically to Alameda County, California, so that field work could be conducted at least cost. In this County, house construction is unionized, a characteristic common to most of California but not to most of the country.

2. Only single-family dwellings, not all residential construction, are included in the study. In this way, we could partly resolve the heterogeneity problem that plagues all work in construction. This limitation, however, is not overly restrictive. In California, for example, single-family dwellings have accounted, historically, for about 60 per cent of all new residential construction.[13] Further, in some postwar years this percentage was as high as 75 per cent for the

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[13] Economic Report of the Governor, 1969, Transmitted to the California Legislature March 1, 1969, p. 41.

Bay Area counties. As shown above, too, single-family residences utilize carpenter manhours more intensively than do the other types of structures analyzed by the Bureau of Labor Statistics. Even in dealing with single-family dwellings, however, the problem of heterogeneity is not completely resolved, because houses vary by size, quality, and materials used. To deal with this aspect, we selected typical houses in four building-cost ranges (costs as entered on the building permits). The method employed in selecting typical houses is explained in Chapter II. Briefly, building specifications were detailed for each typical house and then the cost of constructing the various components of each house was estimated. Estimators' handbooks, price information from various sources, and contractors' records where available were used to make the cost estimates for 12 broad categories of constructing the sample houses. These categories were footings, concrete floors, framing, exterior walls, interior walls, windows, doors, interior trim, floors, roof covering, stairs, and cabinets. These construction costs include about one-half to two-thirds of the total on-site building construction cost. The major on-site activities excluded from this analysis are those of the three subtrades -- plumbing, painting, and electrical work. A start was made on these three subcategories, but the time involved to carry out the detailed work necessary would have involved far more funds than were available for the project. Consequently, emphasis was placed on preparing detailed estimates of costs of those operations that involved the carpenter and then adding as many other labor groups and activites as was possible within our time and budget constraints.

3. The time period selected for intensive study was the 35-year interval from 1930 to 1965. The early year was one when building of houses was in the handicraft stage, while the latter year was one in which merchant builders and tract developments dominated the market. In 1930, on the basis of a 50 per cent sample of all building permits, 265 different builders applied for 414 building permits for single-family dwellings in Alameda County. In this 50 per cent sample, all but seven of the builders built from one to five houses. The remaining seven received permits for from six to 19 houses. By 1965, on the basis of two different size samples, 19 builders in the County applied for 62 per cent of all the permits issued for single-family residences. Each of these 19 builders applied for 50 or more permits in 1965.

Although 1930 is the year selected for detailed analysis, as representative of a handicraft period in residential construction, a review of the trade literature that appeared over the years and interviews with contractors suggests that no major change occurred in residential-construction methods until after World War II. Other often quoted evidence is found in the Fortune article of August 1947.[14] In this article, "The Industry Capitalism Forgot," the authors develop the hypothesis that "...the search for reform in the housebuilding business becomes primarily a search for large-scale operations."[15] But this suggestion already had an antecedent. In 1932, the editors

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[14] Fortune, Vol. XXXVI, August 1947.

[15] Ibid., p. 66.

of Fortune made about the same proposal in a book entitled Housing America.[16] In this work, the editors of Fortune wrote about operative builders and the need to change the distribution system in materials because of the inefficiency of then prevalent methods. In fact, these authors virtually predicted the road that housing would take after World War II when the pent-up demand for houses was to be met.

By the early 1950's, Sherman Maisel[17] made the case that the construction of homes was now an industry. Industrialization, of course, was related to the coming of the merchant builder who now built houses for sale whereas before this time the common method was to build a made-to-order house on an owner's lot. According to Eichler and Kaplan, "...the sudden release of a housing demand that had been accumulating since the early thirties brought with it the most important of all the types of developers...the merchant builder."[18] In the words of these authors "...the merchant builder did not then seek to make basic technological innovations. He began to systematize mass building through standardized design, specialization of labor, and more control over subcontractors. He tried, usually, to eliminate the distributor and deal directly with manufacturers, to reduce unit costs, and to establish specifications simplifying on-site assembly."[19]

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[16] The Editors of "Fortune," Housing America (New York: Harcourt, Brace, 1932).

[17] Op. cit.

[18] Edward P. Eichler and Marshall Kaplan, The Community Builders (Berkeley and Los Angeles: University of California Press, 1967), p. 20.

[19] Ibid., pp. 51-52.

Since the available evidence supports the hypothesis that major changes in house building took place after World War II, we use this hypothesis to show annual rates of productivity growth not only for the 1930-1965 period but also for the 1940-1965 period. Hence, 1930 productivity data are also assumed to apply to 1940.[20]

The plan of the report is as follows.

Chapter II shows how typical houses were selected, describes the sample houses, and presents summary tables of detailed estimating costs for the eight sample houses.[21]

Chapter III includes the major results of the study, i.e., the data showing how skill utilization of carpenters and other labor changed between 1930 and 1965 and the productivity changes that took place. The data averages are based on the individual house data that appear in Chapter II. No benchmark data exist in published form against which our productivity and manhour estimates can be tested. In Chapter III we, therefore, also evaluate as far as possible our estimates.

Chapter IV relates the findings on labor costs shown in Chapter III to other variables that influence the final price of houses. This section sets forth a total picture of house pricing as far as possible with the resources available to us. In the main, this Chapter synthesizes

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[20]When the project was initiated, we planned to study building techniques in 1940, 1950, 1955, and 1960. Some basic work was started for these years. However, with a cut in research funds the work on the intervening years had to be stopped. The data in Appendix B, however, include some of the facts obtained about the intervening years.

[21]Detailed cost estimates for the eight sample houses appear in Appendix A.

various results and poses questions that need to be examined, especially because of the recent emphasis on producing housing for low-income families.

Chapter II

SAMPLE HOUSES USED IN THIS STUDY

1. Methodology for Determining the Typical Houses

The first step in determining how inputs in house construction changed between 1930 and 1965 was to establish descriptions of typical houses, i.e., houses representative of those built during the selected years. Specifically, a typical house was defined as a house most commonly built during the year under study. This procedure assured that the study would take account of differences in the final product constructed. Consequently, the study of changes in labor and materials' inputs has built into it the change that occurred in the quality and size of houses.

The first stage in defining typical houses was a survey of building permits for new, detached, single-family dwellings in Alameda County. This means that the survey excluded permits for remodeling and altering older edifices, as well as duplexes, row houses, and town houses. Data were gathered from each of the issuing cities in the County as well as from the Alameda County administrative office that maintains records for unincorporated areas, areas in the process of incorporation, or cities that do not maintain their own offices. Permit records were examined, therefore, for Berkeley, Oakland, San Leandro, Emeryville, Piedmont, Alameda City, Albany, Hayward, Livermore, Pleasanton, Fremont, Union City, Newark, Castro Valley, San Lorenzo, and the rural area.

Information we endeavored to get for each permit examined included the valuation entered on the permit, floor area, number of rooms, number of floors, address, permit number, builder's name, availability of a basement, type of siding, and type of roof. These details, however, were not available for all of the cities in Alameda County. Further, the 1930 data were, in general, more complete than the 1965 data. The only consistently available information that could be used to account for quality differences was the estimated building cost. Cost thus became the basic variable for distinguishing among houses within the same period on the assumption that this monetary variable reflects differences in quality and size.

All of the building characteristics detailed above were available for the city of Berkeley for 1930. We thus took a 100 per cent sample of the permits in Berkeley. The Berkeley data were examined with respect to permit valuation and square feet, with the means and variances of these two variables computed. The coefficient of variation for these two variables along with assumptions regarding the acceptable sampling error suggested taking a 50 per cent sample of building permits in the other Alameda County communities in 1930.

A different sampling strategy had to be employed for 1965, however, because the merchant builder dominated the market at this time. The survey for this year thus had two parts. We kept the 50 per cent sample for those permits where a builder filed for one permit. However, when the records showed that one builder obtained permits for two or more houses on the same date and in the same vicinity, we took a 100 per cent sample. This procedure for the 100 per cent sample was followed because we could not decide on a satisfactory definition of "merchant builder." In this way, we were given more latitude in making the following tabulation from which persons knowledgeable in the industry can apply their own definition to the size-class that distinguishes a "merchant-builder" from a "custom-builder." The results of the survey show how the structure of the industry changed over the 35 years as small custom builders gave way to large builders. (Table 1)

The building permit survey provided the basis for determining the typical houses that are the subject of this research. The procedure by which eight houses were selected for intensive study was as follows.

For 1930, when custom building dominated the market, houses for which permits were issued in Alameda County were arrayed by building permit cost. This array was divided into quartiles. Within each building cost quartile, houses were distributed by the number of rooms, a characteristic available in the records of most of the cities. In this step, the house selected as typical possessed the median building cost within the quartile and had the number of rooms as represented by the modal group. In this initial stage, therefore, the representative

TABLE 1

Number of Builders and Houses by Size-Class of Permits Filed, Alameda County, 1930 and 1965

Size-class of permits filed	1930		1965			
	50 per cent sample		50 per cent sample		100 per cent sample	
	Number of builders	Number of houses	Number of builders	Number of houses	Number of builders	Number of houses
1 - 5	258	360	247	362	20	57
6 - 19	7	54	11	89	18	206
20 - 49	0	0	2	51	13	484
50 - 99	0	0	0	0	0	397
100 - 199	0	0	0	0	9	1,349
200 or more	0	0	0	0	4	1,070
Total number of single-family dwellings	0	828*	0	1,004*	0	3,563

Source: Building permit records, issuing offices, Alameda County.

Note: The 50 per cent sample is for builders filing for one permit.
The 100 per cent sample is for builders filing for two or more permits.

*Sample number doubled to get the total population.

house was selected by building permit cost and number of rooms. The next step involved the imputation of additional building characteristics. These characteristics for each cost quartile were obtained from a detailed analysis of the 100 per cent Berkeley sample. From this detail, specifications such as the type of roof, type of exterior wall, floor area, existence or nonexistence of a basement were imputed to the house selected in each cost quartile. After the typical house was thus specified, we returned to the sample and selected for study four houses, one in each cost quartile, that resembled most closely the designed typical houses. Consequently, the houses studied in detail are houses that were actually constructed.

For 1965, the above procedure to find typical houses was applied except that for the two highest cost quartile houses we selected custom-built houses (those from the 50 per cent sample) and for the two lowest cost quartile houses, tract houses. In addition, the two tract houses selected for study were those for which actual builders' plans were available so that the cost estimating procedure was facilitated.

When this research started, we were warned of the inadvisability of using building permit information. As the reader has noted, however, this information was used to provide a benchmark with respect to house building costs as of the given year. It is common knowledge that the cost figures shown on building permits are estimates made by the builder which include primarily labor and materials' costs and exclude land, overhead, and profit. Further, most building permit figures are somewhat lower than actual cost, because builders generally place the valuation figure at expected minimum cost. In 1930, as contrasted with 1965, building permit figures also included only the material and labor costs used to construct the "shell" of the house and excluded the price of small fixtures, equipment, and accessories.

The valuation figures were thus useful for our purpose only to establish a rough range for actual costs to the builder. We also assumed that the ratio between the value declared on the permit and the actual cost to the builder was constant across all houses within each of the years.

It must also be noted that the issuance of a building permit does not guarantee that the dwelling will be constructed. In Alameda County, permits are validated for six months, after which time another permit must be obtained if work on the site has not started. We thus had to assume in this study, because of the lack of other information, that the number of permits issued closely approximated the number of houses built in the selected years.

2. General Observations on Estimating the Costs of the Sample Houses

After the process of selecting four typical houses for 1930 and 1965 as described above was completed, we obtained all information available in the County Assessor's Office about the specific houses selected. Further, we took pictures of each house. From these data and pictures, detailed floor plans for each house were drawn. As mentioned above, however, we were able to use actual builder's plans for the two 1965 tract houses selected. Further, in the estimating procedures for the two tract houses we interviewed a number of builders not only in Alameda County but also in Santa Clara and Contra Costa Counties so that the final estimates would incorporate the most widely used building practices as of 1965.

Underlying the estimating procedure followed was the principle that local building codes of the time had been respected. Consequently, if no direct information on an item was available, the issue was decided on the basis of other features of the house in question related to the item, its general characteristics, and knowledge of certain practices. Through a painstaking process, a materials' list for each house was detailed.[1]

The objective in pricing the materials was to use local prices of the time to the builder. For the tract homes, large volume purchasing was also taken into account. Each price was checked as to its source, representativeness, and reliability in general. Where several prices were available, appropriate averages were used. In most cases, this objective could be realized, although extensive research effort was required. In some cases,

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[1]The data provided in the Tables in Appendix A are a summary and aggregation of the much more detailed estimating work.

national prices had to be used, but again the same scrutinizing procedure was followed to insure consistency.

The determination of labor requirements for each house was the result of intensive research. For 1930, Walker's Building Estimator's Reference Book (6th ed., 1930) was used as a basis in almost all cases, although not without careful analysis and adaptation to the requirements of the specific houses. For 1965, many more sources could be employed, including data directly obtained from contractors and subcontractors.

Housing in the Bay Area was nonunion in 1930 and entirely unionized in 1965. Wage data for both years were available from the California Department of Industrial Relations and other sources. Wages used in this study include the basic wage rate plus negotiated fringe benefits. If wage rates changed over the course of the given year, a weighted average was taken.

For all eight houses, functionally identical parts were estimated, so that a direct comparison between them is possible. It does not follow that our estimates represent the same percentage of building costs or sales price in all eight houses; however, that percentage can be expected to be different between houses of the same year and between different years. Nothing can be said *a priori* about the direction in which these differences vary, nor could they be checked with the facts. Most importantly, however, the functionally identical parts are estimated so that comparisons among these parts are possible.

3. Description of the Four 1930 Houses

a. General Features

All four of the typical houses for 1930 are built with No. 2 common dry douglas fir, bought in random lengths and cut to size on the site by hand saw. All nailing is done by hand.

Variations in subflooring and wall sheathing will be noted below, but all roof sheathing is with 1 X 8 boards.

All windows are wood frame and, unless otherwise noted below, double-hung. Closet and pantry doors are included under interior doors and, indeed, are identical to them. As was usual for 1930, even closets of several feet width had just one interior type door. All doors were hung and jambs assembled on the site.

All four houses have three-coat exterior stucco, 3/4 inches thick, float finish, over metal lath.

Trench excavation took place by hand, and concrete was mixed on the site.

b. House I: First Quartile, Most Expensive House

The representative house of the highest quartile is classified by the Assessor's office as a D-7-B house.[2] It has 1,843 sq. ft. of

[2]This is a classification on quality made by the State Board of Equalization in California. As of 1964, the State Board of Equalization defined a D-7 class house as a "good quality double wall (studded) construction built for owner by good contractor. Planned by architect to provide refinements slightly above average standard construction." A typical D-6 house is defined as: "Average quality double wall (studded) standard construction. Usually built for owner by good contractor." A D-5 construction class is defined as: "Minimum quality double wall (studded) house as permitted under uniform code but with certain interior refinements and exterior additions to 'attract' buyer. Attractive but cheap 'speculator built house'."

living space plus an attached garage of 378 sq. ft. There are three bedrooms and one bathroom. All rooms are on the same level, with the garage on a lower level.

The concrete floor of the garage has a 3-inch fill, 3 inches of concrete, and a 3/4-inch finish.

The subfloor, consisting of 1 X 8 boards, is laid diagonally. The roof is of complicated structure, with a 2/3 pitch gable and a 1/3 pitch hip.

The exterior wall sheathing of 1 X 8 boards is laid diagonally.

Interior walls and ceilings have a two-coat hardwall plaster, white finish, on 1-1/2-inch wood lath.

All rooms have base, shoe and crown molding. The dining room, living room, and halls also have picture rails. There are chair moldings in the dining and living rooms. All moldings are oak.

The kitchen has a linoleum floor. The bathroom floor is of tile as is the wall up to four ft. Select quartered oak is used for finished flooring in all other rooms.

The roof is covered with composition shingles.

All workmanship is taken to be first grade.

c. House II: Second Quartile, Second Most Expensive House

The second quartile house has three stories and is classified as D-6.5-B. The basement contains 929 sq. ft., of which 152 sq. ft. is a dirt floor. The first floor has a 324 sq. ft. garage and 975 sq.

ft. of living space. The second floor has 1,124 sq. ft. Total living space is thus 2,099 sq. ft. There are three bedrooms and 1-3/4 bathrooms.

The foundations comprise, besides the regular footings, a supporting wall of 8 by 43 feet, 11 inches thick.

The cement floors (basement and garage) have 3-inch filling, 4 inches of concrete and a 3/4-inch finish.

Subfloors are of 1 X 8 boards, laid diagonally. The house has a hip roof.

Exterior wall sheathing is with 1 X 8 boards, laid straight.

Interior walls and ceilings have 2-coat hardwall plaster, sand finish, on 1-1/2-inch wood lath; basement walls are unfinished.

All rooms have oak base, shoe, crown and picture molding.

The kitchen floor is covered with linoleum, and the bathroom floors and the shower wall with tile. All other floors have select plain oak.

The roof has 4-inch composition shingle strips.

The stairs between the first and second floor have oak treads and risers, and those to the basement, fir.

All workmanship is taken to be first grade.

d. <u>House III: Third Quartile, Third Most Expensive House</u>

This house contains 1,248 sq. ft. of living area, all on one level, plus a 180 sq. ft. garage and a 792 sq. ft. basement. There are two bedrooms and one bathroom. It is classified as D-6.5-B.

The concrete floors of basement and garage have a 3-inch fill, 3 inches of concrete, and a 3/4-inch finish.

The subfloor of 1 X 8 boards is laid straight. The living room has no ceiling joists. There are three gables, with a 1/2 pitch.

Boards for exterior wall sheathing are laid straight.

Interior walls and ceilings have two-coat hardwall plaster, white finish, over 1-1/2-inch wood lath, except for the garage, which has sand finish, and the basement walls, which are unfinished.

Windows include two casement and two picture windows.

All rooms have oak baseboard, shoe and picture molding. The dining room also has an oak chair rail.

The kitchen has linoleum flooring; the bathroom floor is tile. All other floors are select plain oak.

The roof is covered with wood shingles, 5-inch exposure.

The staircase (two short flights with a platform) has fir treads and risers.

All labor is taken to be of ordinary workmanship.

e. House IV: Fourth Quartile, Least Expensive House

The cheapest house has 624 sq. ft. of living area, no garage, one bedroom, and one bathroom. It is classified as D-5.5-B.

There are no concrete floors. There are two gables with a 1/2 pitch. Exterior wall sheathing is laid straight. Interior walls have two-coat lime plaster, white finish. Inside trim includes fir base, and shoe and picture molding in all rooms. The bathroom has linoleum covered flooring, and all other areas have vertical-grain fir (grade c). The roof is covered with 4-in-1 composition shingle strips.

All labor is taken to be of ordinary workmanship.

4. Description of the Four 1965 Houses

a. General Features

Trenches for the footings are excavated with a trenching machine. The footings are reinforced with two 1/2-inch steel rods.

Concrete for the slabs is poured from a ready-mix truck. All rough lumber is of construction grade.

All exterior stucco work has three coats.

Unless otherwise noted, all interior walls and ceilings are covered with 1/2-inch drywall, taped and textured.

Unless indicated otherwise, all windows are preglazed, have aluminum frames, and are of the sliding type with one or two lights depending on the size.

All doors are prehung. Further quality specifications are given below for each house individually.

Interior door trim is included under "doors" in the tables. Aside from window trim, only oak baseboard is installed in all houses, unless otherwise indicated.

b. House I: Most Expensive of the Two Custom Houses

The highest quartile house is classified as D-7-B by the assessor's office. It has 1,636 sq. ft. of living space on the first floor. In the basement, there are 338 sq. ft. of living space, a 418 sq. ft. garage, and 124 sq. ft. of storage space. There is thus a total of 1,974 sq. ft. of living space. This house includes three bedrooms and 1-3/4 bathrooms.

The front section of the house is built on a concrete slab. The rear section has six concrete piers supporting a girder and floor joists laid across. Subflooring is with 2 X 6 tongue-and-groove. The rafters and 2 X 6 redwood tongue-and-groove ceiling of the front section overhang five feet beyond the front wall. The rear section roof sheathing is of 3/4-inch plywood.

Exterior walls of the front section have 30-pound felt and 5/8-inch grooved redwood plywood. The rear section is in three-coat stucco.

The interior walls of the living room are insulated with 3-inch fiberglass batts and covered with 1/2-inch drywall with 1/4-inch select cherry prefinished plywood paneling glued on.

Windows include 10 floor-to-ceiling solid glass and two aluminum louvered windows.

Exterior doors are solid core birch, interior doors hollow core birch, and wardrobe doors include four sliding and one folding door. The garage door is of the overhead type, redwood, 1/2-inch X 8-inch shiplap.

Interior trim includes a picture mold in the living room.

The basement living room has 12 X 12 vinyl asbestos tile, the kitchen and bathrooms vinyl linoleum. The main living room floor is in clear oak and all other rooms are in select oak strip.

The flat roof has 4-ply 15 lb. paper and tar and gravel.

Kitchen cabinets (19 lin. ft. base, 10 lin. ft. wall, 38 sq. ft. counter top) are hardwood grade. There are three drawer units in the wardrobe closets, a linen closet, and two bathroom vanities.

Frame lumber for this custom-built house is taken to be bought in random lengths and cut on site with power saws. No nailguns are used. The stucco is hand-applied.

First grade workmanship is assumed throughout.

c. House II: Least Expensive of the Two Custom Houses

This is a D-6.5-B house with two stories; however, the front section of the lower floor is totally unfinished. The finished lower floor contains 848 sq. ft., the upper floor, excluding the carport, 1,302 sq. ft. There are three bedrooms and 1-3/4 bathrooms.

Seven piers support a girder across which joists are laid. Subfloors are 1-1/8-inch plywood. The roof has two gables with 1/4 pitch. Roof sheathing is with 5/8-inch plywood.

The lower exterior wall has three-coat stucco, the upper section 1 X 10 vertical redwood siding.

Part of the interior wall of the living room is covered with 1/4-inch birch prefinished plywood (27 lin. ft.).

Windows include one picture window. Exterior doors are solid core mahogany and interior doors hollow core mahogany. Wardrobe doors include two sliding and three folding doors.

Floors of the basement and upper floor bathroom are covered with vinyl asbestos tile. The kitchen has vinyl linoleum. All other rooms have select oak strip.

The roof is covered with heavy wood shakes.

Kitchen cabinets (15 lin. ft. base, 12 lin. ft. wall, 30 sq. ft. counter top) are hardwood grade. There are two wardrobe closet drawer units and five Ponderosa pine shelves.

The two staircases (one inside, one outside) have fir treads.

Methods of operation for this custom-built house are the same as those for the previous house in the highest quartile.

d. House III: Most Expensive of the Two Tract Houses

This one-story house, classified D-6.5-C, has 1,679 sq. ft. of living area, and a garage of 469 sq. ft. There are four bedrooms and 1-3/4 bathrooms.

Fifty small concrete piers support the girders. The subfloor is 1-1/8-inch tongue-and-groove plywood. The roof has three hips and two gables with 1/4 pitch. Roof sheathing is spaced, with 1 X 8 boards.

The interior wall between the garage and living room has

5/8-inch drywall. All outer walls are insulated with 2-1/4-inch foil-backed fiberglass.

There are two glass sliding doors. All wood doors are mahogany, solid core for the exterior and hollow core for the interior and closet doors. There is one folding and one pocket door. The garage door is of the overhead type, redwood 1/2 X 8-inch shiplap.

The family room, the kitchen and the two bathroom floors are covered with vinyl linoleum. The foyer has a slate floor. All other rooms have an oak strip floor, clear grade in the living and dining room and select grade in bedrooms and hall. All hardwood floors also have wall-to-wall carpets.

There are five picture windows, and two windows with obscure glass.

The roof is covered with heavy wood shakes.

Kitchen cabinets are of hardwood grade (13-ft, 3-inch base, 19-ft. wall, 7-ft. oven), and the plastic counter top, 15 sq. ft. There are two paint grade bathroom vanities (6 ft. and 5 ft.) and 5 mahogany shelves.

Because this is a tract-built house, all customary labor-saving techniques are assumed to have been used, i.e., all rough lumber is precut, nailguns are used throughout, and stucco is gun-applied.

e. House IV: Least Expensive of the Two Tract Houses

This is a one-story house, classified D-6-B. It has only

1,136 sq. ft. of living space, plus a 396 sq. ft. garage, with 3 bedrooms and 1-3/4 bathrooms.

The foundation structure is like that of the previous house: 34 small concrete piers support the girders. Subflooring is with 1-1/8-inch plywood. There are two gables with a 1/4 pitch. Roof sheathing is with 5/8-inch plywood.

Outer walls are insulated with 1-1/2-inch foil-backed fiberglass.

There is one glass sliding door and one slat louver closet door. All other doors are hardboard with hollow core, including the sliding wardrobe doors (of which one is a pocket door). The garage door is of the overhead type, 3/8-inch plywood.

The bathrooms, kitchen, and dinette have linoleum floors. Floors in the remainder of the house are of No. 1 common oak strip.

The roof is covered with composition shingles.

Kitchen cabinets are paint grade (11-ft. base, 14-ft. wall, 26.5 sq. ft. counter top). There are two bathroom vanities (each 2 ft., 6 inches) with plastic tops and five mahogany shelves.

Operating techniques in this tract-built home are similar to those described in the preceding tract house.

5. Summary Data for Construction Costs and Labor Requirements for the Eight Sample Houses.[3]

Following the estimating procedures described in Section 2,

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[3]Detailed cost estimates of each house and detailed labor requirements appear in Appendix A.

cost estimates and labor requirements were obtained for each house. Details for each sample house described on the preceding pages appear in Appendix A. In this section, the major results are summarized for all houses, and only the most significant findings that emerged are discussed briefly. The results shown here provide the basis for the averages computed in accordance with the discussion at the end of this Chapter. It is these averages that are used in the following Chapters to discuss the basic changes that occurred in on-site building skill requirements between 1930 and 1965.

a. Selected Detail for the 1930 Sample Houses

Tables 2 through 7 are derived from the basic data for 1930 houses as shown in Appendix A. In each case, data for the individual houses are shown under column headings I, II, III, and IV, which refer to the houses representative of the cost quartiles as discussed above.

Table 2 shows how hours per MSF of living area were divided among the 11 major operations for which cost and labor hours estimates were made for both skilled and unskilled labor. The data from Table 2 are used in Table 3, which shows the percentage distribution of hours among the various activities. Table 4 provides refined data for hours required for various suboperations either per MBF (1000 board feet) or MSF (1000 square feet).

Table 5 introduces actual dollar costs of materials used and labor time per MSF of living area for 11 major categories.

In Table 6 the material and labor costs are combined to show total costs per MSF for the same 11 major operations.

Table 7 shows the hours used in each skill category both for the entire house and per 1000 square feet (MSF) of living area. The conversion to MSF of living area is essential for both inter-year and intra-year comparisons.

Certain noteworthy aspects of 1930 building practices, as evidenced in Tables 2-7, are noted below.

From both the labor hours' estimates and the cost data it appears that footings are subject to diseconomies of size and/or quality. The percentage of total unskilled labor time spent on this operation in the smallest house (House IV) is two to four times as high as in the other houses. The percentage skilled time is also higher, but less so. By cost (which in this case is labor cost only), the percentage spent on footings is 1.4 to 6 times higher. This result is partly caused by the fact that House IV has 1-1/2-ft.-high forms, versus 1/2 or 1 ft. for the others. Even though House II has a retaining wall, House IV's share is still dominant.

Data for framing operations are remarkably similar for all classes of houses. Only House I uses substantially more carpenter hours per MSF of living area (31 hours more than House II, the next highest). In terms of percentage of total cost, however, House IV again stands out several points above the others; this is due to the cost of materials, which, on a per MSF basis, is

TABLE 2

Hours per MSF of Living Area, 1930

	I		II		III		IV	
	Unskilled	Skilled	Unskilled	Skilled	Unskilled	Skilled	Unskilled	Skilled
Footings	8.0	4.2	19.5	18.5	17.5	10.7	25.0	21.1
Concrete floors	21.9	3.1	59.7	7.9	60.1	11.7	0	0
Framing	46.0	170.4	37.8	139.4	42.5	128.9	40.4	119.4
Exterior walls	76.3	152.1	64.0	125.6	67.7	119.3	62.3	113.8
Interior walls and ceilings	47.5	120.2	45.0	123.9	44.0	109.3	43.6	114.6
Windows	0	43.4	0	30.5	0	42.1	0	44.9
Doors	0	56.4	0	51.9	0	28.8	0	30.0
Interior trim	6.3	39.9	6.4	43.2	4.6	25.2	6.2	34.3
Floors	28.4	93.4	19.7	65.0	11.2	50.3	6.4	19.1
Roof cover	0	24.8	0	8.9	0	34.4	0	15.5
Stairs	0	0	0	18.1	0	17.6	0	0
Total	234.4	707.9	252.2	632.9	247.7	578.4	184.0	512.7

Source: Appendix A tables.

Note: Detail may not add to total due to rounding.

TABLE 3

Percentage Distribution of Hours, per Operation, 1930

	I		II		III		IV	
	Unskilled	Skilled	Unskilled	Skilled	Unskilled	Skilled	Unskilled	Skilled
Footings	3.4	0.6	7.7	2.9	7.1	1.8	13.6	4.1
Concrete floors	9.3	0.4	23.7	1.2	24.3	2.0	00	0
Framing	19.6	24.1	15.0	22.0	17.2	22.3	22.0	23.3
Exterior walls	32.5	21.5	25.4	19.8	27.3	20.6	33.9	22.2
Interior walls and ceilings	20.3	17.0	17.8	19.6	17.8	18.9	23.7	22.3
Windows	0	6.1	0	4.8	0	7.3	0	8.8
Doors	0	8.0	0	8.2	0	5.0	0	5.8
Interior trim	2.7	5.6	2.5	6.8	1.9	4.4	3.4	6.7
Floors	12.1	13.2	7.8	10.3	4.5	8.7	3.5	3.7
Roof cover	0	3.5	0	1.4	0	5.9	0	3.0
Stairs	0	0	0	2.9	0	3.0	0	0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Appendix A tables.

Note: Detail may not add to total due to rounding.

TABLE 4

Suboperations, Hours per MBF or MSF, 1930

	I		II		III		IV	
	Unskilled	Skilled	Unskilled	Skilled	Unskilled	Skilled	Unskilled	Skilled
Mudsill, girder, floor joists, per MBF	3.5	8.7	4.6	11.1	4.0	11.0	4.0	10.4
Subfloor, per MSF	5.6	11.2	5.6	11.2	5.5	9.0	5.6	9.0
Studs and plates, per MBF	5.0	31.0	5.0	31.0	5.0	21.0	5.0	21.0
Roof framing, per MBF	6.8	32.7	7.0	28.0	7.0	28.0	5.9	25.0
Roof sheathing, per MSF	5.7	10.9	6.7	13.3	5.6	8.0	5.0	8.0
Exterior walls, per MSF	40.2	80.1	39.5	77.6	37.2	65.6	37.2	67.9
Interior walls and ceilings, per MSF	13.3	33.7	13.9	38.2	11.2	27.8	11.1	29.2
Resilient floors, per MSF	0	26.1	0	25.8	0	25.6	0	25.0
Hardwood floors, per MSF	3.8	61.4	5.0	60.0	4.9	60.0	5.0	16.2

Source: Appendix A tables.

TABLE 5

Material and Labor Cost, Dollars per MSF of Living Area, 1930

	I			II		
	Material	Labor		Material	Labor	
		Unskilled	Skilled		Unskilled	Skilled
Footings	0	5.64	4.79	0	14.00	20.79
Concrete floors	16.76	15.36	3.46	50.36	41.02	8.77
Framing	280.70	32.25	191.53	240.08	26.49	156.84
Exterior walls	258.83	69.15	197.43	220.63	58.19	163.73
Interior walls and ceilings	85.92	44.68	155.99	89.18	42.32	159.18
Windows	109.42	0	48.83	74.49	0	34.30
Doors	186.65	0	63.48	159.30	0	58.42
Interior trim	59.20	4.41	44.95	59.93	4.53	48.56
Floors	250.17	21.07	108.01	171.19	14.56	74.94
Roof cover	79.21	0	27.82	42.08	0	10.00
Stairs	0	0	0	12.12	0	20.37
Total	1,326.86	192.56	846.29	1,119.36	201.11	755.90

(continued)

TABLE 5 -- continued

	III			IV		
	Material	Labor		Material	Labor	
		Unskilled	Skilled		Unskilled	Skilled
Footings	0	12.29	11.97	0	17.56	23.80
Concrete floors	57.62	42.09	13.14	0	0	0
Framing	278.27	29.88	145.08	277.90	28.36	134.45
Exterior walls	236.35	61.46	154.49	209.90	56.57	146.75
Interior walls and ceilings	85.58	41.37	142.23	80.50	40.98	147.93
Windows	113.62	0	47.32	73.67	0	50.48
Doors	142.00	0	32.47	113.23	0	33.67
Interior trim	53.50	3.21	28.41	35.26	4.37	38.67
Floors	132.38	8.30	57.48	74.18	4.52	21.75
Roof cover	53.32	0	38.76	83.52	0	17.48
Stairs	6.28	0	19.83	0	0	0
Total	1,158.92	198.60	691.18	948.16	152.36	614.98

Source: Appendix A tables.

TABLE 6

Total Cost per MSF of Living Area, by Dollar Cost and Percentage Distribution, 1930

	Absolute Numbers ($)				Percentage Distribution			
	I	II	III	IV	I	II	III	IV
Footings	10.43	34.79	24.26	41.36	0.4	1.7	1.2	2.4
Concrete floors	35.58	100.95	112.85	0	1.5	4.9	5.5	0
Framing	504.48	423.41	453.23	440.71	21.3	20.3	22.1	25.7
Exterior walls	525.41	442.55	452.30	413.22	22.2	21.3	22.1	24.1
Interior walls and ceilings	286.59	290.68	269.18	269.41	12.1	14.0	13.1	15.7
Windows	158.25	108.79	160.94	124.15	6.7	5.2	7.9	7.2
Doors	250.13	217.72	174.47	146.90	10.6	10.5	8.5	8.6
Interior trim	108.56	113.02	85.12	78.30	4.6	5.4	4.1	4.6
Floors	379.25	260.69	198.16	100.45	16.0	12.5	9.7	5.8
Roof cover	107.03	52.08	92.08	101.00	4 5	2.5	4.5	5.9
Stairs	0	32.49	26.11	0	0	1.6	1.3	0
Total	2,365.71	2,077.17	2,048.70	1,715.50	100.0	100.0	100.0	100.0

Source: Appendix A tables.

Note: Detail may not add to total due to rounding.

TABLE 7

Hours per Skill Category, 1930

	Hours per house									Hours per MSF of living area			
	Absolute numbers				Percentage distribution								
	I	II	III	IV	I	II	III	IV	Average	I	II	III	IV
Carpenters: Total	855.4	829.0	458.8	206.6	49.2	44.6	44.5	47.5	46.5	464.1	394.9	367.6	331.1
Forms	7.8	38.8	13.3	13.2						4.2	18.5	10.7	21.1
Framing	314.0	292.6	160.9	74.5						170.4	139.4	128.9	119.4
Wall sheathing	51.3	40.0	26.7	12.3						27.8	19.1	21.4	19.7
Stucco preparation (exterior)	16.5	17.7	8.8	6.5						8.9	8.4	7.0	10.4
Plaster preparation (interior)	39.0	56.0	18.0	13.0						21.2	26.7	14.4	20.8
Windows and doors and interior trim	257.5	263.5	120.0	68.1						139.7	125.5	96.1	109.1
Hardwood floors	123.5	101.7	46.1	9.3						67.0	48.4	36.9	14.9
Shingles	45.8	18.7	43.0	9.7						24.8	8.9	34.4	15.5
Stairs	0	38.0	22.0	0						0	18.1	17.6	0
Cement Finishers	5.7	16.5	14.6	0	0.3	0.9	1.4	0	0.6	3.1	7.9	11.7	0
Latherers: Total	95.4	96.4	67.6	32.8	5.5	5.2	6.6	7.5	6.2	51.8	45.9	54.2	52.6
Stucco (exterior)	37.0	35.9	23.9	11.0						20.1	17.1	19.2	17.6
Plaster (interior)	58.4	60.5	43.7	21.8						31.7	28.8	35.0	34.9
Plasterers: Total	299.6	313.7	164.2	77.9	17.2	16.9	15.9	17.9	17.0	162.5	149.4	131.6	124.8
Stucco (exterior)	175.5	170.1	89.5	41.2						95.2	81.0	71.7	66.0
Plaster (interior)	124.1	143.6	74.7	36.7						67.3	68.4	59.9	58.8

(continued)

TABLE 7 -- continued

	Hours per house									Hours per MSF of living area			
	Absolute numbers				Percentage distribution								
	I	II	III	IV	I	II	III	IV	Average	I	II	III	IV
Linoleum layers	5.5	4.8	8.0	1.5	0.3	0.3	0.8	0.3	0.4	3.0	2.3	6.4	2.4
Tile setters	43.1	20.0	8.7	1.1	2.5	1.6	0.8	0.2	1.3	23.4	14.3	7.0	1.8
General building laborers	178.9	284.8	170.9	52.9	10.3	15.3	16.6	12.2	13.6	97.1	135.7	136.9	84.8
Hod carriers: Total	208.5	211.7	128.0	60.8	12.0	11.4	12.4	14.0	12.4	113.1	100.8	102.6	97.4
Stucco (exterior)	120.9	117.2	73.1	33.6						0	0	0	0
Plaster (interior)	87.6	94.5	54.9	27.2						0	0	0	0
Tile helpers	44.7	32.9	10.2	1.1	2.6	1.8	1.0	0.2	1.4	24.2	15.7	8.2	1.8
TOTAL:	1,736.8	1,847.8	1,031.0	434.7	100.0	100.0	100.0	100.0	100.0	942.4	885.1	826.1	696.6
Skilled total:	1,304.7	1,318.4	721.9	319.9	75.1	71.5	70.0	73.6	72.5	707.9	632.9	578.4	512.7
Unskilled total:	432.1	529.4	309.1	114.8	24.9	28.5	30.0	26.4	27.5	234.4	252.2	247.7	184.0

Source: Appendix A tables.

Note: Detail may not add to total due to rounding.

almost identical for all houses, and thus forms a higher percentage in the cheapest house. This could again be called a diseconomy of quality and/or size.

Essentially the same can be said for exterior walls. House I alone takes substantially more skilled labor time (26.5 hours more than House II), but hours as a percentage of total time needed in House IV exceed the House I level, which for unskilled labor in particular is quite a departure -- about 6 points above the level in Houses II and III. As a result, IV's percentage of total cost stands about 2 points above the other houses.

It will be recalled that first-class workmanship was assumed in both Houses I and II. This assumption did not produce a clear dichotomy in the final data on hours per MSF of living area for framing and exterior walls. For interior walls, however, I and II stand at about 10 hours more skilled labor time than III and IV. Disparities in wall surface per MSF of living area underlie these somewhat incoherent data. From the quantity columns in Tables 1 through 4 in the Appendix these are:

Square Yards per MSF of Living Area

	I	II	III	IV
Exterior walls	212	180	202	186
Interior walls	396	360	437	436

It can be seen that House II has relatively the least amount of wall surface. More information on this is provided below, when the time of lathers and plasterers is separated. In percentages, however, both of total labor time and of total cost for interior walls, House IV is again above the other houses.

The picture changes when we look at the data for doors. Hours per MSF, percentage of total time, total cost per MSF, and percentage of total cost all indicate a dichotomy between Houses I and II on the one hand, and Houses III and IV on the other.

The influence of quality is clearest for floors. All data indicate a consistent progression as the quality class of the house increases. Underlying this progression, among other things, is the varying grade of wood flooring (from quartered oak to fir), and the amount of tile installed.

Roof cover data do not show such a progression because of complications. House III has, contrary to what could be expected in this class of house, wood shingles, which is rather expensive in labor time. A comparison between Houses II and IV, which have the same kind of composition shingles, shows the economy of a multi-story house, with labor time on a MSF basis almost cut in half. Adding the labor time for stair building in House II, however, destroys this economy.

Table 7 shows the regrouping of the basic data per skill category. With few exceptions, carpenter hours as a percentage of total time are fairly steady around an average over the four classes of houses. The main exceptions are carpenter hours in House I, which is almost 3 points above the average percentage for all houses; tile setter and tile helper time in House I, almost double the average; and general building laborer time, which is lower in I and IV than in II and III. The differences in laborer time can almost wholly be accounted for by the influence of the concrete floor operation which covers less square feet in House I and none in IV.

In Table 2, the decrease of skilled labor time for MSF of living area as the quality of the house decreases can be observed. The same statement is true for carpenter hours per MSF of living area as shown in Table 7, with carpenter hours at 464.1 in the best quality house (I) and 331.1 for the least expensive house (IV).

The separation of lathers' and plasterers' hours clarifies the data of exterior and interior wall operations referred to earlier. Lathers' time is a pure reflection of wall surface area, because no distinctions as to workmanship were used here. Plasterers' work, on the other hand, can be distinguished between first grade workmanship in Houses I and II and ordinary workmanship in Houses III and IV.

Finally, it must be emphasized that no substitution between skilled and unskilled labor is involved in the lower time estimates for general building laborers in Houses I and IV than in Houses II and III. The differences observed are almost solely due to differences in concrete floor coverage in the four houses.

b. Selected Detail for the 1965 Sample Houses

Tables 8 through 13 are comparable to the 1930 tables just discussed and are derived from the basic 1965 data in Tables 5 through 8 in the Appendix. In this section the most significant aspects for the 1965 houses are discussed.

As noted above, Houses I and II for 1965 are custom-built, whereas Houses III and IV are tract houses. The two groups can also be distinguished by the fact that the custom houses have two stories, while the tract homes have all rooms on the same level. This feature gives the tract houses a disadvantage in labor time for footings when calculated per MSF of living area, despite somewhat lower unit labor inputs.[4] (See the first line of Table 8). Partly underlying the higher material cost in the tract houses (Table 11) is also, of course, the larger number of piers, which requires more concrete.

Framing displays an even clearer dichotomy between tracts and custom building. Taking an average of each type, tract houses show 62 hours less skilled and 27 hours less unskilled labor as compared with the custom houses. This labor saving may be largely ascribed to precutting (as compared to completely traditional methods -- save for power saws), and the use of nailguns. Table 11 shows that volume buying results in a net cost of materials for framing below custom building, despite cutting-fee costs. As a percentage of total framing costs, materials for the tract houses figure about 12 points above the custom houses.

Table 10 gives more detailed insight into the labor savings

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[4]This diseconomy would also be relevant to prefabricated housing.

TABLE 8

Hours per MSF of living area, 1965

	Custom-built houses				Tract-built houses			
	I		II		III		IV	
	Unskilled	Skilled	Unskilled	Skilled	Unskilled	Skilled	Unskilled	Skilled
Footings	1.8	5.4	4.6	10.9	3.5	16.1	3.4	16.5
Concrete floors	3.3	3.5	0	0	2.0	2.2	2.5	2.8
Framing	27.4	149.8	39.9	136.7	6.2	81.4	6.4	80.2
Exterior walls	9.2	28.2	7.7	44.0	10.1	29.8	7.3	21.7
Interior walls and ceilings	0	46.1	0	24.0	0	27.6	0	32.9
Windows	0	22.2	0	3.5	0	1.9	0	1.5
Doors	0	12.0	0	7.5	1.1	7.4	1.2	8.8
Interior trim	0	17.1	0	6.7	0	8.7	0	8.6
Floors	0	49.5	0	31.4	0	43.8	0	43.2
Roof cover	0	6.0	0	15.1	0	20.9	0	13.6
Stairs	0	4.1	0	8.4	0	0	0	0
Cabinets	0	4.1	0	2.8	0	2.4	0	3.5
Total	41.8	348.0	52.1	291.1	22.9	242.4	20.9	233.4

Source: Appendix A tables.

Note: Detail may not add to total due to rounding.

TABLE 9

Percentage Distribution of Hours per Operation, 1965

	Custom-built houses				Tract-built houses			
	I		II		III		IV	
	Unskilled	Skilled	Unskilled	Skilled	Unskilled	Skilled	Unskilled	Skilled
Footings	4.3	1.5	8.8	3.7	15.3	6.6	16.3	7.1
Concrete floors	7.9	1.0	0	0	8.7	0.9	12.0	1.2
Framing	65.5	43.9	76.6	46.9	27.1	33.6	30.6	34.4
Exterior walls	22.0	8.1	14.8	15.1	44.1	12.3	34.9	9.3
Interior walls and ceilings	0	13.2	0	8.2	0	11.4	0	14.1
Windows	0	6.4	0	1.2	0	0.8	0	0.6
Doors	0	3.4	0	2.6	4.8	3.0	5.7	3.8
Interior trim	0	4.9	0	2.3	0	3.6	0	3.7
Floors	0	14.2	0	10.8	0	18.1	0	18.5
Roof cover	0	1.7	0	5.2	0	8.6	0	5.8
Stairs	0	1.2	0	2.9	0	0	0	0
Cabinets	0	1.2	0	1.0	0	1.0	0	1.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Appendix A tables.

Note: Detail may not add to total due to rounding.

TABLE 10

Suboperations, Hours per MBF or MSF, 1965

	Custom-built houses				Tract-built houses			
	I		II		III		IV	
	Unskilled	Skilled	Unskilled	Skilled	Unskilled	Skilled	Unskilled	Skilled
Mudsill, girder, floor joists or rim joists and girders, per MBF	3.7	16.4	3.8	15.6	1.0	10.6	1.1	10.9
Subfloor, per MSF covered	3.0	11.0	3.1	9.4	0	8.0	0	8.0
Studs and plates, per MBF	6.0	30.0	6.0	20.0	2.0	11.0	2.0	11.0
Roof framing, per MBF	0	0	6.0	25.0	0	12.4	0	9.5
Roof sheathing, per MSF covered	1.3	27.1	4.9	12.2	0	10.1	0	8.4
Exterior walls, per MSF	6.6	20.1	4.6	26.3	6.5	19.3	6.5	19.3
Interior walls and ceilings, per MSF	0	14.0	0	11.1	0	10.3	0	9.7
Resilient floors, per MSF	0	20.4	0	11.7	0	19.8	0	20.1
Hardwood floors, per MSF	0	64.5	0	55.6	0	55.6	0	55.7

Source: Appendix A tables.

Note: Subfloor and roof sheathing quantities are exclusive of waste.

TABLE 11

Material and Labor Cost, Dollars per MSF of Living Area, 1965

	Custom-built houses						Tract-built houses					
	I			II			III			IV		
	Materials	Unskilled	Skilled	Materials	Unskilled	Skilled	Materials	Unskilled	Skilled	Materials	Unskilled	Skilled
Footings	13.37	7.60	29.04	16.73	19.01	59.06	25.62	14.56	87.28	25.27	14.35	89.30
Concrete floors	94.90	14.01	18.23	0	0	0	55.06	8.15	11.41	68.70	10.17	14.26
Framing	917.17	114.24	809.40	1,018.85	166.30	739.35	775.51	26.07	440.19	863.03	26.58	433.08
Exterior walls	245.16	46.62	155.65	441.20	38.52	240.79	137.22	52.28	166.68	100.00	38.08	121.47
Interior walls and ceilings	371.96	0	248.77	147.76	0	129.95	174.68	0	149.07	200.17	0	177.64
Windows	274.74	0	120.09	130.56	0	18.84	188.08	0	10.45	99.43	0	8.32
Doors	233.17	0	64.83	124.49	0	40.44	290.83	4.72	40.20	252.03	5.14	47.54
Interior trim	47.88	0	92.66	15.79	0	36.54	27.04	0	47.28	20.81	0	46.82
Floors	258.86	0	272.47	171.50	0	172.21	417.42	0	240.00	153.04	0	238.60
Roof cover	66.30	0	30.18	207.75	0	81.06	289.25	0	113.08	150.14	0	72.09
Stairs	35.94	0	21.88	55.46	0	45.21	0	0	0	0	0	--
Cabinets	374.87	0	21.88	265.12	0	15.07	419.59	0	12.86	403.60	0	19.01
Total	2,934.32	182.47	1,885.08	2,595.21	223.83	1,578.52	2,800.30	105.78	1,318.50	2,336.22	94.32	1,268.13

Source: Appendix A tables.

TABLE 12

Total Cost per MSF of Living Area, by Dollar Cost and Percentage Distribution, 1965

	Absolute numbers ($)				Percentage distribution			
	Custom-built houses		Tract-built houses		Custom-built houses		Tract-built houses	
	I	II	III	IV	I	II	III	IV
Footings	50.01	94.80	127.46	128.92	1.0	2.2	3.0	3.5
Concrete floors	127.14	0	74.62	93.13	2.5	0	1.8	2.5
Framing	1,840.81	1,924.50	1,241.77	1,322.69	36.8	43.8	29.4	35.8
Exterior walls	447.43	720.51	356.18	259.55	8.9	16.4	8.4	7.0
Interior walls and ceilings	620.73	277.71	323.75	377.81	12.4	6.3	7.7	10.2
Windows	394.83	149.40	198.53	107.75	7.9	3.4	4.7	2.9
Doors	298.0C	164.93	335.75	304.71	6.0	3.7	7.9	8.2
Interior trim	140.54	52.33	74.32	67.63	2.8	1.2	1.8	1.8
Floors	531.33	343.71	657.42	391.64	10.6	7.8	15.6	10.6
Roof cover	96.48	288.81	402.33	222.23	1.9	6.6	9.5	6.0
Stairs	57.82	100.67	0	0	1.2	2.3	0	0
Cabinets	396.75	280.19	432.45	422.61	8.0	6.4	10.2	11.4
Total	5,001.87	4,397.56	4,224.58	3,698.67	100.0	100.0	100.0	100.0

Source: Appendix A tables.

Note: Detail may not add to total due to rounding.

TABLE 13

Hours per Skill Category, 1965

	Hours per house								Hours per MSF of living area			
	Absolute numbers				Percentage distribution							
	Custom		Tract		Custom		Tract		Custom		Tract	
	I	II	III	IV	I	II	III	IV	I	II	III	IV
Carpenters: Total	612.0	569.9	321.0	229.0	79.5	77.2	72.0	79.3	310.0	265.1	191.2	201.6
Forms and reinforcement	8.6	21.5	25.1	16.7					4.4	10.0	14.9	14.7
Framing	295.8	293.9	136.7	91.1					149.8	136.7	81.4	80.2
Wood siding (ext.) (incl. box eves)	13.4	58.2	0	0					6.8	27.1	0	0
Wood siding (int.)	26.6	8.2	0	0					13.5	3.8	0	0
Insulation	6.7	0	11.2	7.0					3.4	0	6.7	6.2
Drywall	57.7	43.5	35.1	30.4					29.2	20.2	20.9	26.8
Windows, doors, int. trim	101.4	38.1	30.4	21.5					51.4	17.7	18.1	18.9
Hardwood floors	85.8	54.2	47.8	45.7					43.5	25.2	28.5	40.2
Shingles	0	28.3	30.7	12.6					0	13.2	18.3	11.1
Cabinets install.	8.0	6.0	4.0	4.0					4.0	2.8	2.4	3.5
Stairs	8.0	18.0	0	0					4.0	8.4	0	0
Cement finishers	7.0	0	3.7	3.2	0.9	0	0.8	1.1	3.5	0	2.2	2.8
Latherers	11.7	10.1	16.4	8.1	1.5	1.4	3.7	2.8	5.9	4.7	9.8	7.1

- continued -

TABLE 13 -- continued

	Hours per house								Hours per MSF of living area			
	Absolute number				Percentage distribution							
	Custom		Tract		Custom		Tract		Custom		Tract	
	I	II	III	IV	I	II	III	IV	I	II	III	IV
Plasterers	30.5	26.4	33.7	16.6	4.0	3.6	7.6	5.7	15.4	12.3	20.1	14.6
Carpet-linoleum-soft tile layers	11.9	13.3	15.5	3.4	1.5	1.8	3.5	1.2	6.0	6.2	9.2	3.0
Tile setters	0	0	10.3	0	0	0	2.3	0	0	0	6.1	0
Trenching machine operators	2.0	2.0	2.0	2.0	0.3	0.3	0.4	0.7	1.0	0.9	1.2	1.8
Teamsters	0	4.1	4.4	2.8	0	0.5	1.0	1.0	0	1.9	2.6	2.5
Roofers	11.9	0	0	0	1.5	0	0	0	6.0	0	0	0
General building laborers	67.3	98.9	21.6	15.4	8.7	13.4	4.8	5.3	34.1	46.0	12.9	13.6
Hod carriers	15.2	13.2	16.9	8.3	2.0	1.8	3.8	2.9	7.7	6.1	10.0	7.3
Total	769.5	737.9	445.5	288.8	100.0	100.0	100.0	100.0	389.8	343.2	265.3	254.2
Skilled total	687.0	625.8	407.0	265.1	89.3	84.8	91.4	91.8	348.0	291.1	242.4	233.4
Unskilled total	82.5	112.1	38.5	23.7	10.7	15.2	8.6	8.2	41.8	52.1	22.9	20.9

Source: Appendix A tables.

Note: Detail may not add to total due to rounding.

due to different methods of operation. All five lines in this Table dealing with framing operations show savings in the tract houses. Moderate labor saving is visible in subflooring and roof sheathing (but substantial when compared with House I's roof sheathing which involved redwood, tar and gravel). The traditional floor joist system is seen to take about 50 per cent more labor time than the piers and girders in tracts. Traditional methods of cutting and erecting stud walls take two to three times more labor time than precut methods.

Just as for 1930, disparities in the amount of exterior and interior wall surface make it more useful to look at hours per MSF of wall (Table 10). The somewhat higher figures for exterior walls in I and II (compared to the all-stucco tracts) can be seen as a result of better quality stucco work outweighing the shorter time needed to install wood siding. (But the latter has a heavy impact on material cost -- see Table 11). The added cost for interior walls is for the most part due to interior wood siding in the custom houses.

Labor time for windows in House I is very high due to the 10 solid glass windows. House II, as compared with the tract houses, shows the saving from volume work. In contrast, for doors no significant differences in labor time are evident although much less time per unit was allowed in the tract houses. Interior trim is only significantly higher in the first class house.

Time for floors presents a varied picture because of the peculiar specifications for each house. House I has almost 3/5 of its floors covered with first grade hardwood. House II has more than half in resilient covering, thus accounting for the low labor time. House III again has 3/5 hardwood, and carpeting on top of it, while IV has hardwood on 4/5 of the floor area.

If the tract houses in our study had been built after February 1967 the floor coverings most likely would have been different, since at that time FHA dropped its requirement that hardwood floors be placed, and allowed for placement of carpets only with underlayment of particle board or masonite. If this change had occurred before 1965, then our estimates in Tables 7 and 8 in Appendix A would have been changed as follows:

Appendix Table 7 (House III)		Material Square feet	Skilled hours	Material cost	Labor cost
Deduct:	Hardwood floors	859	47.8	$158.24	$265.51
Add :	Resilient floors	87	1.8	27.50	9.36
Total	for floors would then be	--	27.6	570.11	146.82
Appendix Table 8 (House IV)					
Deduct:	Hardwood floors	820	45.7	140.22	253.47
Add :	Carpeting	820	9.1	273.00	47.32
Total	for floors would then be	--	12.5	306.63	64.90

Computed on the basis of MFS of living area, labor time for flooring would then be 16.4 hours in House III and 11.0 hours in House IV, substantially below the custom-built houses.

Roof cover figures are lowest for House I with its tar and gravel. Houses II and III have the same type of roof, but II reflects the economies of multi-story building with fewer square feet of roof area. However, when time for stairs is added in the multi-story building nothing is left of this economy.

Parallel to Table 7, Table 13 groups the basic data by the different skills. The difference between custom and tract building is clearly present in almost all labor categories.

6. Aggregation of the Detailed Estimates for 1930 and 1965

The detailed estimates for houses in different classes are interesting in and of themselves, but cannot be used *per se* to obtain answers to the question posed initially: *i.e.*, How have skill requirements and labor needs for carpenters changed between 1930 and 1965? To answer this question, the above data have been aggregated to obtain averages for each year. The computed average figures are used in the following chapters of this study in order to answer the basic questions posed in this research.

In order to obtain averages, two different procedures were followed. For 1930, the averaging process was simple. Inasmuch as the structure of the industry was dominated by custom builders in 1930, the house representative of each cost quartile was given a weight of 25 per cent. Hence, a simple arithmetic mean was computed for all relevant hours and cost data.

The 1965 averaging process, however, was complicated by the different influence of custom versus tract building. It was then necessary to determine the weight that had to be assigned to each house estimated for 1965. Weights were derived by using the distribution of building permit valuations from the 1965 data survey.[5]

The procedure used was as follows. First, the 1004 houses in the custom-built class had to be allocated between Houses I and II for 1965. According to the building permit value, House I had a building cost of $26,000, while that selected as House II had a permit value of $21,500. The distribution of all 1004 houses was summarized as follows on the basis of the table in Appendix B.

Permit Value	Number of houses	Houses allocated to Quartile I	Quartile II
Less than $13,000	94	--	94.0
$13,000 - 20,999	326	--	326.0
21,000 - 21,500	23	--	23.0
21,501 - 25,999	231	115.5	115.5
26,000 or more	330	330.0	--
Totals	1004	445.5	558.5

All houses of $21,500 or less were allocated to Quartile II and those houses of $26,000 or more were allocated to Quartile I.[6] Then, arbitrarily, the number of houses with costs between these two limits were equally divided between the two quartiles. For simplicity,

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[5]Appendix B shows the cost distribution of custom and tract houses according to the building permit survey.

[6]Technically speaking, since the weights are no longer 25 per cent, we do not have quartiles in a rigorous sense. The term as used for 1965 thus refers to four groups representative of Houses I, II, III, and IV discussed above.

the numbers have been rounded to 446 for Quartile I and 558 for Quartile II.

In order to divide the tract houses into two groups, as represented by Houses III and IV, the first of which had a permit value of $19,147 and the second, $12,000, the same reasoning as applied above was used to establish weights.

The distribution of all 3,563 houses was summarized as follows on the basis of the table in Appendix B.

Permit Value	Number of houses	Houses allocated to Quartile III	Quartile IV
Less than $12,000	499	--	499
$12,000 - 17,999	2102	1051	1051
$18,000 or more	962	962	--
Totals	3563	2013	1550

Again, as above, those houses with building permit values in the $12,000 - $17,999 range were equally divided between the two classes of houses.

By distributing the houses for 1965 according to the above method, the following weights were derived and were used to calculate the averages used in the following Chapters.[7]

Quartiles	Number of Houses	Weights
I	446	.098
II	558	.122
III	2013	.441
IV	1550	.339

[7]Obviously, any weighting method which is based on some arbitrariness can be criticized. However, a different weighting scheme used, which was not as precise as the one above yielded weights of .146, .073, .505, and .276 for Houses I through IV respectively. Annual rates of growth in productivity computed on the basis of these less scientifically computed weights were almost the same as those shown in Chapter III.

Chapter III

CHANGES IN CRAFT REQUIREMENTS IN THE BUILDING OF SINGLE-FAMILY DWELLINGS

1. Introduction

To understand how changes occurred in the use of carpenter manhours over the 35-year period, it is necessary to show how changes affected all crafts with which we dealt because of (1) substitution that occurred among the different on-site labor categories and (2) substitution between labor and materials, or on-site and off-site labor.

In this Chapter, therefore, data for individual houses have been averaged as explained in Chapter II so that single figures could be used for the two years studied. Labor requirements are based on a basic output measure of 1000 square feet (MSF) of living area which takes account of the whole house and also provides a homogeneous output measure.[1] (The ratio of 1000 sq. ft. to manhours required is converted where needed to square feet per manhour in order to facilitate comparisons.) In this way, labor requirements for each year can be compared on the basis of the same standard. For example, if framing a house with 1000 square feet of living area required 120 labor hours in 1930 and 80 hours

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[1]By using square feet of living area, differences that could arise from different types of garages, or no garage, or basements and no basements are excluded. However, in the data for the individual houses, manhours needed for garages and basements are included if the house had these attributes.

in 1965, then labor time for framing decreased by 33 percent over the 35 years. It must be emphasized that when hours per MSF of living area are compared between 1930 and 1965 the resultant changes shown take account of several effects simultaneously, i.e., changes in work methods, in quality, and in the quantity of each broad operation. Furthermore, the two years differ with respect to unionization. In 1930, the construction industry in Alameda County was nonunion. In 1965, the industry, including residential construction, was entirely unionized.

In Section 2, all crafts and labor groups are examined so that the shifts that occurred among the occupational groups we studied can be understood. Insights into the changing nature of labor requirements in the several occupations are provided by focusing the discussion in this section around the operations performed in the building of single-family dwellings.

All major operations used in the building of single-family dwellings required less labor per MSF of living area in 1965 than in 1930. Reduced labor time was especially significant in operations utilizing prefabricated components. Hence, we see the substitution of off-site work (represented by materials) for on-site labor. The analysis of this aspect of the research in Section 3 reviews the labor cost -- materials' cost relationships in the two years which show the trade off that took place over the thirty five years.

In Section 4, the data on manhours per MSF of living area are transformed into a physical labor productivity measure that relates output to a single manhour. In addition, estimates of total square feet of living area built in 1930 and 1965 are made in order to determine the magnitude of the total demand change over 35 years. These data are then used to estimate total manhours required of carpenters and other building tradesmen. Finally, annual compounded rates of growth per annum are computed for total output, total manhours required, and labor productivity, and these results are related to manpower forecasting. In addition, a rough estimate is made of the amount of labor saved because of changes in building practices.

In the remainder of this study, the concept of physical labor productivity used is average labor productivity and not marginal labor productivity, the variable that is basic in economic theory. Consequently, this study conforms to other empirical studies dealing with labor productivity where the average productivity concept can be justified if a particular production function, Cobb Douglas, is assumed. Such a production function assumes that the marginal product is a constant multiple of average product. Hence, a rise in average product means the same proportional increase in marginal product. Another argument can be made to justify use of average productivity. For the long run case, the average product is of more theoretical importance than is marginal product because: (1) in the long run under competitive conditions, price tends to minimum average cost, and

(2) in pricing, firms price products on the basis of average cost.[2]

In Section 5, we proceed under the assumption that building practices in 1940 were the same as in 1950. On this basis, labor productivity growth rates are computed for the 25 year period, 1940-1965. These rates are provided, obviously, as a rough approximation. However, intensive study of the trade literature suggested that this digression has merit with respect to the state of the arts in house building. Perhaps the two growth rates appearing in this study will stimulate additional research that will test the findings presented here.

2. Changes in Labor Requirements per MSF of Living Area, by Occupation and Operation, 1930-1965

The following discussion emphasizes changes that took place in the use of carpenters' skills and the shifts in relationships among the labor groups. Table 14 summarizes the evidence by showing the distribution of hours to build 1000 sq. feet of living area among the various occupational groups. Further, the operation in which these hours were used is given for each occupation. As seen in this table, the largest reductions in labor time per MSF of living area over the 35 years affected lathers, plasterers, laborers, tile helpers, and hod carriers. Only the labor time of

[2] See Raymond L. Richman, comments on paper by George L. Stigler, "Economic Problems in Measuring Changes in Productivity," in Output, Input, and Productivity Measurement (Princeton, N.J.: Princeton University Press, 1961), p. 75.

TABLE 14

Hours per 1,000 Square Feet (MSF) of Living Area for Carpenters and Other Occupations, by Operations, for Single-Family Dwellings, 1930 and 1965

Occupation and Operation	Hours per MSF of living area		
	Absolute number		Percentage change
	1930	1965	1930-65
1. Carpenter - Total	393.9	215.4	-45.3
Footings (forms)	13.6	13.2	-2.9
Framing	139.5	94.4	-32.3
Exterior walls	30.7	4.0	-87.0
Wall sheathing	22.0	0	-100.0
Stucco preparation	8.7	0	-100.0
Wood siding	0	4.0	0
Interior walls and ceilings	20.8	30.8	48.1
Plaster preparation	20.8	0	-100.0
Wood paneling	0	1.8	0
Insulation	0	5.4	0
Drywall (drywall installors)	0	23.6	0
Windows	40.2	4.0	-90.1[a]
Doors	41.8	8.3	-80.1
Interior trim	35.7	12.3	-65.6
Cabinet installation	0	3.0	0
Other	35.7	9.3	-74.0[a]
Floors (hardwood floor layers)	41.8	33.5	-19.9
Roof (shinglers)	20.9	13.4	-35.9
Stairs	8.9	1.4	-84.3

- continued -

TABLE 14 -- continued

Occupation and operation	Hours per MSF of living area: Absolute number 1930	1965	Percentage change 1930-65
2. Cement finishers (concrete floors)	5.7	2.3	-59.6
3. Lather	51.1	7.9	-84.5
Exterior walls (stucco)	18.5	7.9	-57.3
Interior walls (plaster)	32.6	0	-100.0
4. Plasterer	142.1	16.8	-88.2
Exterior walls (stucco)	78.5	16.8	-78.6
Interior walls (plaster)	63.6	0	-100.0
5. Linoleum layer[b] (floors)	3.5	6.4	82.9
6. Hard-tile setter (floors)	11.6	2.7	-76.7
7. General building laborer	113.5	19.3	-83.0
Footings	17.5	3.4	-80.6
Concrete floors	35.4	2.1	-94.1
Framing	41.7	12.5	-70.0
Exterior walls	9.1	0.4	-95.6
Doors	0	0.9	0
Interior trim	5.9	0	-100.0
Floors	3.9	0	-100.0
8. Hod carrier	103.5	8.4	-91.9
Exterior walls	58.5	8.4	-85.6
Interior walls	45.0	0	-100.0
9. Tile helper (floors)	12.5	0	-100.0

- continued -

TABLE 14 -- continued

Occupation and operation	Hours per MSF of living area		
	Absolute number		Percentage change
	1930	1965	1930-65
10. Skilled only (sum of lines 1-6)	607.9	255.6[c]	-57.9
11. Unskilled only (sum of lines 7-9)	229.5	27.6	-88.0
12. All occupations (sum of lines 1-9)[d]	837.4	283.2[c]	-66.2

[a]In 1930, window trim appears under <u>Windows</u>. In 1965, window trim is included under <u>Interior trim</u>. Consequently, the percentage reduction in windows is slightly overstated and that for interior trim is slightly understated. This methodology reflects the shift that occurred by 1965 when all trim around aluminum windows was performed by a finish crew doing the interior trim. Door trim, in contrast, appears under <u>Doors</u> in both years. To be consistent, we should have included door trim in 1965 under <u>Interior Trim</u> because tract builders have all trim installed by the same crew so that all of this trim is one operation. The inconsistency does not change the argument, however, for as seen in the table, hours in windows, doors, and interior trim dropped substantially.

[b]Carpet, soft-tile and linoleum layers.

[c]Total includes 4.1 hours for trenching machine operators, teamsters, and roofers.

[d]Detail by operations is shown in Table 15. This classification is referred to in the text as the integrated crew.

Note: Detail may not add to total due to rounding.

linoleum, carpet, and soft-tile layers increased over this period, a reflection of the shift to new materials. Table 15 shows in detail the distribution of hours among the operations for the integrated crew, i.e., all the occupations we studied. Added detail on changes in skill requirements is provided in Tables 16 and 17 which expand the information to include suboperations.

Qualitative accounts in the trade literature regarding changes that have taken place in on-site construction since the advent of the merchant builder and mass house production are supported by the data in Table 14. Overall, carpenter manhours per MSF of living area declined by 45.3 per cent. Significant reductions by task occurred in window and door installation, 90 and 80 per cent respectively, and in interior trim, excluding cabinets, down by 74 per cent. This substantial curtailment in hours per MSF reflects: (1) the use of aluminum windows in 1965 that could be installed at the site as contrasted with double-hung or other wood frame windows that were cut and fit on the site in 1930; (2) pre-hung doors in 1965; and (3) the abolition of much of the interior trim that could be found in 1930 homes. Reductions in window installation are impressive except when special jobs such as large solid glass placement on site is involved.

Framing activity by on-site carpenters decreased by 32.3 per cent per 1000 square feet between 1930 and 1965. The reduction in framing hours came about largely from the influence of the mass building of houses. As the detailed house data in Chapter II show,

TABLE 15

Hours per MSF of Living Area, by Operations, for the Integrated Crew, 1930 and 1965

Operation	Hours per MSF of living area		
	Absolute number		Percentage change
	1930	1965	1930-65
Footings	31.1	17.9	-42.4
Concrete floor	41.1	4.4	-89.3
Framing	181.2	106.9	-41.5
Exterior walls	195.3	37.5	-80.8
Interior walls and ceiling	162.0	30.8	-81.0
Windows	40.2	4.0	-90.1
Doors	41.8	9.2	-78.0
Interior trim	41.6	9.3	-77.6
Floors	73.3	42.6	-41.9
Roof	20.9	16.2	-22.5
Stairs	8.9	1.4	-84.3
Cabinets	0	3.0	0
All operations	837.4	283.2	-66.2

Note: Detail may not add to total due to rounding.

TABLE 16

Percentage Decreases in Labor Requirements, Framing Suboperations, 1930 - 1965

Suboperation	House I		House II		House III		House IV	
	General laborers	Carpen-ters	General laborers	Carpen-ters	General laborers	Carpen-ters	General laborers	Carpen-ters
Subfloor underlayment: Mudsill, girder, floor joists, <u>or</u> rim joists and girders, per MBF	-19.6	46.4	-17.4	40.5	-75.0	-3.6	-72.5	4.8
Subfloor, per MSF	-46.4	-1.8	-44.6	-16.1	-100.0	-11.1	-100.0	-11.1
Studs and plates, per MBF (wall framing)	20.0	-3.2	20.0	-35.5	-60.0	-47.6	-60.0	-47.6
Roof framing, per MBF	-100.0	-100.0	-14.3	-10.7	-100.0	-55.7	-100.0	-62.0
Roof sheathing, per MSF	-77.2	148.6	-26.9	-8.3	-100.0	26.2	-100.0	5.0

TABLE 17

Framing Suboperations, Hours per MBF or MSF, 1930 and 1965

Suboperation	1930			1965			Percentage change, totals
	General laborers	Carpenters	Total	General laborers	Carpenters	Total	
Subfloor underlayment: Mudsill, girder, floor joists <u>or</u> rim joists and girders, per MBF	4.3	10.9	15.2	1.6	11.9	13.5	-11.2
Subfloor, per MSF	5.6	10.1	15.6	0.7	8.5	9.2	-41.0
Studs and plates, per MBF (wall framing)	5.0	26.0	31.0	2.9	14.0	16.9	-45.5
Roof framing, per MBF	6.7	28.4	35.1	0.7	11.7	12.4	-64.7
Roof sheathing, per MSF	5.7	10.0	15.7	0.7	11.4	12.1	-22.9

carpenter requirements in framing in the Class I and II houses underwent almost no change between 1930 and 1965 but decreased about one-third in Class III and IV houses. These data support the contention that as far as carpenters are concerned, framing has not changed much in custom houses. Further, precutting, trusses, nailguns, and other modern methods in tract building have produced important but not drastic labor saving (to 1965).[3]

Detail regarding how these changes came about in framing is provided in Table 16, which shows the changes in suboperations for each class of house, and Table 17, which shows the same information but on the basis of the computed averages.

As seen in Table 17, total labor time for the subfloor underlayment (i.e., mudsill, girder, and floor joists) per 1000 board feet MBF, decreased by 11.2 per cent. This decrease came about basically from the reduction in laborer hours and a small decrease in carpenter hours in House III. (As shown above, House III represented 44.1 per cent of all houses built in 1965.) In fact, the traditional system of subfloor underlayment work took more skilled hours in 1965 than in 1930 per MBF (Table 17) even though total hours decreased. In tract houses, rim joists and girders per MBF permitted only a small change in carpenter hours (up by

[3] A word of qualification is necessary. Although the framing methods assumed in the cost estimating procedures for custom houses (power saw and random lengths) and for tract houses (complete precut) are considered typical, they are nevertheless "pure" types with respect to labor intensity. More likely, various mixes of traditional and precut methods take place. One common mix includes the use of precut studs only; another, to use precut lumber for all operations but roof framing.

4.8 per cent in House IV and down by 3.6 per cent in House III).

Subflooring per MSF, despite the changeover to plywood and the use of nailguns in tracts, required only 11.1 per cent fewer carpenter hours in 1965 than in 1930 in Houses III and IV. Total labor time for subflooring, however, decreased by 41 per cent on the average, as laborers were virtually eliminated from the operation by 1965.

All hours per MBF for wall framing (studs and plates) decreased on the average by 45.5 per cent between 1930 and 1965 (Table 17). This reduction was due to less carpenter hours in the two tract houses built in 1965, down by 47.6 per cent in each house, and also to a reduction of 35.5 per cent in carpenter time in the Class II house, even though no precutting was involved in this latter class. In contrast, carpenter time, per MBF in the highest quality house, House I, was virtually unchanged over the 35 years despite the changeover from handsaw to powersaw.

Roof framing per MBF took 65 per cent less total labor time in 1965 than in 1930. In this case, again, laborer time was practically eliminated, while carpenter time per MBF decreased by almost 60 per cent. This difference in time reflects labor savings resulting from prefabricated trusses and precutting.

Roof sheathing per MSF, despite new methods such as the use of nailguns in tracts and plywood or spaced sheathing, required somewhat more carpenter hours in all but the Class II house (see Table 16). On the average, however, carpenter hours per MSF increased only to 11.4 in 1965 from 10.0 in 1930 (Table 17). Again, the large reduction in hours was for laborers, so that total labor hours per MSF were down by 23 per cent between 1930 and 1965.

In all of the above activities included under framing -- i.e., subfloor underlayment, subflooring, wall framing, roof framing, and roof sheathing -- laborer time has been virtually eliminated while, on the average, for framing as a whole, carpenter hours per MSF of living area decreased by 32.3 per cent over the 35 years (Table 14).

As shown in Table 15 total labor hours (skilled and unskilled) on exterior walls declined by 80.8 per cent per MSF of living area. In particular, wall sheathing required 22 carpenter hours per MSF of living area in 1930 but none in 1965. Substantial productivity increases in exterior stucco work reduced the hours worked per MSF not only for carpenters, but also for lathers and plasterers. In 1930, lather hours per MSF spent on the stucco exterior totaled 18.5, and for the plasterer, 78.5 (see Table 14). By 1965, exterior stucco work required far less time for all categories of workers because of the substitution of wood grounds by line wire, the use of lighter asphalt papers, and the faster application of stucco itself, even when done by hand. For the carpenter, only part of the loss in hours on exterior wall work was recouped by 1965, as the use of wood siding meant, on the average, 4.0 hours per MSF of living area versus the loss of 22.0 hours per MSF of living area in 1930 for wall sheathing.

This substantial reduction in labor time required in exterior stucco work could be traced to five major changes in the postwar period.

1. Since about 1957 contractors shifted from 15 lb. to lightweight (or black saturated) felt. Such felt is not only about 28 per cent cheaper (using 1968 prices), but also takes about half the time to apply as 15 lb. felt.

2. Stapling guns to apply wire lath were introduced in 1959. They require self-firring wire lath, which is about 2.5 per cent more expensive than simple wire lath (in 1969 prices). One company, which started using stapling machines in 1962, found that its labor time decreased from 5.9 hours to 3.7 hours per 100 sq. yd. for a reduction in time of 37 per cent for this operation.

3. Since 1959 machine plastering of the scratch and brown coats came in use. This operation requires a special cement, raising its cost 9.1 per cent over the price of the mix of common and plastic cement used before. (This implies a 4.3 per cent cost increase in plasterer's materials -- sand and cement for three coats.) A comparison of labor time on tract work between hand application (by a crew of four plasterers and two hod carriers) and gun application (by a crew of four plasterers and two hod carriers) shows that plasterer time is reduced from 13.0 to 11.7 hours per 100 sq. yd., or by 10 per cent and hod carrier time, reduced from 6.6 to 5.9 hours per 100 sq. yd., or by 9.4 per cent. These figures are for three-coat stucco of which two are gun-applied, and the finishing coat hand-applied, as is done in almost all cases.

Introduction of the plaster gun, however, was not without problems. One company reported buying one in 1958 and again in 1963. Each time the guns were discarded almost immediately because of unsatisfactory results. Finally, a new plaster gun bought in 1968 produced good results. Further, in custom work all three coats are usually applied by hand since the plaster gun setup is too complex for only one house. Typical labor time in custom work is, in addition, about 20 per cent above the time for hand application given above, because of the higher grade workmanship.

4. At least since 1968 self-firred paperback, which combines felt paper and wire lath, has been used. This product has raised lathing-material costs by about 20 per cent, but reduced labor time on tract work from 5.7 to 4.9 hours per 100 sq. yd., for a reduction of 14 per cent.

5. At least since 1968 the cement used for hand-applied brown and scratch coat has changed from half common/half plastic to plastic cement only. This raises material costs because the cost of only plastic cement is 3.8 per cent above the mix. For three coats, total plasterer materials thus are two per cent higher. However, this cement makes plaster application easier.

Labor time for interior walls and ceilings per MSF (Table 15) decreased 81 per cent between 1930 and 1965. This substantial drop came from the total elimination of hod carrier, lather, and plasterer time -- respectively 45.0, 32.6, and 63.6 hours per MSF in 1930 (see Table 14). In this case, carpenters widened their jurisdiction to include drywall installation, so that carpenter hours per MSF rose from 20.8 hours per MSF in 1930, which involved time in plaster preparation such as wood grounds and building paper installation, to 23.6 hours per MSF for drywall installation. The carpenter benefited a little from interior paneling, with this activity taking 1.8 carpenter hours per MSF in 1965, and insulation requiring 5.4 manhours per MSF. Hence, while the carpenter lost 20.8 hours per MSF because of the phasing out of interior plaster, he found work in drywall, interior paneling, and insulation for a total of 30.8 hours per MSF. On balance, then, the carpenter gained an average of 10.0 hours per MSF on interior walls and ceilings. In this case it should be observed that by widening jurisdiction to drywall from an activity that was formerly the domain of another craft, carpenter manhours per MSF of living area were higher than they would have been without this new work assignment. As will be seen later, this fact plays a role in the productivity growth rate for carpenters.

The extensive use of drywall can be seen in the following data. Drywall was used in three to four per cent of all residential construction in Northern California in 1939. By 1950, it was used in 80 per cent of the houses. In 1969, it became the major interior wall material used in 98 per cent of the houses built.

Labor time for installing drywall increased gradually from 1950 to 1965, from four to five hours per MSF, or by 25 per cent. This increase in labor time was the result of a higher quality of workmanship, including, e.g., the lining of studs. (The practice of lining studs is, however, a rare practice now.) The pace of work also slowed down to a more tolerable level as compared to the pace required when drywall was first introduced on a broad scale.

Finishing time for drywall, i.e., for taping and texturing, followed a time pattern similar to that of installation, but from 1960 forward, the trend was reversed. First, the type of cement used was improved. Second, the taping machine, earlier versions of which were already in wide use in 1955, improved sufficiently by 1960 to allow substantial labor savings. As a result, labor time for finishing in tract work increased from 3.9 to 4.9 hours per MSF from 1950 to 1955, or by 26 per cent. Hours per MSF then decreased to 2.9 by 1965, or 41 per cent below the 1955 figure. Changes in custom work are of the same magnitude with 5.8 hours per MSF required in 1950, 7.3 hours per MSF in 1955, and then 4.4 hours by 1965.

Carpenter hours per MSF of living area decreased by 20 per cent (Table 14) in hardwood floor laying. This reduction in hours, smaller than that which took place in most of the other carpenter's functions (see Table 14) reflects an offset to improved nailing and sanding machines by quality changes. In House III, for example, only a small loss of hours per MSF occurred between 1930 and 1965, from 36.9 to 28.5, because both hardwood floors and carpeting were installed. But for House IV, carpenter hours per MSF actually increased, from 14.9 in 1930 to 40.2 in 1965, because of quality improvement with the shift from fir to oak strip floors. If hardwood floors had been eliminated from the two tract houses in 1965, then a sharper reduction in carpenter hours per MSF would have resulted.

Hardwood flooring per se, however, underwent many changes since 1930. Nailing machines although introduced by 1930, gradually improved, especially with respect to the feeding of nails. By 1950 performance of these machines reached the level prevailing today (1969). The nailing machines ultimately reduced the time required for laying and nailing from 53 to 23 hours per MSF, or by 57 per cent. Today, the machines are still pounded by hand, however, because air pressure guns have not yet proved successful. In addition, between 1930 and 1940, a more powerful sanding machine came into use -- a machine 12-inches wide, with 2-1/2 horsepower instead of an 8-inch, one-horsepower machine. This machine reduced labor time for sanding from 16 to 11 hours per MSF, or by 31 per cent. The improvement of the sanding machine had an equally large effect on finishing time. Instead of puttying each nail separately, putty is now placed over the whole surface, and then the entire surface is sanded.

Carpenter hours (i.e., shingler time) for the roof covering decreased from 20.9 hours per MSF in 1930 to 13.4 hours per MSF in 1965 (Table 14). But these data are hard to compare because the types of roof coverings were changed over the years to reflect the most commonly applied in each of the price ranges. In House I the roof cover was composition shingles in 1930 and tar and gravel roof in 1965, so that in the latter year a roofer was used rather than a shingler. For House II, a change occurred from composition shingles to wood shakes; for House III, from wood shingles to wood shakes. Only House IV had the same kind of roof cover in both years, composition shingles.

It should be noted, however, that the application of shakes and wood or composition shingles has seen little technical change since 1930. The only exception is the practice (since about 1952) of prestocking the roof with material by means of a scissors truck. Shingler time (for shakes or wood shingles) can thus be reduced from 1.5 to 1.2 hours per 100 sq. ft. of roof area, or 20 per cent. Prestocking, however, which became unionized by teamsters, takes from 0.1 to 0.2 hours per 100 sq. ft. of roof area. For composition shingles, preloading allows a time reduction of from 0.81 to 0.64 hours per 100 sq. ft. of roof area, or a 21 per cent reduction, with preloading time of 0.08 to 0.16 hours per 100 sq. ft. of roof area. However, it is not certain that the 20 per cent labor time reduction can be attributed completely to prestocking. A reduction in quality of the work may also have taken place, leading to compensatory changes in building codes such as the requirement of 30 lb. instead of 15 lb. felt and of galvanized nails.

Nailguns have been tried in roofing but have not proved successful. Their break-even point seems to lie at an output of 900 to 950 square feet per eight-hour day.

The only craft in which hours per MSF of living area increased between 1930 and 1965 was that of carpet, soft-tile, and linoleum layers. In this case, extensive use of carpeting and resilient floor covering materials more than offset the following changes in technology that occurred over the 35-year period. Around 1947 tackless stripping and pole stretchers, introduced in carpeting, reduced labor time by 20 per cent. The introduction of tile cutters for the installation of asphalt tile between 1940 and 1950 reduced labor requirements in this activity by 66 per cent.

From the above analysis, it is clear that the changes in home building between 1930 and 1965 had a direct influence on the skills employed by carpenters. The data in Table 14 are recapitulated in terms of percentage distribution in order to show how hours per MSF were distributed in the two years (Table 18).

The results in Table 18 have implications for training programs. The emphasis in both periods was the framing operation. Bay Area on-the-job training received by apprentices in framing supports the importance of this task among others the carpenter does. A survey of former carpenter apprentices in four of the San Francisco Bay Area counties showed that only 5.1 per cent of the 721 respondents to a questionnaire received no training at all in framing.[4] In contrast, 22.3 per cent of these former apprentices received no training in finish work. This finding, too, is not surprising inasmuch as the 1965 distribution of carpenter hours in Table 18

[4]Special preliminary summary of results prepared by Sara Behman (Center for Labor Research and Education, Institute of Industrial Relations, University of California, Berkeley, May 1968), mimeo., 12 pp.

TABLE 18

Percentage Distribution of Carpenter Manhours per MSF of Living Area in Single-Family Dwellings, 1930 and 1965

Activity	1930	1965
Total carpenter hours	393.9	215.4
Per cent	100.0	100.0
Footings (forms and reinforcement)	3.4	6.1
Framing	35.4	43.9
Exterior walls	7.8	1.9
Wall sheathing	5.6	0
Stucco preparation	2.2	0
Wood siding	0	1.9
Interior walls and ceiling	5.3	14.3
Plaster preparation	5.3	0
Wood paneling	0	0.8
Insulation	0	2.5
Drywall	0	11.0
Windows	10.2	1.9
Doors	10.6	3.9
Interior trim	9.1	5.7
Cabinet installation	0	1.4
Floors (hardwood floor layers)	10.6	15.6
Roof (shinglers)	5.3	6.2
Stairs	2.3	0.7

Note: Detail may not add to total due to rounding.

shows that only 11.5 per cent of the time went into finish, defined here as the combination of hours in windows, doors, and interior trim.[5] In contrast, interior finish work in 1930 took 29.9 per cent of the carpenter manhours.

The above evidence bears upon a statement commonly made that carpenters today are not of the quality as carpenters of yesteryear. The evidence supports the hypothesis that the change in emphasis, i.e., installation of parts for intricate on-site fitting methods, reduced the need for heavy training in interior finish work. And the fact that 22.3 per cent of the apprentices responding to the survey never had on-the-job training in finish work suggests such training was not given because it is limited in amount. In the Bay Area counties, apprentices must "hustle their own jobs." The degree of specialization that has occurred in the craft in recent years makes it difficult, if not impossible, to obtain all-around training. With specialization too has come the need for a high degree of speed and proficiency in a particular task. Hence, it does not seem proper to compare carpenters in the two periods. In 1930, craftsmanship related to cut and fit methods was the requirement; in 1965, proficiency in a particular task and speed became requirements. A way in which proficiency in specialized tasks and speed are achieved is through piece work, even though

[5] In the questionnaire, respondents were asked about time spent in "finish work." The definition above may be at variance from the respondents' interpretation. Consequently, the above percentage should be considered only an approximation.

this practice is in violation of the labor-management agreement.[6]

Drywall hanging as a task has been separated from the main body of carpentry, reflecting again the distribution of time as shown in Table 18. As seen there, 11 per cent of the hours spent in building 1000 sq. ft. of living area was in drywall hanging in 1965. In the Bay Area a special labor-management agreement prevails for carpenter training in drywall installation. The period of training is for two years rather than four years required for regular apprenticeship training programs that cover all aspects of the trade.

To sum up, this section has shown: (1) fewer labor hours per MSF were required in 1965 than in 1930 for all building trades studied except carpet, soft-tile, and linoleum layers, and (2) how the shifts to new materials, new techniques, and prefabricated components created a change in the tasks performed by carpenters. These findings suggest, of course, that off-site work was substituted for on-site work. What was the extent of this substitution? In the next section this question is examined in detail for the integrated crew and for carpenters alone.

3. The Trade Off between On-Site and Off-Site Labor

Along with the reductions in labor requirements per MSF

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[6]According to comments made during the various interviews conducted. According to Barry D. Whelchel, "Informal Bargaining in Construction," Industrial Relations, 10 (Feb. 1971), pp. 105-109, piece-work has a dual effect: it enables the contractor to control labor costs but it also gives the construction worker "...more control over his work environment." Whelchel's findings are based on extensive interviews over a five-year period with contractors and workers in the San Diego construction industry.

of living area, labor costs for seven of eleven functions estimated declined relative to material costs between 1930 and 1965. In 1930, all labor costs were 80 per cent of all material costs and by 1965 were 58 per cent. This finding, documented in Table 19, suggests that, in general, materials were substituted for labor. For carpenters, however, the carpenter cost -- materials' cost ratio (using only materials with which the carpenter worked) was not as dramatic (see Table 20). The ratio of carpenter costs to the costs of materials they handled was .54 in 1930 and .51 in 1965.

For all occupations combined, the integrated crew, as shown in Table 19, earnings of labor relative to material costs dropped most significantly in the work on interior walls and ceilings and in stairs. These data are interesting for they show that the most visible trade-off between labor and materials occurred in the two most labor-intensive functions in 1930. These were the only two functions in 1930 in which all labor costs were more than double material costs. The same statement can be made for carpenters alone. As shown in Table 20, carpentry labor was used more intensively relative to materials in both interior walls and ceilings and stairs. Why, however, did the overall carpentry labor cost -- materials' cost ratio show less of a decline over the 35 years than did that of all labor costs relative to all materials costs? There are two possible answers. First, carpenters became a more dominant occupation generally by 1965, when their

TABLE 19

Labor and Material Costs, per MSF of Living Area, All Occupations
by Function, 1930 and 1965

	1930 Costs				1965 Costs				1965 LC/MC minus 1930 LC/MC
	Total	Materials	Labor	LC/MC	Total	Materials	Labor	LC/MC	
Footings	$ 27.71	$ 0	$ 27.71	0	$ 116.38	$ 23.22	$ 93.16	4.012	0
Concrete floors	62.15	31.19	30.96	.993	76.94	56.87	20.07	.353	-.640
Framing	455.46	269.24	186.22	.692	1411.20	848.75	562.45	.663	-.029
Exterior walls	458.37	231.43	226.94	.981	376.81	172.27	204.54	1.187	.206
Interior walls and ceilings	278.97	85.30	193.67	2.270	365.56	199.37	166.19	.834	-1.436
Windows	138.03	92.80	45.23	.487	181.00	159.50	21.50	.135	-.352
Doors	197.31	150.30	47.01	.313	300.68	251.73	48.95	.194	-.119
Interior trim*	96.25	51.97	44.28	.852	482.90	416.54	66.36	.159	-.693
Floors	234.64	156.98	77.66	.495	516.69	282.25	234.44	.831	.336
Roof cover	88.05	64.53	23.52	.364	297.45	210.30	87.15	.414	.050
Stairs	14.65	4.60	10.05	2.185	17.95	10.29	7.66	.744	-1.441
Total	$ 2051.59	$ 1138.34	$ 913.25	.802	$ 4143.56	$ 2631.09	$ 1512.47	.575	-.227

*Includes cabinets in 1965.

TABLE 20

Carpenter Labor and Material Costs, per MSF of Living Area, by Function, 1930 and 1965

	1930 Costs			1965 Costs			1965 CC/MC minus 1930 CC/MC
	Materials	Labor	CC/MC	Materials	Labor	CC/MC	
Footings	$ 0	$ 15.34	0	$ 23.22	$ 71.48	3.078	0
Framing	269.24	156.98	.583	848.75	510.46	.601	.018
Exterior walls	75.60	34.54	.457	60.59	21.43	.354	-.103
Interior walls and ceilings	9.11	23.37	2.565	199.37	166.19	.833	-1.732
Windows	92.80	45.23	.487	159.50	21.50	.134	-.353
Doors	150.30	47.01	.313	251.73	45.13	.179	-.134
Interior trim*	51.97	40.15	.773	416.54	66.36	.159	-.614
Floors	104.20	47.07	.452	106.80	186.10	1.743	1.291
Roof cover	64.53	23.52	.364	203.80	74.53	.366	.002
Stairs	4.60	10.05	2.184	10.29	7.66	.744	-1.440
Total	$ 822.35	$ 443.26	.539	$ 2280.59	$ 1170.84	.513	-.026

*Includes cabinets in 1965.

manhours accounted for 76.1 per cent[7] of the 283.2 total manhours required per MSF of living area, versus 47.0 per cent of the 837.4 total manhours per MSF of living area in 1930 in the 11 operations analyzed in this study (see Table 14). Second, for the major carpentry function, framing, the carpenter cost -- materials' cost ratio increased by .018 of a point. This virtual stability in the carpenter cost -- materials' cost ratio for framing can be traced in part to our findings that laborers' time in tract

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[7]This percentage cannot be compared with the figure found in the Bureau of Labor Statistics study, Bulletin No. 1404, Labor and Material Requirements for Private One-Family House Contruction (June 1964) for several reasons: (1) This study excludes the major subtrades, i.e., plumbing, painting, and electrical work; (2) Drywall installation apparently took more hours in this study than in the BLS study; (3) The BLS study has averages for the entire West while this study deals with a northern California County. Interestingly, when our data are adjusted to conform to the BLS definitions, the discrepancy for carpenter manhours on-site is about 10 per cent, a not unreasonable error considering the many sources of estimating differences. In particular, BLS uses as a basis the construction price which is the FHA estimated replacement cost of the property or the actual (or asking) sales price, whichever is lower, less the FHA estimated market price or value of the improved lot. For the West, this price averaged $14,449 in 1962. On this basis, there were 21.3 carpenter manhours per $1000 of on-site construction price in the West. In this study, the estimated sales price of the 1965 typical house was $24,954 (see Table 28, Chapter IV). Subtracting the lot value, the construction price equivalent to the BLS figure was $19,832. Adjusting our carpenter manhours data from MSF of living area to $1000 of construction price, we obtain 18.0 carpenter manhours (excluding drywall installers in order to conform to the BLS practice) for every $1000 of construction price. Differences in geographic coverage (West versus Alameda County, California) and in time (1962 versus 1965) could easily contribute to the differnce of 3.3 hours, not to mention the procedural differences between the BLS study and ours.

home building was virtually eliminated in all framing operations but subfloor underlayment and wall framing. Some of the duties in the 1965 building methods were taken up by carpenters. Finally, as shown in Table 17, roof sheathing required more carpenter hours per MSF in 1965 than in 1930, although total labor time in this activity per MSF decreased over the 35 years.

When reviewing the data in both Tables 19 and 20, it must be recalled that we are dealing with an average house for each period. Our data thus represent averages around which cost figures of individual firms should cluster, some firms having higher figures and others lower ones, depending on the mix of their techniques, the number of houses they produce (because our interviews suggested that economies can be achieved for volume purchases), and the efficiency of the firm. For example, interviews conducted in 1969 suggested that precutting of lumber was being more widely used in this year than four years earlier, the ending date of this study. One estimate was that during 1969, from 60 to 70 per cent of the tract builders were using the precut method. This method means that all lumber is precut, i.e., the lumber going into the mudsill,girders, subfloor, wall framing, roof, and exterior trim. An efficient contractor could reportedly cut labor costs by from 10 to 20 per cent over other methods if all the lumber were precut. Further, precutting reportedly could lead to materials' saving because of reduced wastage estimated at from 10 to 20 per cent. Inasmuch as savings could occur in both labor and materials, however, it is possible that the 1969 carpenter cost -- materials' cost ratio would not be much different from that shown in Table 20.

Also expanding significantly since 1965 has been the use of preassembled roof trusses, which is part of the broader topic of precut lumber. One estimate suggested that only 10 per cent of the contractors in the Bay Area used these components in 1965. By 1969, about 60 per cent of the contractors were using preassembled roof trusses.

Another insight on what cost differences may exist among firms in framing is provided by comparing labor and materials' costs per square foot between two building methods, i.e., the firm using its own cutting yard and a firm using completely precut components. One company used both methods in tracts that were built. For houses built in the tracts with precut lumber, the labor cost per square foot was \$0.66 and the materials' cost, \$0.92 per square foot. For houses built in tracts which had a cutting yard at the site, the labor cost per square foot was \$1.18 and that for materials about \$1.21 per square foot. It is worth repeating that our cost estimating procedure for framing included "pure" types with respect to labor intensity. Our data thus have incorporated in them the extremes of the cost range in framing. Consequently, any mix of situations encountered in the real world are contained within our range of estimates.

The major finding in this section is that the substitution between materials and carpenter labor was not large over the 35 years, with carpenters' earnings at 54 per cent of materials' costs in 1930 and at 51 per cent in 1965. This virtual stability in the ratio can be traced partly to the substitution that occurred between the labor groups, especially the carpenters including in their jurisdiction drywall hanging and changing methods that sharply reduced laborer time. These figures reflect the fact that by 1965 carpenter time accounted for 76.1 per cent of all labor time per MSF of living area for the functions we estimated, whereas in 1930, carpenter hours accounted for 47.0 per cent of all labor hours in the same functions per MSF of living area. The more interesting question for policy issues is what happened to the labor cost -- materials' cost ratio for the integrated crew for the functions we analyzed. For the entire crew, this ratio did drop significantly, substantiating casual observations made that off-site labor has been substituted for labor on the site. Changes that occurred in building and the rising prices and wages brought the following percentage increases in the earnings to labor and materials per square foot:

	Percentage change, 1930-1965
Total costs	101.9
Total materials' costs	130.7
Total labor costs (integrated crew)	65.9
Total carpenter costs	164.1
Total cost of materials used only by carpenters	173.7

As seen in the summarized data above, with more emphasis on materials, labor costs for the integrated crew increased by about half as much as materials' costs over the 35 years. This finding will be elaborated in Chapter IV where the effect of unit labor costs on the price of houses is analyzed.

4. Annual Rates of Growth for Total Output, Total Manhours, and Physical Labor Productivity

The preceding analysis can now be applied to two of the three policy issues mentioned at the start of this paper: (1) forecasting of labor requirements for carpenters and (2) unemployment rates of carpenters.

As shown above, carpenters and the other workers could produce 1000 sq. ft. of living area in less time in 1965 than in 1930. Obviously, then, their physical labor productivity increased over the 35 years, i.e., the ratio of output to manhours. The discussion in this section converts the productivity measure to square feet of living area per manhour. For this, the data in Table 14 are used with 1000 sq. ft. divided by the manhours needed.

a. The General Formula Required for Forecasting Labor Requirements

As mentioned in Chapter I, there has been disagreement regarding productivity gains in residential building. The data accumulated for this project suggest that productivity gains have occurred in the building of single-family dwellings, at least in the portion of the house constructed here. Using the data in Table 14 and converting the ratio of 1000 sq. ft. of living area divided by manhours to square feet per manhour, annual rates of growth in productivity (compounded rates of change) have been derived. In this section, then, we look at the issue of how rates of growth in productivity affect total manhours needed to furnish total output. Starting with the basic identity

$$O \equiv MH\ (O/MH),$$

where O is total square feet of living area built in Alameda County, MH is the total manhours required, and O/MH is square feet of living area produced per manhour.

The above identity is a multiplicative relationship and it can be shown that the rates of growth are additive, or

$$g_O = g_{MH} + g_{O/MH}.$$

The rates of growth for the above equation appear in Table 22. In order to derive these growth rates estimates of total output, total labor requirements, and physical labor productivity had tc be made for 1930 and 1965. The next section deals with how the basic estimates were made. Further, the estimates are evaluated by comparing them with available data that could be found.

b. Computation and Evaluation of Basic Data Needed

During 1930, 1,320,232 sq. ft. of living area were built in Alameda County. This figure was obtained by multiplying the total number of building permits issued in Alameda County, 908, in 1930 by the average sq. ft. of living space in the house built, computed at 1454, from the building permit sample of 1930 for single-family dwellings. Several caveats are in order regarding the permit number and the average square foot number used.

In our survey of building permits of single family dwellings we obtained a total of 828 permits authorized. This figure, however, is biased downward, because no data were available for the City of Hayward, whose records previous to 1953 were destroyed by fire. Nor were data available for any communities outside of Albany, Berkeley, Oakland, San Leandro, Piedmont, and Alameda. The cities for which data were gathered in 1930 represented 91 per cent of the population of Alameda County in 1930. Hence, the tabulated permit data were increased to adjust for the nine per cent of the population excluded. Average square feet of living area used for 1930 represent the average for the four typical houses selected for the study.

Using the total square feet of living space calculated for 1930 as the total output figure, i.e., 1,320,232, and the productivity estimate (2.539 sq. ft. per manhour), the total manhours figure derived for carpenters is 519,981 manhours (see Table 21). This figure, divided by 908 houses built, means that the average house took 572.7 carpenter manhours in 1930. An indirect check on all of our computations is possible by using the 572.7 figure mentioned above. (No direct check is possible because contacts with numerous builders failed to provide anyone who had 1930 records available.)

In the September 1931 issue of the magazine, The Small Home (published by the Architects' Small House Service Bureau, pp. 16-18), three homes with prices to consumers of $9,907, $8,597, and $7,390 were detailed by costs of labor and materials. For each of the houses, carpenter labor was valued at $733. If we assume that the wage rate per hour for carpenters was the union rate as published in the Bureau of Labor Statistics Bulletin No. 1547, Union Wages and Hours: Building Trades, then by interpolating the index numbers presented, the 1931 rate for carpenters was $1.288. On this basis, each of the three houses in the magazine article mentioned above would have required 569.1 carpenter manhours to build. Our estimate of 572.7 carpenter manhours per house for 1930 is thus only 0.6 per cent higher. This small difference suggests that we can have confidence in our estimating procedure.

For 1965, the output figure used is 8,469,037 square feet of living area. This estimate is derived by multiplying the average square feet per house, 1817, by the number of building permits issued in Alameda County in 1965 for single-family dwellings. In this case, the 4,661 figure is that taken from the Department of Commerce report issued by the San Francisco Field Office, i.e., Construction Reports: Authorized Construction--San Francisco Bay Area for 1965.[8] While the number of houses is based on a published statistic, the average square feet per house in 1817 had to be estimated. This estimate was derived as follows. Square feet were available only for the 50 per cent sample of houses, those for which one permit was filed at one time for a given location. Further, these data were available for only San Leandro, Hayward, and Pleasanton. On the basis of these data, the average size

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[8]Our collection of data for 1965 from the Alameda County issuing offices showed 4,567 single-family dwelling permits; hence, there was only a two per cent difference between our figure and that of the Department of Commerce.

of the house would have been calculated at 1,883 square feet. This figure served only as a benchmark for the final square foot figure used because it was based on a limited number of observations and was judged to be biased upward because these areas had in common the characteristic that they had more land available for new construction in 1965 (as contrasted, for example, with the core cities), so that larger houses could be built on larger lots.

With this top average limit available, we then examined square feet data available from our building permit survey for both sample years, 1930 and 1965 and found that the average house increased in size by 23.1 per cent. This average increase was arbitrarily rounded up to 25 per cent, so that the 1930 average square feet of 1,454 were expanded by 1.25 to get a 1965 estimate of 1,817. A check on the validity of the 23.1 per cent increase from our data (rounded to 25 per cent) was made by using data published in Sales of New One-Family Homes, Annual Statistics, 1965 (U.S. Department of Commerce and Home Finance Agency). Table S-19 of this report shows that the average square feet of furnished floor area for all homes were 1340.[9] (The larger house size for all homes results because

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[9] This average of 1,340 sq. ft. differs from that of 1,224 reported in the FHA report, FHA Homes 1965. The difference probably arises from differing survey techniques. The data in Sales of New One-Family Homes, Annual Statistics, 1965 are based on monthly sample surveys. The sample for any one month consists of a sample of buildings for which permits were issued and of homes started in nonpermit areas during the month, plus the sample units selected in earlier months that were not yet sold by the beginning of the current month. The characteristics of FHA-insured homes appearing in the FHA report cited are based on data from a variable sample of houses insured under Section 203-b.

homes financed by conventional mortgages include more higher-priced houses than the FHA group.) For example, in Table S-4 of the report, for the Western Region, all homes sold had an average sales price of $23,200, while that for the FHA-insured category was $19,300. According to FHA Homes 1965, the average square feet per house in the San Francisco-Oakland Area were 1470 in 1965 versus 1,224[10] for the U.S. average, or 1.201 times larger. By using the 1525 average for 1965 for all houses and inflating the number by 1.201, the San Francisco Area average would be 1,831. In this case, the 1,817 used in this report would be 99.2 per cent of this figure. On this basis the 1,817 square feet used in this report appears reasonable. While it is 3.4 per cent less than the 1,883 calculated from our building permit figure, the smaller number (1,817) is considered a better approximation, because as mentioned above, the data available locally were from areas that had sufficient land to permit larger homes in terms of square feet. As a point of interest, however, had 1,883 square feet for the average houses in 1965 been used, it would have meant a difference of 307,626 square feet of living area. This increase in the output figure would have increased the average annual growth rate for total output to 5.6 per cent as compared with 5.4 per cent shown in Table 22. The growth rate for carpenter manhours would have been 3.9 per cent rather than 3.7 per cent.

Using the 1965 data derived above, 8,469,037 sq. ft. for total output and dividing the number by carpenter productivity, the total

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[10] Ibid.

manhour requirement in 1965 for carpentry labor is 1,824,044 (see Table 21). Consequently, on the average, in 1965 the typical house required 391.3 carpenter manhours (1,824,044 carpenter manhours divided by 4,661 houses). How reasonable is the 391.3 manhours per house figure? The figure was checked in two different ways.

First, according to a 1962 survey of single-family residences conducted by the Bureau of Labor Statistics, on the West Coast (based on a sample of 25 houses) carpenter on-site manhour requirements per $1000 of construction price for the private one-family houses were 21.3 hours.[11] (This was the lowest for any region in the U.S.). Using the construction price for houses of 1,400 and more square feet ($17,524), carpenter manhours totaled 373.3 per house according to this survey. As shown above, average house size in Alameda County would easily exceed 1,400 square feet. On this evidence, although the years differ (1962 versus 1965), the Alameda County average of 391.3 hours for carpentry labor per house estimated in this report does not seem unreasonable. It is 4.8 per cent higher than the roughly calculated BLS figure.

Another way to check on the 1965 figure is provided by an indirect route. In an analysis of manhours worked by carpenters during 1965, it was found that 4,920 carpenters of union locals in Alameda County (excluding hardwood floor layers and shinglers) were at work

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[11] See Bureau of Labor Statistics, Labor and Material Requirements for Private One-Family House Construction, Bulletin No. 1404 (Washington, D.C.: U.S. Government Printing Office, June 1964).

during some time or another during 1965.[12] However, this number had to be adjusted to include only those carpenters working in residential construction. The adjustment was made by using data in the Becker report[13] which showed that 58 per cent of all building value was in residential construction. Applying 58 per cent to the total number of carpenters (4,920) yielded a total of 2,854 carpenters in residential construction. This figure for all residential construction was adjusted to include only single-family dwellings, which in Alameda County in 1965 was 43.4 per cent.[14] Hence 1,239 carpenters were estimated to be in residential construction. These carpenters worked an average of 1,251 manhours per year.[15] On this basis carpenter manhours (excluding hardwood floor layers and shinglers) totaled 1,549,989 in the building of single-family dwellings. This number divided by the number of dwellings built, 4,661, gives a per house average of 332.5 carpenter manhours. The data estimated in this report (see Table 14) show that when hardwood floor layers and shinglers are excluded, carpenter manhours per MSF are 168.48. Inflating this number to account for 1,817 square feet per house, the per house average becomes 306.1 manhours of carpentry. This figure is 7.9 per cent lower than average of 332.5 manhours estimated on the basis described above. Considering

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[12] B. William Becker, "Manhours Worked During 1965 by Carpenters in the 46 Northern California Counties," (Center for Labor Research and Education, Institute of Industrial Relations, University of California, Berkeley, May 1968, mimeo.).

[13] Ibid.

[14] Department of Commerce report cited above.

[15] Derived from the Becker report cited above. A weighted average of mean manhours to account for the lower means in areas where residential construction predominated.

all of the assumptions needed to arrive at the figure derived from the 1965 manhours study, this error is considered reasonable.

The several checks of the data conducted above suggest that the estimates of output, manhours required, and productivity are reasonable.

c. Total Output Produced

As described above, 908 single-family dwellings were built in Alameda County in 1930 as contrasted with 4,661 in 1965. For these years average square feet of living area per house were 1,454 and 1,817 respectively. Total output in terms of square feet of living area produced consequently was:

1,320,232 in 1930 and
8,469,037 in 1965.

The average annual compounded rate of change between these two years is 5.4 per cent. As explained above, the sum of the average annual compounded rates of change for total manhours required and for real output per manhour equal by definition the rate of growth for total output. In forecasting occupational requirements the annual average compounded rate of change for total manhour requirements will equal the corresponding rate for output if and only if the rate of growth in real labor productivity is zero. The historical statistics derived here show the hazard involved in assuming a zero growth rate for labor productivity.

d. Total Manhour Requirements and Physical Labor Productivity

The data in Table 14 show hours per 1000 square feet of living area. In this section these data are converted to a physical labor productivity measure showing output in square feet of living area per manhour (see Table 21). The absolute data are then used to derive the average annual compounded rates of change between 1930 and 1965, or the growth rates for physical labor productivity shown in Table 22. As shown above, these rates of growth and the growth rates for total manhour requirements are needed in order to discuss the policy issues related to changing building methods and their impact on the construction trades.

In Table 21, the absolute labor requirements by occupational groups are shown. These figures were derived by dividing the total output figure of each year (i.e., 1,320,232 in 1930 and 8,469,037 in 1965) by the output per manhour figures. Growth rates for these figures are given in Table 22.

As seen in Table 22, growth rates for physical labor productivity and total manhour requirements add to the growth rate for total output.

e. Analysis of Growth Rates in Productivity

As shown in Table 22, growth rates for physical labor productivity varied considerably among the crafts. These differential rates of productivity growth were the result of both changes in work methods and also changes in materials, work assignments, and quality. In

TABLE 21

Total Manhour Requirements and Physical Labor Productivity (Square Feet of Living Space per Manhour), 1930 and 1965

Occupations	Absolute numbers			
	Total manhour requirements[a]		Physical labor productivity[b]	
	1930	1965	1930	1965
1. Carpenters:				
All operations	519,981	1,824,044	2.539	4.643
All operations except drywall	519,981	1,624,287	2.539	5.214
All operations except drywall, hardwood floor laying, and shingling	437,307	1,226,330	3.019	6.906
2. Plasterers	187,612	142,279	7.037	59.524
3. Lathers	67,462	66,907	19.570	126.582
4. General building laborers	149,856	163,462	8.810	51.814
5. Hod carriers	136,644	71,139	9.661	119.050
6. All skilled occupations estimated[c]	802,572	2,164,886	1.645	3.912
7. All unskilled occupations estimated[c]	303,014	233,745	4.357	36.232
8. All occupations estimated (integrated crew)[c]	1,105,721	2,398,481	1.194	3.531

[a]Derived by multiplying the total output figure by the real labor productivity figure (i.e., square feet of living space per manhour).

[b]Taken from Table 14. Derived by dividing 1,000 sq. ft. of living space by manhours per MSF.

[c]See Table 14 for the occupations included.

TABLE 22

Growth Rates[a] for Total Output, Physical Labor Productivity, and Total Manhour Requirements, 1930-1965
(Per cent per annum)

Occupation	Total output	Physical labor productivity	Total manhour requirements
1. Carpenters:			
a. All operations	5.4	1.7	3.7
b. All operations except drywall	5.4	2.1	3.3
c. All operations except drywall, floor laying and shingling	5.4	2.4	3.0
2. Plasterers	5.4	6.3	-0.9
3. Lathers	5.4	5.5	-0.0[b]
4. General building laborers	5.4	5.2	0.2
5. Hod carriers	5.4	7.4	-2.0
6. All skilled occupations	5.4	2.5	2.9
7. All unskilled occupations	5.4	6.2	-0.8
8. All occupations estimated (integrated crew)	5.4	3.2	2.2

[a]Average annual compounded rates of change between the two years.

[b]Actual figure is -0.01.

Source: Derived from data in Table 21.

other words, the rates of growth shown for physical labor productivity include the effects of technological change as well as other effects.[16]

The labor productivity growth rates in this study thus include the following major effects:

1. Technological change, which for the house building industry was essentially the new technique of organization and marketing brought to residential construction by merchant builders.

2. The arrival of the merchant builder introduced economies of scale, or "economies of mass production", through labor specialization and volume purchases of materials obtained at a discount.

3. The rate of diffusion of best practice techniques also played a role. For example, as shown in Section 2 above, the newest techniques that increase labor productivity are not used by all firms at the time of their introduction. Rather, they seem to be introduced gradually.

4. The influence of quality change in both basic materials and in the final product, the house. For example, in materials, thinner gauge plywood; in the final product, interior trim used to enhance appearance in 1930 virtually disappears by 1965.

5. The marked changes in materials used, e.g., precut studs

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[16] As Mansfield points out, the rate of technological change is only one determinant of the rate of growth of labor productivity. Other determinants are the substitution of capital for labor in response to changes in relative input prices, increases in economies of scale, increases in the use of productive capacity, the rate of diffusion of best-practice techniques, and the nature of the technological change as well as its rate. See Edwin Mansfield, The Economics of Technological Change (W.W. Norton and Co., New York, 1968), p. 22.

for random length studs; aluminum windows for double-hung windows; drywall for wet plaster, etc. Such changes in materials used increased on-site labor productivity.

Besides these effects on all of the crafts, labor productivity growth rates in the individual occupations reflect the impact of changing work assignments. In particular, carpenters had the jurisdiction for drywall in 1965, hence adding an activity that in 1930 was in the domain of lathers and plasterers as plaster was applied to interior walls. The effect worked to reduce the growth rate in productivity for carpenters below the all-occupation average. In contrast, the loss of former activities reduced manhours for plasterers, and building laborers, for example. In this case the loss of former tasks induced growth rates for productivity in these occupations that were larger than the all-occupation average.

As mentioned at the start of this study, there has been no definitive answer as to whether or not productivity growth has taken place in housebuilding. The data in Table 22 show that productivity growth has taken place on the construction site insofar as about two-thirds of the on-site operations are taken into account. In terms of the integrated crew studied, which excludes the major subtrades, productivity increased at a rate of 3.2 per cent per annum from 1930 to 1965 (see line 8, Table 22). This all-occupations' estimate of productivity growth was influenced by the substantial productivity gain for unskilled labor. For all unskilled labor combined, productivity grew at a rate of 6.2 per cent per annum as contrasted with the all-skilled-occupations' rate of 2.5 per cent (see lines 6 and 7, Table 22).

Obviously, the large productivity increases in the unskilled category reflect the virtual elimination of tasks performed by these workers in 1930. The same is true for plasterers, whose productivity growth per annum was 6.3 as the use of drywall replaced their 1930 functions.

For carpenters, three rates of productivity growth are shown in Table 22. The annual rate for carpenters that includes the total jurisdiction of the carpenter's union is 1.7 per cent per annum. Note that because the carpenters took over the activity of another craft, drywall supplanting plastering, the productivity rate was increased by 0.4 of a per cent point. As seen in Table 22, when carpenter activity excludes drywall, the productivity growth rate is 2.1 per cent. If drywall and two other definitive specialties, hardwood floor laying and shingling are excluded, then the growth rate in productivity is even higher, rising to 2.4 per cent per annum. As shown above, the productivity of carpenters in the widest definitional sense grew at a rate of 1.7 per cent per annum. What forces contributed to this growth? In Table 23, growth rates in productivity are given for the 11 major operations that comprised the tasks performed by carpenters.

The data in Table 23 show, in a different way, the same results produced in Table 14. The major sources of productivity growth came from the use of prefabricated components, i.e., prefabricated windows and prehung doors. In exterior walls, the 6.00 per cent per annum rise in productivity derived from the abolition of wall sheathing. The framing function had a lower rate of productivity advance than the total. The failure of this activity to show much productivity growth weighed heavily in keeping the overall carpenter rate below that for the integrated crew because framing accounted for an average of 40 per cent of the carpenter's work in the two years.

As has already been pointed out, productivity actually declined in interior walls and ceilings. In this case carpenters received added work from drywall hanging so that in the ratio, 1000 sq. ft. of living area divided by manhours, the denominator was increased so that productivity declined.

This analysis of the forces underlying the total productivity rate for carpenters shows that the low productivity growth in framing (which accounted for 40 per cent of the total work), and the decline in productivity in interior walls (which accounted for an average of about 10 per cent of the time) as carpenters assumed jurisdiction for drywall hanging contributed to yielding a lower annual rate of growth for carpenter productivity than for integrated crew.

f. Manpower Forecasting

One of the aims of this study was to apply the results above to the problem of manpower forecasting. As shown in Table 22, the annual average compounded rate of growth in total output is the sum of the rates of growth in total labor requirements and physical labor productivity. If then, manpower forecasts start with a projection of demand for a product, the same rate of growth can be applied to total labor requirements if and only if a zero rate of

TABLE 23

Productivity Growth Rates for Activities Performed by Carpenters, 1930 - 1965

Carpenter Activity	Productivity growth rate (Per cent per annum)
1. All activities	1.74
2. Footings	0.10
3. Framing	1.12
4. Exterior walls	6.00
5. Interior walls and ceilings	-1.11
6. Windows	6.81
7. Doors	4.73
8. Interior trim	3.09
9. Floors	0.63
10. Roof	1.28
11. Stairs	5.43

growth is projected for labor productivity. The above evidence in Table 22 suggests that if productivity growth had been assumed to be zero, then actual forecasts would have been too high. For example, manhours in carpentry would have been projected to grow at 5.4 per cent per annum rather than 3.7 per cent per annum.

Another problem in making occupational forecasts in construction is the shifting allocation of tasks that takes place when techniques change. For example, in the period studied here, drywall installation essentially displaced plasterers and lathers. Now, installed kitchens involve a delicate division of tasks between cabinet installers and plumbers. Given the division of tasks under present institutional arrangements, manpower forecasting is complicated. As new work methods are developed, the determination must be made as to which craft will perform the job. In those countries where the construction work force is organized industrially this complication in manpower forecasting would be precluded, of course, if there were inter-occupational mobility.

The above issue means that the forecaster must understand clearly the definition of the occupation. For example, the evidence here suggests that for carpenters in the widest jurisdictional sense, productivity grew at a rate of 1.7 per cent per annum. Hence, labor requirements on this definition grew at a rate of 3.7 per cent per annum. But, with drywall hangers involved in a separate training program, the definition excluding this group from the carpentry group would be more appropriate. On this definition, carpenter labor requirements grew by 3.3 per cent per annum. By excluding drywall installers, about 200,000 fewer general carpenter manhours would be required.[17] In terms of men, this would mean 111 if they worked 1800 hours a year, but 160 men if they worked 1251 hours a year on the average.[18] The latter estimate of men needed can be disputed as one valid for manpower forecasting because it uses the actual average hours worked per year in residential construction, which is obviously lower than a full work year in construction (say 1800 hours, the figure most be widely used). As long as building construction has elements of casual as well as seasonal unemployment which would raise the level of frictional unemployment in this industry above an all-industry average, it seems logical to deal with the actual hours worked data rather than a theoretical norm of 1800 hours. This consideration, obviously, adds another complication that cannot be overlooked in manpower forecasting. This institutional characteristic must be considered to get realistic estimates of the <u>workers</u> needed in the construction industry. Obviously, this characteristic adds a complicating dimension to manpower forecasting. Not only are the kind of data that appear in Table 22 needed, but information is needed on converting full-time equivalents to actual manpower needs. As long as on-site construction activity has seasonal and casual aspects, it seems that forecasts must allow room for a less-than-full work year.

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[17]Derived from Table 21.

[18]See footnote 15 above.

This discussion leads logically to a second policy problem related to changing methods in construction, i.e., unemployment and secular change in the construction industry. Given the industry has seasonal and casual elements that lead to unemployment rates in the construction trades that exceed the general overall unemployment rate, how much unemployment persists because new techniques require less manpower than before but supply is slow to adjust to new demand requirements?

Evidence in this study cannot answer this question directly. However, in the next section we provide some insights with regard to how much less labor was needed in 1965 than in 1930. Further research would be needed to determine the lags in adjustment between demand and supply so that some notion of persistent excess supply (if, indeed, such exists) could be determined.

g. Changing Building Methods and Labor Saved

The preceding data are used in this section to show in a rough way how many fewer carpenters were needed in 1965 than in 1930 because of the changing methods in residential construction. As noted above this discussion has bearing on the unemployment issue because if supply adjustments to changing demand are slow, more persons will enter these trades than can be fully utilized so that the disequilibrium will persist.

How many carpenter manhours were saved, or how many fewer carpenters were utilized, in 1965 because of the changes that occurred in building methods? This question is answered as follows. The actual relevant data for 1930 and 1965 are repeated in Table 24.

As seen in Table 24, the number of houses increased by more than 400 per cent over the 35 years. Further the house became larger. Had 1930 techniques prevailed, how many manhours would have been needed to build the larger number and the larger-sized houses in 1965.

Holding house size at 1,454, then 2,669,355 carpenter manhours would have been required. (572.7 manhours times 4,661 houses.) However, when the 1965 average house size of 1,817 sq. ft. of living area is used, then the number of manhours required would have been 715.7 on the basis of 1930 techniques. (This figure is obtained by applying the 1930 MSF figure of 393.9 to 1817 sq. ft. of living area.) The number of carpenter manhours that would have been used to build the 1965 house of 1817 sq. ft. of living area would then have equalled 3,335,878 (or 4,661 houses times 715.7). These data are summarized in Table 25.

As shown above, the changing building methods, including the market penetration by the merchant builder, meant that 413 per cent more houses could be built with 845,311 fewer manhours than would have been required by 1930 standards, holding the house size constant (2,669,355 minus 1,824,044). Then, even though the average house increased in size, 666,523 fewer manhours were needed in 1965 than in 1930 (3,335,878 minus 2,669,355). Consequently, because of changes

TABLE 24

Selected Data, 1930 and 1965

	1930	1965
Number of single-family dwellings	908	4,661
Average size of house (sq. ft. of living area)	1,454	1,817
Carpenter manhours of MSF of living area	393.9	215.4
Carpenter manhours per house	572.7	391.3
Total carpenter manhours required	519,981	1,824,044

TABLE 25

Total Carpenter Manhours Saved, 1930-65

Carpenter manhours		Difference from actual hours of 1,824,044
Actual, 1965: 1,824,044		
Would have been required in 1965 if 1930 techniques used:		
(a) House size, 1454 sq. ft.:	2,669,355	845,311
(b) House size, 1817 sq. ft.:	3,335,878	1,511,834

in the industry a total of 1,511,834 carpenter manhours were saved between 1930 and 1965.

How many fewer carpenters were needed in 1965 than in 1930 as a result of the changes in technology and industrial organization? The answer to this question is given on the basis of full-time equivalent employees, i.e., each carpenter worked 1800 hours a year, the work year as specified by the labor-management agreement now in effect, 36 hours per week times 50 weeks.

The data in Table 26 show that if 1965 demand and house size had prevailed but no change had taken place in construction technology or industrial organization, then the number of carpenters needed to work year-round would have totaled 1,853. However, with the changes that did take place over the 35 years, 1930-65, the full-time equivalent in 1965 was 54.6 per cent of the hypothetical number 1,853. Put in another way, the increased output over the 35 years was accomplished with a reduction of 45.4 per cent in full-time employees, from 1,853 in 1930 to 1,013 in 1965.

The above discussion obviously must be regarded as a rough approximation of carpenter manhours or employees saved over the 35 years. Another method of obtaining these data would have been to use the four sample houses in 1965 and estimate costs by applying 1930 building practices to them. This procedure was beyond our financial means so that the rough approximations above are presented to give readers a notion of the order of magnitude of labor saving that is involved.

TABLE 26

Carpenter Manhours Converted to Number of Carpenters
(Full-Time Equivalents)

1. Total manhours saved since 1930 by using 1965 building practices	1,511,834
a. Full-time equivalent employees saved (line 1 divided by 1800 hours)	840
2. Actual carpenter manhours estimated for 1965 in building single-family dwellings	1,824,044
a. Actual full-time equivalent employees (line 2 divided by 1800 hours)	1,013
3. Number of carpenters, employed full-time, if 1930 techniques had been used in 1965 (line 1a plus line 2a)	1,853

The final policy question related to the issues examined in this paper is that of the impact of rising wage rates on the prices of houses. The productivity data developed here obviously are needed to examine this issue because it is labor cost per unit of output that plays the critical role in discussing the inflationary bias, it such exists, of wage rate increases. This issue is treated in Chapter IV where the discussion centers about the variables involved in pricing houses. Before proceeding to Chapter IV, however, we digress to examine physical labor productivity growth rates over the years 1940-1965.

5. Physical Labor Productivity, 1940-1965

In Chapter I we noted that available evidence supports the hypothesis that major changes in house construction took place after World War II. On this basis, we assume that the physical productivity data developed in detail for 1930 can be an approximation for 1940's technology and industrial organization. Consequently, physical labor productivity growth rates can be derived for the 25-year period, 1940-65. The resultant growth rates for labor productivity are shown in Table 27.

These growth rates are useful as a benchmark for the debate that has surrounded the issue regarding productivity gains in single-family residential construction. The most important figure is that of 4.4 per cent for the integrated crew. This rate of productivity growth compares with 3.0 per cent for output per manhour in the entire private economy.[19]

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[19] Derived from data in Table C-34, Economic Report of the President, 1970, and in the Bureau of Labor Statistics Bulletin, No. 1249, "Trends in Output per Man-hour in the Private Economy, 1909-58," December 1959. Productivity data in these two reports were spliced in order to account for the shift in base years.

TABLE 27

Growth Rates for Physical Labor Productivity, 1940-1965
(Average annual compounded rates of change)

Occupation	Productivity growth rate
1. Carpenters:	
a. All operations	2.4
b. All operations except drywall	2.9
c. All operations except drywall, floorlaying, and shingling	3.4
2. Plasterers	8.9
3. Lathers	7.8
4. General building laborers	7.2
5. Hod carriers	10.6
6. All skilled occupations	3.5
7. All unskilled occupations	8.8
8. All occupations estimated (integrated crew)	4.4

Source: Derived from data in Table 21 on the assumption that physical labor productivity in 1930 was applicable to 1940.

Chapter IV

WHAT VARIABLES INFLUENCE THE PRICE OF SINGLE-FAMILY DWELLINGS?

1. Introduction

The third policy question remaining for discussion is: What was the influence of unit labor cost on rising house prices between 1930 and 1965? The physical labor productivity figures derived in Chapter III play an important part in answering this question for by definition unit labor cost is the hourly wage rate (wage rate plus fringes) divided by average physical labor productivity. If hourly wage rates increase by a larger percentage than physical labor productivity, then unit labor costs rise and such costs can have an inflationary bias if the rising costs are added to the price of the house. Consequently, to discuss this policy question information is needed on the price of the typical house for 1930 and 1965. In this Chapter, the analysis is extended in order to provide insights into the issue of how much, if at all, unit labor cost contributed to rising house prices.

The influence of unit labor costs must be put in perspective when discussing price changes in houses, however. A house is a durable commodity placed on a natural resource, land, whose price has a significant bearing on the final house price. Further, because large capital requirements are needed to initiate projects, money must be borrowed so that interest costs play an important role in the house price. Consequently, in this Chapter, the price of the typical house for 1930 and 1965 is estimated. Section 2 discusses the methodology used to determine these prices, and introduces extraneous information to evaluate the derived price estimates.

In Section 3, the changes that occurred in all of the house-price determinants are examined and related to changes that took place in the two components of unit labor cost, i.e., the hourly wage rate and average physical labor productivity. Thus the impact of changes in unit labor cost on changing prices can be analyzed. The data derived show that the price per square foot of the typical house in Alameda County increased at a rate of 2.98 per cent per annum, i.e., the compounded rate of change between 1930 and 1965, and that unit labor cost estimated in this study, i.e., the labor cost for 11 identical operations (cabinets being a subgroup under interior trim) increased by 1.46 per cent per annum. When weighted to account for the other house-price components, this increase in unit labor cost accounted for seven per cent of the annual rate of growth in the unit price of the house. The other determinants entering the pricing structure thus accounted for 93 per cent of the annual increase in the unit price of the house.

In order to provide readers with an understanding of how the other house-price determinants influence house prices, Section 4 develops the analysis beyond the basic data developed for this study to answer such questions as:

1. Can further labor productivity gains stem the price

increases in single-family dwellings?

2. To what extent have consumer tastes for amenities increased house prices?

3. What is the role of land and land developments costs?

4. What is the importance of the cost of financing?

To answer these and other questions, Section 4 provides a basic cost function and examines each variable separately.

2. The Price of the Typical House in 1930 and 1965

a. Derivation of the Typical House Prices

In order to provide consistent estimates of the average price of a house in Alameda County for 1930 and 1965, the final house prices were estimated by using a building-block method that required several sources. These data are shown in Table 28.

The basic figure in deriving the price estimates was the mean building permit value for each year computed from the building permit survey. Hence, the final price is tied to the basic costs prevailing in 1930 and 1965. (See Appendix B.) For 1930, the mean building permit value was inflated by 10 per cent in order to adjust for exclusions. This 10 per cent adjustment was suggested by several persons familiar with the 1930 building practices. As noted in Chapter II, building permit figures in 1930 included only material and labor costs used in constructing the "shell of the house" and excluded the price of small fixtures, equipment, and accessories. The building permit value figure includes direct construction costs,

TABLE 28

Estimated Final House Prices and Related Data, by Totals and Per Square Foot, 1930 and 1965

Category	1930 House (1454 sq. ft.)		1965 House (1817 sq. ft.)		Percentage change, 1930 - 1965, per square foot
	Total	Per square foot	Total	Per square foot	
1. Building permit value	$ 5,277	$ 3.63	$ 17,245	$ 9.49	161.4
(a) Estimated building cost	2,984	2.05	7,530	4.14	101.9
(1) Labor costs[b]	1,328	0.91	2,747	1.51	65.9
(2) Materials' costs[b]	1,655	1.14	4,781	2.63	130.7
(b) Nonestimated building costs	2,293	1.58	9,715	5.35	238.6
2. Overhead and profit	792	0.55	2,587	1.42	158.2[a]
3. Site value	1,071	0.74	5,122	2.82	281.1
4. Total price	7,140	4.92	24,954	13.73	179.1
1. Average hourly wage rate for the integrated crew [included in line 1(a)(1)][c]	1.09		5.35		390.9
2. Square feet per manhour in 11 operations [average labor productivity][d]	1.194		3.531		195.7

[a]Percentage is slightly different from that in line 1 because of rounding.

[b]Derived from costs per MSF in Table 19.

[c]Derived from data in Tables 14 and 19.

[d]Taken from Table 21.

the builder's financing costs, and marketing costs.

Excluded from the building permit value are overhead expenses and profit and land value. Estimates for these two price components were made as follows.

We assumed that overhead expenses and profit are 15 per cent of the building permit value figure. This percentage was applied to the permit value because it is used by the Northern California Real Estate Research Committee in preparing house-cost estimates.

The site value, or land cost, figures for each of the years were based on FHA data in order to obtain consistency and hence permit a 35-year comparison. Although there are no FHA data for 1930, FHA figures for site value are available for the San Francisco-Oakland Metropolitan Area for 1938 and 1940.[1] According to these data, the average site value for 1940 was $795, or 14.5 per cent of the property value. For 1938, the mean site value was $908, which was 15.6 per cent of the property value average. On the basis of these figures, the site-value ratio for our typical houses was arbitrarily set at 15 per cent, a figure between the 1938 and 1940 FHA site-value ratios. The derived site value of $1,071 appears reasonable because it exceeds the FHA 1940 figure of $908, as would be expected on the basis of our building permit survey. The reasoning is as follows. In particular, the building permit survey showed that the mean value of permits declined from $4,797 in 1930 to $4,404

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[1]Federal Housing Administration, FHA Homes in Metropolitan Districts: Characteristics of Mortgages, Homes, Borrowers Under the FHA Plan, 1934-1940 (Federal Housing Administration, 1942), p. 206.

in 1940. Hence it is reasonable to assume that the average 1930 house carried a higher price tag than the 1940 average house. Consequently, if the site-value ratio were the same in the two years, the 1930 site value would be higher than in 1940. As shown above, the derived figure for 1930 is higher than the 1940 FHA site-value figure.

For 1965, the site - value figure used is the mean figure for new homes in the San Francisco-Oakland Area taken from FHA Homes, 1965, the Federal Housing Administration report.

It is worth stressing that use of FHA data for the site price (noting that the 1930 estimate was geared to FHA data) means that the data are consistent so that changes that took place over the 35 years in the site or land prices can be discussed.

The sum of the three estimates described above, i.e., the building permit value, site value, and overhead expenses and profit, yields the average price of the typical house in Alameda County in 1930 and 1965. These data are shown in Table 28.

Besides the three major categories explained above, the building permit value figures are itemized to show estimated and nonestimated building costs. Estimated costs refer to the labor and materials' costs dealt with in this study, i.e., the on-site construction costs for 11 building operations shown in Table 19. In 1930, the estimated building cost of $2,984 accounted for 57 per cent of the building permit value figure, while in 1965 this cost-component of $7,530 accounted for 44 per cent of the building permit value. The decline in the relative share of this estimate reflects the larger gain proportionally in nonestimated building costs, the difference between the building permit value and the estimated building costs. These costs in both years included payments to the major subtrades not studied here, i.e., painting, plumbing, and electrical work, and loan interest costs paid by builders. In 1965, however, the figure also includes marketing and sales expenses, costs that reflect the industry's change in industrial organization over the 35 years with the advent of the merchant builder. As well, the 1965 figure as will be shown below includes quality changes that required additional on-site labor time for electrical work and plumbing in particular. Consequently, the relative share for nonestimated building costs increased over the 35 years.

b. Evaluation of the Price Estimates

Before analyzing the data in Table 28, it is important to know whether or not the derived prices, $7,140 in 1930 and $24,954 in 1965, and the price components are reasonable estimates. In this section, therefore, these data are evaluated against other evidence.

The price of $24,954 for 1965 can be checked directly against the 1965 FHA Homes publication of the Federal Housing Administration. According to this publication, the mean price for new houses in the San Francisco-Oakland Metropolitan Area in 1965 was $21,449. If this value is multiplied by the factor 1.202 in order to include all homes sold (see Chapter III), then the average price for all new homes sold would be $25,782. This figure is 3.3 per cent higher than the 1965 estimate in Table 28. The lower figure of $24,954 shown in Table 28 is consistent with using the FHA site-value figure which is most likely an underestimate because of the bias discussed in Chapter III. Considering all of the chances for error, given the building block method of estimating the price of the typical house in this study as discussed above, the difference of 3.3 per cent does not seem unreasonable.

The 1930 price of $7,140 cannot be checked directly against other evidence. However, the following analysis suggests that this price estimate is also reasonable. We assume that prices of houses showed little change between 1930 and 1938 in the San Francisco Bay Area for two reasons. First, the population of the area increased by 117,255 between 1930 and 1940, or by 8.9 per cent over the 10 years, as contrasted with a population growth of 53.3 per cent between 1940 and 1950 and 24.2 per cent between 1950 and 1960. This relatively lower rate of population growth between 1930 and 1940 could imply that little pressure was present on housing prices from the demand side. Second, the 1930 price average shown in Table 28, $7,140, is 22.8 per cent higher than the FHA 1938 average of $5,814 for 1938. This relationship is in the expected direction because the FHA-insured homes' average is consistently lower than the average including all homes sold. In 1965, for example, to repeat, the FHA-homes--all-homes-sold ratio for the West was 1.202. The above data suggest an FHA-homes--all-homes-sold ratio of 1.228 for 1930. These ratios diverge by about two per cent. On this reasoning, the price of $7,140 for 1930 seems reasonable.

On the basis that the total price figures are reasonable estimates of prices for the typical house in 1930 and 1965, the price-components' data are evaluated by converting the total price of the house to the price per square foot in order to standardize for the change in house size that occurred over this period. These price and/or cost data per square foot are shown in Table 28, along with their percentage changes over the 35 years. Further, to facilitate the discussion, the relative share of each price component with respect to the unit price, i.e., the price per square foot of living area, is given in Table 29. Review of the per square foot cost figures in Table 28 and their relative share in Table 29 suggests the major points that need comment regarding the estimates derived.

The 1965 relative share for the site value, or the land cost, appears low for the following reasons. In Section 4, the FHA detailed data show that in the San Francisco-Oakland Area the site-value ratio in percentage terms was 23.9 per cent in 1965. Further, data provided by two different local builders, one for a 1,450 square foot house selling for $21,350 in 1965 and the other for a 1,965 square foot house selling for $30,500 in 1965, included land and land development costs equal to $3.62 and $4.02 per square foot of selling price, respectively. These amounts accounted for 24.6 per cent and 25.9 per cent respectively of the unit price. On this basis of these

TABLE 29

Allocation of Unit Price (Price per Square Foot) Among the Components, 1930 and 1965

Unit price and price components	Per cent distribution of unit price	
	1930	1965
Price per square foot	$ 4.92	$ 13.73
Per cent	100.000	100.000
1. Building permit value	.738	.691
(a) Estimated building cost	.417	.301
(1) Labor costs	.185	.110
(2) Materials' costs	.232	.191
(b) Nonestimated building costs	.321	.390
2. Overhead and profit	.114	.103
3. Site value	.150	.205

Source: Derived from data in Table 28. (Individual square foot figures divided by the price per square foot.)

Note: Detail may not add to 100.000 due to rounding.

site-value ratios, our ratio of 20.5 per cent for 1965 in Table 29 would appear to be biased downward. As mentioned above, however, we are interested in changes that took place over a 35-year period. Inasmuch as both site value figures are based on a consistent set of data, i.e., FHA data, the 35-year increase in land prices should be meaningful.

The share for overhead expenses and profit could be biased downward because as mentioned above the cost for this variable was derived by taking 15 per cent of the building permit value, following the procedure of the Northern California Real Estate Research Committee. If in fact the 15 per cent were applied to the entire package, including land, then our data in Table 28 would represent an underestimate for both years, and the relative share shown in Table 29 would be biased downward. Again, however, the estimates for the two years are consistent so that the interyear comparisons should have merit.

The major building block for the selling price figure is the building permit value, which was, on a square foot basis, \$3.63 in 1930 and \$9.49 in 1965. Inasmuch as this figure is the key variable in estimating the final price of the house, can it be supported? Unfortunately, we have no direct evidence against which to test the 1930 figure. The 1965 figure, however, can be checked against data provided by two local builders. As seen in Table 30, the direct construction, marketing and financing costs per square foot of living area (the building permit value figure in Table 28) for the typical house are close to the two actual cost estimates from local builder

TABLE 30

Comparison of Our Data with Those of Two Local Builders, 1965

	Direct construction, marketing, and financing costs, per square foot	Labor costs for carpenters and laborers per square foot
Typical house, Alameda County	$ 9.49[a]	$ 1.25[c]
Local builder, house of 1,450 sq. ft.[b]	8.95	1.23[d]
Local builder, house of 1,965 sq. ft.[b]	9.16	1.14[d]

[a]See Table 28, line 1.

[b]Derived from confidential records given to us for this study.

[c]Derived from data in Table 20. Does not include amount for payroll taxes but includes hourly fringe benefits.

[d]Includes amount for payroll taxes which could not be disaggregated because the total figure includes both taxes and fringe benefits. See footnote c above.

data. The records of the two builders also permitted a check on the labor cost per square foot for carpentry and general labor (included under estimated labor costs in Table 28). As seen in Table 30, the unit labor cost figure estimated for this study for carpenters and general labor was close to those derived from the builders' records.[2]

Although the building permit value per square foot could be estimated from the records of the two builders, the distribution of this value between estimated and nonestimated labor costs was possible only from the data furnished by one of the builders. The comparison between the figures for the builder of the 1,965 sq. ft. house that sold for $30,500 with the data derived from our estimates appears in Table 31. The labor cost per square foot for carpentry and general labor is repeated in order to facilitate the following discussion.

As shown in Table 31, the unit labor cost for carpentry and general labor was 11¢ higher for the typical house we estimated than for the builder's house. However, estimated costs for the typical house were 50¢ lower for the typical house than for the builder's house, while nonestimated costs for the typical house were 83¢ higher per square foot. These data suggest that the nonestimated cost figure in this study may be biased upward. However, it must be noted that a strict comparison with our data was not

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[2]The builders' records did not permit a check on the other estimated labor costs because these costs were lumped together in one figure for labor and materials.

TABLE 31

Per Square Foot Costs for Selected Items, 1965

Cost per square foot	Typical house, Alameda County	Local builder, House of 1,965 sq. ft.
1. Estimated costs (line 1(a), Table 28)	$ 4.14	$ 4.64
Carpentry and general labor cost	1.25	1.14
Other estimated labor and materials' costs	2.89	3.50
2. Nonestimated costs (line 1(b), Table 28)	5.35	4.52

possible because of a difference in the way the items were detailed by the builder. Hence, part of these differences, one higher and the other lower, may derive from errors of measurement. What is important, however, is that for the key variable involved in the following discussion regarding the inflationary bias of labor costs, i.e., unit labor cost for carpentry and general labor, the differential is only 11¢.

As noted above, the figure we show for nonestimated labor costs may be biased upward, and research regarding this aspect would be needed to determine the magnitude, if, indeed, such a bias exists. However, it must be noted that it is the nonestimated cost figure that has incorporated in it certain quality and consumer preference changes that occurred over the 35 years to enhance the comfort of single-family dwellings. In particular, this would include the increase in actual plumbing fixtures and more extensive electric wiring to support the growing use of various appliances. In 1965, for example, the final price of the house included kitchen and laundry appliances which could add about 20¢ per square foot. The inclusion of the appliances as a part of the total house package occurred in 1945 with the FHA ruling that appliances could be installed in a new house and so could be amortized with the total price of the home. Further, the 1965 house was better-equipped than the 1930 house with respect to electricity and plumbing. Electrical installation, wired for 100 or 200 Amps, 220 volts, was common in 1965 because of the larger capacity needed for modern kitchen and laundry equipment.

Further, the 1965 house had more circuits to service wall outlets and lighting units. At the same time, 1-1/2 to 2 bathrooms per house were common in new homes in 1965. In 1960, for example, 73.5 per cent of the existing homes in the San Francisco Bay Area had <u>one bathroom</u>. In that year, too, 91.5 per cent of the new homes built had 1-1/2 or 2 bathrooms. The cumulative effect of this quality change was that by 1965, 55.7 per cent of the existing homes had one bathroom and 42.8 per cent had 1-1/2 or 2 bathrooms. More importantly, the trend was apparently up, for of the new homes built in 1965, 85.0 per cent had 1-1/2 or 2 bathrooms, and 9.8 per cent had 2-1/2 or more bathrooms. Five years earlier, only 1.1 per cent of the new homes built in the Bay Area had 2-1/2 bathrooms or more.[3] By 1965, also, fireplaces became popular and were installed as units pre-built from the factory. But this option raised the cost of a house by from $500 to $800.

The direct costs just examined have been included here to show that consumer tastes for more convenience in a home have also played a role in the square foot cost of a house. Obviously, rising family incomes over the 35 years have enabled consumers to satisfy their tastes for comfort and convenience. In fact, our research suggests that by 1965 consumers were no longer satisfied with just houses, as was the case in 1950 when builders could sell identical houses because of the postwar scarcity. By 1965, quality variations

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[3]All data in this paragraph are taken from two reports: <u>FHA Homes, 1960, Data for States and Selected Areas</u>, Table 83M, and the same report for 1965, Table 10M. These reports are published by the Federal Housing Administration.

within single tract developments were important to sell houses. This qualitative impression from the interviews is supported by the data in Appendix B. As shown there, in 1950, the building permit value of 84 per cent of the tract houses was in the $6000 to $7999 class. By 1965, no one cost category dominated the permit value distribution. These data in Appendix B are also consistent with Levitt's report to the President's Committee on Urban Housing. Comparing the Levitt operation just after World War II with that in the mid-sixties, Levitt commented that, "Instead of building 5000 identical houses at a single site in one year, we now build 5000 houses in 150 varieties at 18 sites during the same time, houses whose designs are dictated primarily by marketing, not production disciplines."[4]

3. Sources of the Price Increase in Single-Family Dwellings in Alameda County

As seen in Table 28, the price per square foot of housing increased by 179.1 per cent between 1930 and 1965. Of the individual components included in the price structure, the site value rose by the largest amount, 281.1 per cent, and the estimated unit labor cost, i.e., the cost of employing the crafts used to perform the 11 operations studied here, rose by the smallest amount, 65.9 per cent. That the labor cost per unit variable rose by 65.9 per cent

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[4]Levitt and Sons, Inc., "Levitt's Comments", in The Report of the President's Committee on Urban Housing, Technical Studies, Volume II (Washington, D.C.: U.S. Government Printing Office, 1968), p. 69.

at the same time that the average hourly wage rate for the integrated crew performing the 11 operations increased by 390.9 per cent reflects the influence of the advance in physical labor productivity over the 35 years. As seen in the last line of Table 28, average labor productivity for the crew increased by 195.7 per cent from 1930 to 1965. Because the hourly wage rate increased at a faster rate than labor productivity, unit labor cost advanced over the 35 years.

As shown in Chapter I, unit labor cost is defined as the ratio of the hourly wage rate to average labor productivity. For 1930, this ratio equals $0.91 ($1.09 divided by 1.194); for 1965, $1.51 ($5.35 divided by 3.531). Thus the unit labor cost figure in 1965 is 1.659 times as large as that in 1930. Or, in percentage terms as shown in Table 28, unit labor cost increased by 65.9 per cent from 1930 to 1965. These data suggest that unit labor cost did have an impact on the increase in house prices because hourly wage rates rose at a faster rate than productivity.

It should be repeated at this point that this study does not provide labor productivity estimates for <u>all</u> on-site activity involved in building single-family dwellings. Consequently, the entire discussion with regard to the impact of rising unit labor cost on rising house prices deals with the portion of the on-site work developed in detail here. The major activities omitted are painting, plumbing, and electrical work.[5]

Dealing with the integrated crew, unit labor cost on site increased by 65.9 per cent over the 35 years. This amount represented a constant rate of growth of 1.5 per cent per annum, the difference between the annual rate of growth of 4.7 per cent in the hourly wage rate of this crew (last line, Table 32), and the annual rate of growth of productivity of 3.2 per cent (Table 22). As shown in Table 22, productivity growth rates varied among the individual occupations as did the growth rates in hourly wage rates as shown in Table 32. Wage rates increased per annum from a low of 4.0 per cent for plasterers

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[5]Payments to these major subtrades are part of <u>nonestimated</u> building costs in Table 28. My guess is that the rate of labor productivity growth in these three subtrades was probably close to that for the integrated crew dealt with here. There are several reasons for this judgment. If the <u>nonestimated building costs</u> in Table 28 are disaggregated, roughly to be sure, then comparability with the 1930 figure is possible by excluding from the 1965 figure the following costs: marketing, financing (on the assumption that the magnitude in 1965 was more substantial than in 1930), the fireplace (common in 1965), and the electrical appliance package (common in 1965). These elements together would account for about $1.62 of the $5.35, leaving a balance of $3.73 to be compared with 1930. (The $1.62 is based on the review of a variety of sources, including the two house builders giving us detailed data.) The percentage change from $1.58 in 1930 to $3.73 in 1965 is 136.1 per cent as contrasted with 238.6 per cent for all nonestimated building costs from 1930 to 1965 as shown in Table 28. This would mean that the unit cost of the three major subtrades excluded from this study besides some other minor items would have increased by 136.1 per cent. However, part of this increase undoubtedly includes (1) materials' costs not part of the 1930 estimate, i.e., those for additional plumbing and electrical fixtures, and (2) additional hours required to install these fixtures. On the other hand, new techniques are now used in painting and plastic pipe is used in plumbing, so that labor productivity should have increased for painters and plumbers, respectively. Further, as shown in note 3 of Table 32 below, the rate of growth in hourly wage rates for the three major subtrades between 1930 and 1965 was within the range of growth rates for the individual occupations studied (see Table 32). The above reasons suggest that labor cost per unit of output for the three major subtrades could have increased at approximately the same rate as that of the integrated crew. Obviously, however, this judgment would have to be tested against evidence such as that found here for the integrated crew.

TABLE 32

Wage Rates Including Fringe Benefits, by Occupations, San Francisco-Oakland Bay Area, 1930 and 1965

Occupations	Wage rates including fringe benefits		
	Absolute numbers ($)		Average annual compounded rate of change, 1930-65
	1930	1965	
1. Individual occupations:			
Carpenter	1.125	5.40	4.6
Shingler	1.125	5.55	4.7
Hardwood floor layer	1.125	5.55	4.7
Cement finisher	1.125	5.11	4.4
Lather	1.250	5.80	4.5
Plasterer	1.375	5.48	4.0
Carpet, soft-tile and linoleum layer	--	5.20	--
Hard-tile setter	1.250	5.50	4.3
General building laborer	0.700	4.17	5.2
Hod carrier	0.940	5.20	5.0
Hard-tile helper	0.750	4.67	5.4
2. Averages for groups:			
Skilled occupations studied	1.196	5.433	4.4
Unskilled occupations studied	0.812	4.518	5.0
All occupations studied	1.091	5.345	4.7

Notes: 1. If contract rates changed during the year, the figure shown is a weighted average, weighted by the number of months the rate was in force.

2. These wage rates applied to Alameda County which is within the San Francisco-Oakland Metropolitan Area.

3. The 1930 July rates for the three major subtracts excluded from this study were $1.12 for electricians, $1.12 for painters, and $1.25 for plumbers. The July 1965 rates were $6.32 for electricians, $5.31 for painters, and $6.54 for plumbers. The rates of growth in wages were thus 5.1 per cent per annum for electricians, 4.6 per cent for painters, and 4.9 per cent for plumbers.

4. The group averages shown represent the data for individual occupations weighted by hours spent in the various operations.

Sources: California Department of Industrial Relations, Division of Labor Statistics and Research and various labor-management agreements.

to a high of 5.4 per cent for hard-tile helpers. More generally, hourly wages grew at a faster rate per annum for the unskilled group than for the skilled group, 5.0 versus 4.4, respectively.[6]

Unlike the productivity growth rates which showed a large variance about the average for the integrated crew (Table 22), the hourly wage rate growth rates did not show as wide a dispersion about the average (Table 32). This difference is logical inasmuch as men of different crafts work together on the same projects. It is not unreasonable that the trade unions involved would attempt to get wage increases of about the same percentage, even though on-site activities differ. This does not mean that each occupational group would have the same wage rate per hour. What it does mean is that having started at some wage level in 1930, then relative wage changes over the years should have been fairly close. Because of changing supply-demand conditions, however, the structure by 1965 could be different from that of 1930, as is the case. In July 1930, in the Bay Area, plasterers had the highest hourly rate, $1.37 per hour, among a group of 14 building trades' occupations.[7] By July 1965, plasterers had dropped to fourth place in this same group. It is reasonable to assume that the declining demand[8] for these workers

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[6]This finding supports the hypothesis that long-run <u>relative</u> skill differentials have narrowed which is consistent with evidence produced by Paul G. Keat in "Long-Run Changes in Occupational Wage Structure, 1900-56", <u>Journal of Political Economy</u>, LXVIII (December 1960), pp. 584-600.

[7]This group included carpenter, cement mason, electrician, painter, plasterer, plumber, roofer, lather, shingler, sheet metal worker, tile layer, general building laborer, hod carrier, and tile helper.

[8]As seen in Table 22, total manhour requirements for plasterers declined by 0.9 per cent per annum over the 35 years.

played a role in their falling in rank in this building trades' wage structure even though their productivity growth rate was almost twice as large as that for the integrated crew.

As shown above, growth rates for labor productivity and hourly wage rates, including fringes, varied among the on-site occupations studied. Important for the price impact is, however, what happened for the integrated crew. For this crew, to repeat, average physical productivity increased by 3.2 per cent per annum while the average hourly wage rate increased by 4.7 per cent per annum. By definition, the ratio of these two variables equals unit labor cost, so that by mathematical manipulation it can be shown that the difference in the growth rates between these two variables is equal to the growth rate of unit labor cost. Hence, unit labor cost for the on-site integrated crew increased 1.5 per cent per annum between 1930 and 1965. Obviously this cost increase implies that an inflationary bias is present from this source. The question that remains to be answered is: How much is the inflationary bias inasmuch as the labor costs involved represent but one of several components that enter the pricing of single-family dwellings.

To answer this question, which is of course an answer to the third policy issue in this study, the rates of growth are shown in Table 33 for the unit price (i.e., the price per square foot of living area) and for the major price components. In addition, this table shows the allocation of the unit price growth rate among the components, with the allocation made by weighting the component growth rates

TABLE 33

Rates of Growth Per Annum in the Unit Price and Its Components and the Allocation of the Price Growth Rate Among Its Components

Category	Rates of growth per annum[a]	Allocation of the price growth rate	
		Percentage points in growth rate	Per cent of growth rate
Unit price	2.98	2.98	100.000
Estimated labor cost	1.46	.21	.072
Estimated materials' cost	2.42	.52	.172
Nonestimated building cost	3.55	1.26	.424
Overhead expenses and profit	2.75	.30	.100
Site value	3.90	.69	.232

[a]Average annual compounded rate of change between 1930 and 1965.

Note: Detail may not add to total due to rounding.

Sources: Growth rates derived from columns 2 and 4 in Table 28. Allocation of growth rates derived by applying average relative share computed from data in Table 29 to the sectoral growth rates.

by the average relative share.[9]

As seen in Table 33, the unit price of the house, i.e., the price per square foot, increased at a rate of 2.98 per cent per annum between 1930 and 1965. In contrast, unit labor cost in 11 on-site operations grew at a rate of 1.46 per cent per annum. When the various growth rates are allocated by the average weights of the relative shares, the increase in this unit labor cost figure accounts for seven per cent of the 2.98 per cent annual growth rate in the unit price of the house. With the shift that took place reducing on-site hours by the substitution of prefabricated materials, the materials' cost per square foot figure grew at a rate of 2.42 per cent per annum, accounting for 17.2 per cent of the unit price increase.

The nonestimated building cost growth rate accounted for 42.4 per cent of the price rise over the 35 years, or for the largest share. As mentioned above, however, this estimate is a conglomerate of several forces, e.g., developments in the major subtrades, equipment and fixtures not included in 1930, and expenses not incurred in 1930.

The growth rate of the site value was the largest, with site cost increasing at a constant rate of 3.90 per cent per annum. This variable accounted for 23.2 per cent of the overall price rise over the 35 years.

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[9]The average of the relative shares given for each year separately in Table 29.

To sum up: Unit labor cost had an inflationary bias on the price of houses. However, not only was the growth rate for this variable lower than that of the other components, but, in addition, when weighted by its relative share in the price, this variable accounted for seven per cent of the annual rate of increase in the unit price of a house between 1930 and 1965. This finding suggests that efforts to hold down the price of single-family dwellings cannot succeed by focusing only on on-site labor costs. The trade-off from on-site to off-site work has not been costless for the materials estimated in this study rose at a rate of 2.42 per cent per annum. Further, the increase in price because of added amenities over the years cannot be considered inflationary inasmuch as this increase in price represents a different bundle of services than was provided by the 1930 house. Finally, the fastest rate of growth among the price components was the increase in the site value, which involves a scarce natural resource.[10]

In the next section, the above variables in addition to others are discussed in detail in order to provide other insights into the issues involved when answering the question regarding the reasons for the increase in the prices of single-family dwellings.

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[10] This result is consistent with findings in a broader study basically addressed to the same problem reported in Sara Behman and Donald Codella, "Wage Rates and Housing Prices," Industrial Relations, 10 (February 1971), p. 90.

4. The Costs Involved in Final Pricing

In this section, we examine a general builder's cost function and comment on each aspect. The analysis is meant to provide the reader with information on the important variables that should be considered in the final price of the home. (No attempt is made to discuss building codes and their relationship to costs.[11])

As the reader will discover, the approach in this section differs from that in the preceding sections and chapters in the study because we no longer deal with original data but rather with data from a variety of sources in order to synthesize the many ideas that came to our attention during the progress of this research.

a. House-Cost Analysis, General

An example of a basic cost function that may assist policy-makers in formulating the questions that need to be answered in order to understand the reason for rising prices in single-family dwellings is outlined below. Such a cost function would include the following variables:

1. Land costs,
2. Lot development, or site development costs,
3. Direct labor costs on the site,
4. Direct payments to subcontractors,
5. Cost of materials,
6. Cost of capital services,
7. Marketing costs, which include the sales expense per house,
8. Cost of holding houses prior to sale,

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[11]See Leland S. Burns and Frank G. Mittelbach, "Efficiency in the Housing Industry," The Report of the President's Committee on Urban Housing, Technical Studies, Vol. II (Washington, D.C.: U.S. Government Printing Office, 1968), for a review of the evidence on this issue.

9. The cost of borrowing money, i.e., the builder's loan costs, and
10. Other costs, including indirect costs and variable construction costs which involve items relating to the building of each project such as architectural fees, various government fees, insurance, and the length of the production schedule.

The reader should observe that these are costs relating to the supply side of the residential market. In an analysis dealing with the consumer side of the market, not only would the price of the house be important but in addition there would need to be a consideration of occupancy costs which would be influenced by interest rates and taxes.

Each of the above cost items is now examined.

b. Land Costs

After the initial decision is made to build a given number of houses the builder must acquire land. It is possible that land may be acquired several years before the actual building starts. According to a special survey of the National Association of Homebuilders, the average price per acre of raw land in the United States increased as follows from 1950 to 1968: 1950--$1222; 1960--$2591; 1965--$4101; and 1968--$5475.[12] According to these data, the price of raw land increased at an annual compounded rate of 8.4 per cent between 1950 and 1965 and of 8.7 per cent between 1950 and 1968. These figures are consistent with the annual compounded rates of growth of the

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[12] Data obtained from a reprint of the original information provided by Mr. William Page, Bank of America, San Francisco.

site value reported in FHA Homes.[13] Between 1950 and 1965, for the United States, the value of the property site increased at an annual rate of 8.1 per cent and between 1950 and 1968 at a rate of 8.5 per cent. In contrast, the average property value of the new FHA homes increased at an annual rate of 4.7 per cent between 1950 and 1965 and at a rate of 4.9 per cent between 1950 and 1968. This faster rate of growth in land costs than in other costs included in the price of new homes raised the site-value ratio for FHA homes in the United States from 11.2 per cent in 1950 to 20.7 per cent in 1968. The same trend applied to the San Francisco-Oakland Metropolitan Area, which includes Alameda County. The price of the lot as a percentage of the final price of the house (for new houses) increased from 14.4 per cent in 1950 to 24.8 per cent in 1968. The average lot price in fact increased from $1,339 in 1950 to $6,385 in 1968 in this area, for an annual compounded rate of growth of 9.1 per cent over the 18-year interval. As the following data show, for the metropolitan area which includes Alameda County, the site price within the total house price rose steadily from 1950 to 1967 and then edged down a little in 1968. (Table 34)

Sherman Maisel studied the land cost situation for single-family housing and separated the factors entering into the cost of developed lots as follows: the cost of development, density of land use, and the price of raw land.[14] Studying the change that occurred

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[13] Annual publication of the Federal Housing Administration.

[14] See Sherman J. Maisel, "Land Costs for Single-Family Housing," California Housing Studies, Center for Planning and Development Research, University of California, Berkeley, 1963, p. 6.

TABLE 34

Value of Houses and Developed Sites Insured by the FHA, San Francisco-Oakland Metropolitan Area, 1950-1968

	Total price ($)	Site only ($)	Site value/total price (in per cent)
1950	9,308	1,339	14.4
1955	13,250	2,139	16.1
1956	14,961	2,531	16.9
1957	16,793	2,974	17.7
1958	16,707	3,121	18.7
1959	17,352	3,190	18.4
1960	17,536	3,295	18.8
1961	17,945	3,434	19.1
1962	18,245	3,742	20.5
1963	19,784	4,148	21.0
1964	20,660	4,451	21.5
1965	21,449	5,122	23.9
1966	23,639	5,877	24.9
1967	25,646	6,557	25.6
1968	25,713	6,385	24.8

Sources: Data for 1950-1960 taken from Sherman J. Maisel, "Land Costs for Single-Family Housing," California Housing Studies, Center for Planning and Development Research, University of California, Berkeley, 1963.

Data for 1961 forward taken from FHA Homes: Data for States and Selected Areas (annual releases by the Federal Housing Administration).

in the cost of a typical Bay Area lot between 1950 and 1962, Maisel's analysis shows that the FHA value of the lot increased from $1300 in 1950 (data rounded to nearest $100) to $3850 in 1962, or an increase of $2550 over these 12 years. This increase was allocated among the three factors as follows:

> $720 in cost and quality of development = 28 per cent,
> $1325 in value of raw land = 52 per cent,
> $505 from the change in the size of the lot, which increased from 5500 square feet to 6500 square feet = 20 per cent.

In Section III of his study Maisel outlines a theory of the factors influencing the price of raw land. For purposes of the study at hand, we simply note the fact that raw land had increased substantially in price in the Bay Area, and observe that if the builder is to build houses he must pay the asking price for that land. This variable then cannot be slurred over in any study of furnishing housing to the lower and middle income groups. It is also a fact that some regions have seen higher increases in land as a percentage of the final price of the house. It is important to note, however, that lot sizes have increased on the average. For this Maisel says two factors have been at work. One is the effect of higher incomes. Because space is costly, and, to many people a valuable good, we should expect that as people become wealthier they will buy more space. The other factor has derived from planning commissions and zoning ordinances. These data on land costs as a rising proportion of total property value suggest that this cost variable must be taken into account as an important element to be reckoned with when decisions are made regarding the production of low-cost housing.

c. Site Development Costs

The increase in lot price as mentioned above reflected not only the price of raw land increase but also included 28 per cent because of an increase in site development. As Maisel pointed out, this increase reflected both a rise in the unit costs of development and an increase in required standards. Counties have insisted on more improvements in streets and sewers, so that the builder has had to pay a larger share of total improvement costs.[15] Evidence available indicated that this cost has increased substantially since the early postwar years. The costs involved here were not known in the booming building years after World War II.

Detailed insights into reasons for the rise in land development costs come from a statement made to the National Commission on Urban Problems, chaired by Senator Paul Douglas, during mid-1967. At these hearings, Lawrence Weinberg detailed the cost of a house built in 1967 and one built in 1950 on the same size lot. Land development costs in 1967 were $2000 versus $650 for a lot of the same size. His statement was:

> Now, in order to put land development costs into proper perspective, in 1950 we didn't have sewers, we didn't have street lights, we didn't have underground utilities, we didn't have sidewalks either. So I would say that those items I've just enumerated account for $400 or $500 of this difference. In addition there has been a substantial increase, as we are all aware, in the costs of labor and material that go into the improving of a lot. There are additional costs because of the sophistication, and properly so, of the agencies involved. They

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[15] Maisel, op. cit., pp. 2 and 7.

> ... now requiring certain soil tests and certain accommodations to whatever those soil tests indicate in terms of the development to the lot. There are, in addition -- depending on what community you are operating in -- certain fees we did not have 18 or 20 years ago. I'm not certain these are the best systems, but these fees are for the purpose of hooking up sewer systems, of creating park districts, being able to drain your property, and so on. Depending on the community, in Southern California these fees can range between $200 and $600 a lot.[16]

It should be observed that some part of the increase that has taken place is the result of underground utilities. According to House and Home, August 1965, FHA policy became such that no insurance would be granted for home mortgages in new subdivisions unless utility wires were buried. Prior to this date, including the cost of underground wiring in the mortage was not general practice. However, consumer tastes apparently were taken into account. A consumer survey in Seattle showed that prospective home buyers were willing to pay up to one per cent more on a new home if wires were hidden.[17]

d. Direct Labor Costs on the Site

Although wage rates are negotiated by labor-management agreements, total costs can be controlled by reducing manhours spent on the job site by changing materials and construction methods. In particular, the more prefabricated materials are used on the site, the more can on-site manhours be reduced. Our evidence in Chapter III

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[16] Lawrence Weinberg, op. cit., p. 49.

[17] House and Home, August 1965, p. 10.

supports this notion. Two specific examples can also be provided to support this view.

Example 1 uses the testimony of Weinberg[18] who kept records for his 1967 house of 1678 square feet and the 1950 house of 720 square feet. In 1967, Weinberg's house sold for $25,000 and in 1950 for $7,200. In 1967, construction costs accounted for 43.2 per cent of the $25,000 final price, or for $6.436 per square foot. In the 1950 house, the construction cost was $5.70 per square foot, and accounted for 57 per cent of the final price. As Weinberg pointed out, the square foot cost of construction <u>per se</u> increased by about 13 per cent over these 16 years, although as Weinberg points out ". . .in 1950 we were paying our carpenters $1.85 an hour and today we are paying them over $5 an hour,. . . ."[19]

The second example comes from the cost analysis provided quarterly in the Bay Area Real Estate Report prepared by the Bay Area Real Estate Research Committee, affiliated with the Bay Area Council.[20] In 1951, for this cost analysis, a typical house was specified on the technology of that period, and then for each quarter prices of the various items were brought up to date. In January 1961, a new typical house was designed to take account of new building methods and materials. In Table 35 below, prices attached to this

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[18] Op. cit., pp. 47-50.

[19] Ibid., p. 50.

[20] Known now as the Northern California Real Estate Research Committee.

TABLE 35

Changes in Housebuilding Costs for Two Typical Houses, 1951 and 1961

	1951 house (1,026 sq. ft.)		1961 house (1,395 sq. ft.)	
	January 1951	October 1960	January* 1961	
1. Preliminary	$ 115	$ 152	$ 293	
2. Insurance and taxes	126	326	134	
3. General contractor's overhead and profit	1,027	1,336	1,786	
Subtotal	1,268	1,814	2,213	
4. Materials only, general contractor				
Structural concrete (housing only)	187	192	468	Concrete foundation
Rough lumber	806	754	1,285	
Finish lumber	596	636	113	
Doors and jambs	204	215	234	(Preassembled doors includes patio sliding door and aluminum windows)
Window frames and sash	214	324	377	
Rough hardware and building paper	79	72	48	
Finish hardware	160	179	60	
Kitchen and other cabinets	147	220	292	
Window shades	30	46	0	
Subtotal	2,423	2,638	2,877	
5. Labor only, general contractor				
Carpentry	957	1,551	1,222	(Rough = $ 1,005 Finish = 217)
Construction labor	292	477	0	
Supervision -- foundation	0	12	0	
Clean up	40	85	65	
Subtotal	1,289	2,125	1,287	

- continued -

TABLE 35 -- continued

	1951 house (1,026 sq. ft.)		1961 house (1,395 sq. ft.)	
	January 1951	October 1960	January* 1961	
6. Subcontractors	$	$	$	
Stucco exterior	0	0	647	
Plumbing	960	1,289	1,443	(Includes $45 for bathroom fixtures)
Painting	575	960	585	
Electric wiring and fixtures	305	330	598	
Sheet metal and heating	438	518	582	
Hardwood floors	459	388	385	
Linoleum floors	131	130	325	
Tile work	247	209	370	
Fireplace and hearth	250	380	456	
Sheetrock	508	738	732	Gypsum board
Roof covering	338	336	594	
Subtotal	4,211	5,278	6,717	
7. Construction cost (sum of 4, 5, 6)	7,923	10,041	10,881	
8. Total cost (sum of 1, 2, 3, 7)	9,191	11,855	13,094	
Total cost per square foot	$ 8.96	$ 11.55	$ 9.39	
9. Cost per square foot for carpentry	0.93	1.41	0.87	

*Excluded from the other costs are: $135 for excavation and site development and $200 for sewer line and connection. These costs are part of land development costs and presumably would be paid regardless of the type of building put on the site.

Source: Bay Area Real Estate Report, Bay Area Real Estate Research Committee, Affiliated with the Bay Area Council, selected quarters. (Now known as the Northern California Real Estate Report issued by the Northern California Real Estate Research Committee. Title changed in 1965.)

basic house are shown for the initial period, January 1951; then for October 1960, the last time the 1951 house was priced out for materials and wages; and then for the new house in 1961. The changes in cost between January 1951 and October 1960 represent only cost changes and do not account for any changes in building methods that may have occurred. The new house in 1961, however, has a new set of material and labor hours, so that the prices now include costs of that period along with the changes in specifications made to the house. As can be seen, when the 1951 and 1961 figures are compared, the total cost per square foot increased from $8.96 to $9.39. However, the cost per square foot for carpentry actually declined, from $0.93 to $0.87. The important change was the use of more rough lumber versus finish lumber.

As can be seen, price changes and wage increases did occur, for comparing January 1951 and October 1960 indicates that rising prices and wages increased the total cost per square foot from $8.96 to $11.55, or by 28.9 per cent. Over these same 10 years, the wage rate of carpenters increased from $2.45 to $4.085 (which includes fringe benefits) or by 66.7 per cent.

These data make it possible to decompose the change in cost per square foot over the 10 years into price changes and other changes due to different building methods, different house specifications, and differing quality. The cost per square foot in 1961 is the sum of the cost in 1951 and the amount that occurred from factor cost increases from 1951 through October 1960 minus the amount that would represent the effect of the new house model that was based on different building methods. Specifically, this formulation is

$$\$9.39 = \$8.96 + \$2.59 - \$2.16 .$$

As shown above, factor cost increases amounted to $2.59 ($11.55 less $8.96). Meanwhile the building methods were changing. In fact they changed sufficiently so that when the new house design was introduced in 1961, the price per square foot was $2.16 less than it would have been for the 1951 model built on the basis of 1951 construction practices. In particular, even with rising wage rates, direct labor costs (Item 5 in Table 35) per square foot to the general contractor were $1.27 in 1951 but $0.92 in 1961.

e. Direct Payments to Subcontractors

The general contractor has to deal with subcontractors to complete projects. Such costs might be affected to some extent by reducing quality specifications when asking for bids. According to the data in Item 6 in Table 35, the cost per square foot going to the group of subcontractors was $4.10 in 1951 and $4.81 in 1961. The 1961 house, however, had two bathrooms and more electrical services. The $0.71 increase is composed of a $1.04 increase in factor prices (i.e., rising materials; and wage costs) offset by a $0.33 decline that derived from the model change and new building techniques. That a $0.33 decline did occur is interesting because the number of subcontractors with whom the general contractor deals in completing subdivisions has increased over the past 10 years. Ten years ago, about 25 to 30 subcontractors were used but at present about 40 subcontractors may be required.[21] According to Eisele, this increased specialization has complicated supervision and scheduling on the site and extended the number of days required to complete a house as contrasted with the late fifties and early sixties.

f. Cost of Materials

The major single variable under materials is lumber which, in Alameda County, is the primary materials' input. Because lumber is a natural resource, however, the builder has periodically been subjected to more than anticipated changes in the price of lumber which must either be absorbed through a reduction in profits or passed on to the final consumer if possible.

The evidence does suggest, however, that the reliance on lumber has diminished over the years. According to the data furnished in FHA Homes,[22] in 83 comparable metropolitan regions, 56 per cent of the houses had a wood exterior in 1940, but by 1967, 30.3 per cent of the houses had an exterior of wood or wood shingles. Inasmuch as the carpenter's main line of work is dealing with wood, the question arises as to how much the shift from wood to other materials was the result of the growing scarcity of lumber and hence a rise in price

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[21] Private communcation received from Arthur T. Eisele, California State Council of Carpenters, April 10, 1971.

[22] See FHA Homes in Metropolitan Districts: Characteristics of Mortgages, Homes, Borrowers under the FHA Plan, 1934-40 (Federal Housing Administration, 1942). See also FHA Homes 1967, Data for States and Selected Areas (Federal Housing Administration.)

versus the rising price of the carpenter's labor services. Harold Barnett[23] has examined economic scarcity in natural resources, dealing with four types of natural resources, i.e., all extractive resources, agricultural output, minerals, and timber. He found that according to his method of measuring economic scarcity, only timber products gave evidence of economic scarcity. Between 1870 and 1955, except for an interruption in the 1900 data, the time series show a steady decline in timber's labor productivity relative to the economy as a whole. Further, relative prices of all timber products quadrupled over the 85 year span he examined. In 1955, output levels in timber products were no greater than in 1900, but the 1955 prices were almost triple those in 1900.

The erratic nature of lumber prices when supply pressures restrict the flow to the housing industry can be seen by following the changes in the price of lumber that entered the typical Bay Area house mentioned above (see Table 35).

As seen in Table 36, rough lumber prices are erratic. In fact, the table fails to capture the entire volatility of these prices. For example, in January 1969 the rough lumber cost entering the price of the model home reached $2,450. Severe supply pressures hit the market for lumber products during 1968 and early 1969. This lumber price increase severely affected local builders who had not anticipated

[23] Harold J. Barnett, "The Measurement of Change in Natural Resource Economic Scarcity," in Output, Input and Productivity Measurement, Studies in Income and Wealth, Vol. 25, (Princeton University Press, Princeton, 1961), pp. 96-99.

TABLE 36

Cost of Rough Lumber for July of Each Year

1951 house		1961 house	
Year	Cost ($)	Year	Cost ($)
1951	830	1961	1,410
1952	791	1962	1,505
1953	842	1963	1,487
1954	846	1964	1,426
1955	837	1965	1,392
1956	792	1966	1,522
1957	729	1967	1,430
1958	727	1968	1,983
1959	790	1969	1,838
1960	750	1970	1,692

Source: Bay Area Real Estate Report, Bay Area Real Estate Research Committee, Quarterly Reports.

such a sharp advance when they did the initial estimating on their houses in progress.

A possible hypothesis that might be examined is that each time erratic price changes have occurred in lumber products, there has been increased momentum to find substitute products. Obviously, such substitutes could reduce the work of the carpenter unless the union were able to broaden its jurisdiction. This hypothesis would lead to the generalization that builders have control over kinds of materials used if they are able to find materials in which on-site labor hours can be traded for cheaper off-site labor hours. In Chapter III of this study we have already shown how the use of prefabricated components of various types did reduce the need for hours on the site.

g. Cost of Capital Services

Cost of the services received from capital equipment can also be varied by the builder, for these costs are related to the labor utilized. If it is found, for example, that the cost of supplying a nail gun is cheaper than using a carpenter with a hammer, the cost of capital services would rise on the presumption, of course, that this increase would be more than offset by the reduced manhours required on the construction site. A point made by most persons knowledgeable in this field, however, has been that the cost of capital services, i.e., the use of machinery on the site has never been of primary significance in the cost of building. Nevertheless, large builders are in a position to purchase large pieces of equipment because their use would be warranted if sufficient houses were to be built. Small builders, on the other hand, probably cannot be as capital-intensive, because the cost of some machinery would be noneconomic for use on a small number of houses per year.

h. Marketing Costs

These costs represent a fixed cost to the builder. Some estimates indicate that such costs represent about five or six per cent of the final price of the house. Weinberg's sales-price analysis showed that marketing costs accounted for four per cent of the final price of the house. These costs include not only payments to the sales force but also maintenance and tax payments on model homes that are built in order to attract consumers to particular house models.

i. Cost of Holding Houses Prior to Sale

This cost can vary considerably but appears to be beyond the control of the builder. If a development is highly successful, and market conditions are favorable, the builder may have a zero cost of holding houses. If, on the other hand, the market has been misjudged, then the cost of holding houses may rise substantially, for certain fixed costs must be paid such as interest payments on loans, insurance, and taxes. Further, maintenance costs would have to be paid in order to keep up the value of the property.

j. Cost of Borrowing Money

The impact of this cost is far-reaching, for this variable enters the price of the house in its several stages. There is no one common method of financing projects. However, a typical way might be as follows, and in each stage the rate of interest charged enters the cost. First, if the builder must obtain a land loan, the going rate of interest to purchase the land is included. Second, when he makes a land improvement loan he must pay the going rate of interest. Third, when he makes a construction loan, which in most cases is used to repay the land and land improvement loans, he must pay the going rate of interest. A rule of thumb is that the rate paid is about 1 to 1-1/2 per cent above the prime rate in effect. Finally, there is a loan for final financing, or "take-out financing". If FHA insures the loan, the builder must pay points in order to cover the difference between the FHA rate and the market rate of interest being charged by lenders. In each of these stages of financing, the cost of money in a sense pyramids and adds to the final sale price of the house.

Weinberg's records showed that financing costs accounted for 10.8 per cent of the sales price of his $25,000 house. Of the $2700 involved, $1500 was for the discount on sale of the FHA mortgage. This figure from Weinberg's testimony is supported by Levitt in his paper in the Report of the President's Committee on

Urban Housing (p. 70). According to the Levitt statement, "A mortgage discount of $1200, which seems typical today for a $25,000 house, constitutes an unproductive cost that we must reflect in our selling price ." Other evidence regarding the magnitude of the cost of money is given by Eichler and Kaplan.[24] "Even under the highly competitive conditions of the 1960's, the combined interest and fees for constructing a $20,000 house (sales price) can run between $500 and $1,000."[25]

k. Other Costs

These costs along with profit to the builder account for about 10 to 15 per cent of the sales price of the house. In the Weinberg house they accounted for 10 per cent of the $25,000 house. In its cost analysis of the typical house, the Northern California Real Estate Research Committee (formerly the Bay Area Real Estate Research Committee) allows 15 per cent of the construction cost for the builder's overhead and profit. In this instance, the only variable that could be adjusted would be the profit to the builder if he must absorb rising costs that cannot be passed on in the final sales price. This would probably vary with the strength of demand for houses.

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[24] See Edward P. Eichler and Marshall Kaplan, The Community Builders (University of California Press, Berkeley, 1967), pp. 46-47, for another description on how subdividers and merchant builders finance projects.

[25] Ibid., p. 47.

1. Cost Synthesis

After reviewing the various costs which the builder must include in the typical project, we are left with the question as to how much tradeoff is possible among costs. If our reasoning above is correct, then it would seem that the major tradeoff that is possible is in the area of construction costs that involve direct manhours paid for on the construction site and materials used. It is probably for this reason that efforts have been made to minimize the cost between these two items, for under present institutional arrangements the remaining costs are those over which the builder has but little control and consequently they have been taken as given. Is the evidence clear, however, that low-cost housing needs can be met by only reducing direct construction costs? These direct construction costs which are within the builder's control, account roughly for from 44 to 53 per cent of the final sales price. The question comes down to the following: Can direct construction costs (whether in tract developments or in factory housing) be reduced much further in order to offset increases in the variables beyond the control of builders?

The new housing effort is directed at a section of the demand curve for new housing on which no information is available because it is the portion of the market that has been excluded by the price of houses built to date. Some inroads have been made, perhaps, on a part of this market by the increasing sales of mobile homes. Families purchasing such homes of course are purchasing shelter services only, for they make no investment in land. Do low and moderate income families have aspirations for shelter only, or are their aspirations built on viewing a home as a capital asset that will yield services of permanence beyond their ownership and also personal satisfaction in excess of shelter requirements? Answers to these questions are as important as finding the proper mix of direct construction, land, and financing costs to market a house low and moderate income families can afford to buy, because the services a house provides include many nonpecuniary elements to consumers.

APPENDIXES

APPENDIX A

Detailed Cost Estimates for the Eight Sample Houses

Comments Regarding the Sample Size

Obviously, with the data in this study based on a few sample points in each year, a comment regarding the sample size is in order. For 1965, for example, our houses representing 4,661 dwellings cannot be considered a satisfactory sample in rigorous statistical terms. However, by distributing the houses to account both for custom versus tract building methods and qualitative differences in order to select "representative" houses in one of each of the four cost groups we, in effect, have a larger effective sample. Further, mass-produced homes accounted for 78 per cent of the building in 1965 and every effort was made to contact many tract builders to get a consensus on various aspects of building. The magnitude of the problems involved in this type of in-depth study is confirmed by the Bureau of Labor Statistics study. The Bureau relied on 101 different houses for its 1962 study of private new one-family dwellings. Their effective sample was larger because some reports for individual houses represented similar homes in large housing developments.[1] This characteristic, however, also applies to our sample as mentioned above.

The BLS sample was, with few exceptions, restricted to FHA appraised or mortgage-insured homes.[2] Restricting the report to FHA-insured or appraised homes means that the BLS study is biased in the direction of less expensive houses. For example, in 1964, only 23 per cent of all

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[1]Bureau of Labor Statistics, Bulletin No. 1404, June 1964, p. 2.

[2]*Ibid.*, p. 2.

homes sold were FHA-insured, and these homes had an average sales price of $16,100 versus $22,600 for conventional mortgage homes which accounted for 63 per cent of all homes sold.[3] In addition to this bias, which obviously was necessary to conduct an intensive study because of the richness of the information in FHA records, the BLS sample of 101 different houses compares with a universe of all single-family dwellings started in 1962 of 991,300.[4] In this report, the four houses are representative of the entire population of 4,661 dwellings.

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[3]U. S. Department of Commerce and Home Finance Agency, Sales of New One-Family Homes, Annual Statistics, 1964, Table S-4, p. 16.

[4]U. S. Department of Commerce, Bureau of the Census, Housing Construction Statistics, 1889 to 1964, p. 20.

TABLE A-1: Detailed Cost Estimates for House I, 1930

Operation	Material Unit	Material Quantity	Hours Laborer	Hours Skilled	Material Cost ($)	Labor Cost ($) Laborer	Labor Cost ($) Skilled
Footings: Total:			14.8	7.8		10.39	8.82
Excavation (including backfill)	CY	5.44	8.3			5.81	
Forms	SF	196	6.5	7.8		4.58	8.82
Concrete Floor: Total:	SF	378	40.4	5.7[1]	30.89	28.31	6.38[1]
Framing: Total:			84.8	314.0	517.34	59.44	353.00
Mudsill (including bolts), beam	BF	292	1.6	5.5	17.83	1.13	6.21
Floor joists, blocking, bracing	BF	3,162	14.2	33.2	101.18	9.96	37.35
Subfloor	BF	2,111	10.5	21.1	67.55	7.38	23.54
Studs, (including basement), sole plate, top plate, bracing, blocking	BF	4,138	20.7	128.3	132.42	14.48	144.30
Ceiling joists, blocking, bracing	BF	1,275	5.7	15.0	40.80	4.02	16.85
Rafters, collar beams, bracing blocking, ridge poles	BF	2,526	17.2	82.5	73.85	12.01	92.33
Roof sheathing	BF	2,616	14.9	28.4	83.71	10.46	31.92
Outside Walls: Total:			140.6	280.3	477.02	127.45	363.87
Wall sheathing	BF	3,945	19.7	51.3	126.24	13.80	57.69
Stucco - grounds and building paper	SF	3,500		16.5	24.60		18.56
- lathing	SY	390		37.0[2]	119.48		46.31[2]
- plastering	SY	390	120.9[3]	175.5[4]	206.70	113.65[3]	241.31[4]

TABLE A-1: Detailed Cost Estimates for House I, 1930 cont.

Operation	Material: Unit	Material: Quantity	Hours: Laborer	Hours: Skilled	Material Cost ($)	Labor Cost ($): Laborer	Labor Cost ($): Skilled
Interior Walls: Total:			87.6	221.5	158.35	82.34	287.50
Plaster grounds	BF	501		39	17.00		43.87
Lathing	SY	730		58.4[2]	50.00		73.00[2]
Plaster	SY	730	87.6[3]	124.1[4]	91.35	82.34[3]	170.63[4]
Windows: Total: (including trim and hardware)	PC	20		80.0	201.67		90.00
Doors: Total:				103.9	344.00		117.00
Exterior & interior (including closets)(including trim & hardware)	PC	15		92.2	258.98		103.78
Garage (including trim & hardware)	PC	1		11.7	85.02		13.22
Inside trim: (excluding windows & doors): Total:	LF	1,972	11.6	73.6	109.10	8.12	82.84
Floors: Total:			52.3	172.1	461.07	38.83	199.07
Resilient floors	SF	211		5.5[5]	19.63		6.21[5]
Hardwood floors	SF	2,011	7.6	123.5	304.30	5.29	138.97
Tile (including wall & kitchen drainboard)	SF	224	44.7[6]	43.7	137.14	33.54[6]	53.87
Roof Cover: Total:				45.8	145.98		51.28
Composition shingles	SF	2,616		45.8[8]	145.98		51.28[8]
TOTAL			432.1	1,304.7	2,445.42	354.88	1,559.76

See footnotes after Table A-8

TABLE A-2: Detailed Cost Estimates for House II, 1930

Operation	Material: Unit	Material: Quantity	Hours: Laborer	Hours: Skilled	Material Cost ($)	Labor Cost ($): Laborer	Labor Cost ($): Skilled
Footings: Total:			41.0	38.8		29.38	43.64
Excavation (including backfill)	CY	6.3	9.6			6.73	
Forms (footings, wall)	SF	815	32.4	38.8		22.65	43.64
Concrete Floors: Total:	SF	1,100	125.4	16.5[1]	105.70	87.78	18.40[1]
Framing: Total:			79.4	292.6	503.93	55.61	329.20
Mudsill (including bolts)	BF	188	1.1	4.3	14.59	0.79	4.86
Floor Joists (2 floors), blocking, bracing	BF	3,870	17.4	40.6	123.84	12.19	45.72
Subfloor (2 floors)	BF	2,257	11.3	22.6	72.22	7.89	25.39
Studs (3 floors), plates, bracing, blocking	BF	4,992	24.9	154.7	159.74	17.46	174.09
Ceiling joists (top floor), blocking, bracing	BF	1,139	5.1	12.0	36.45	3.58	13.45
Rafters, dormer studs, ridge pole, blocking	BF	1,374	9.6	38.5	43.97	6.73	43.28
Roof sheathing	BF	1,660	10.0	19.9	53.12	6.97	22.41
Exterior Walls: Total:			134.3	263.7	463.11	122.15	343.67
Wall sheathing	BF	3,808	17.1	40.0	121.86	12.00	44.98
Stucco - grounds & building paper	SF	3,400		17.7	25.02		19.91
- lathing	SY	378		35.9[2]	115.89		44.89[2]
- plastering	SY	378	117.2[3]	170.1[4]	200.34	110.15[3]	233.89[4]

TABLE A-2: Detailed Cost Estimates for House III, 1930 cont.

Operation	Material Unit	Material Quantity	Hours Laborer	Hours Skilled	Material Cost ($)	Labor Cost ($) Laborer	Labor Cost ($) Skilled
Interior Wall & Ceiling: Total:			94.5	260.1	187.20	88.83	334.12
Plaster grounds	BF	718		56.0	24.38		63.02
Lath	SY	756		60.5[2]	51.80		75.60[2]
Plaster	SY	756	94.5[3]	143.6[4]	111.02	88.83[3]	195.50[4]
Windows: (including trim & hardware) Total:	PC	16		64.0	156.36		72.00
Doors: (including trim & hardware) Total:				108.9	334.37		122.63
Exterior & interior (including closets)	PC	17		97.2	279.35		109.41
Garage	PC	1		11.7	55.02		13.22
Inside trim: (excluding windows & doors) Total:	LF	2,416	13.4	90.6	125.80	9.51	101.92
Floors: Total:			41.4	136.5	359.34	30.57	157.31
Hardwood	SF	1,695	8.5	101.7[9]	225.88	5.93	114.41[9]
Resilient	SF	186		4.8[5]	16.05		5.43[5]
Tile (including wall & kitchen drainboard)	SF	219	32.9[6]	30.0[7]	117.41	24.64[6]	37.47[7]
Roof Cover: Total:				18.7	88.32		21.00
Composition shingles	SF	1,660		18.7[8]	88.32		21.00[8]
Stairs: Total:	SF	515		38.0	25.44		42.75
TOTAL			529.4	1,328.4	2,349.57	423.83	1,586.64

See footnotes after Table A-8

TABLE A-3: Detailed Cost Estimates for House III, 1930

Operation	Material Unit	Material Quantity	Hours Laborer	Hours Skilled	Material Cost ($)	Labor Cost ($) Laborer	Labor Cost ($) Skilled
Footings: Total:			21.9	13.3		15.34	14.94
Excavation (including backfill)	CY	7.1	10.8			7.58	
Forms	SF	332	11.1	13.3		7.76	14.94
Concrete Floors: Total:	SF	972	75.0	14.6[1]	71.91	52.53	16.40[1]
Framing: Total:			53.1	160.9	347.28	37.29	181.06
Mudsill (including bolts), beams, posts	BF	404	1.7	6.0	21.56	1.21	6.71
Floor joists, blocking, bracing	BF	1,561	6.2	15.6	49.95	4.37	17.56
Subfloor	BF	1,310	6.5	10.5	41.92	4.58	11.79
Studs, (including basement), plates, bracing, blocking	BF	2,959	14.8	62.1	94.69	10.36	69.90
Ceiling joists, blocking, bracing	BF	805	3.2	8.0	25.76	2.25	9.06
Rafters, studs, ridge boards	BF	1,517	10.6	42.5	48.54	7.43	47.79
Roof sheathing	BF	2,027	10.1	16.2	64.86	7.09	18.25
Exterior Walls: Total:			84.5	148.9	294.96	76.70	192.80
Wall sheathing	BF	2,541	11.4	26.7	81.31	8.00	30.01
Stucco - grounds & building paper	SF	2,269		8.8	15.43		9.86
- lathing	SY	252		23.9[2]	64.66		29.92[2]
- plastering	SY	252	73.1[3]	89.5[4]	133.56	68.70[3]	123.01[4]

TABLE A-3: Detailed Cost Estimates for House III, 1930 cont.

Operation	Material Unit	Material Quantity	Hours Laborer	Hours Skilled	Material Cost ($)	Labor Cost ($) Laborer	Labor Cost ($) Skilled
Interior Walls & Ceilings: Total:			54.9	136.4	106.80	51.63	177.51
Plaster grounds	BF	236		18.0	7.94		20.24
Lath	SY	546		43.7[2]	37.19		54.60[2]
Plaster	SY	546	54.9[3]	74.7[4]	61.67	51.63[3]	102.67[4]
Windows: (including trim & hardware) Total:	PC	15		52.5	141.80		59.06
Doors: (including trim & hardware) Total:				36.0	177.22		40.52
Exterior & interior (including closets)	PC	8		24.5	120.40		27.58
Garage	PC	1		11.5	46.82		12.94
Inside trim: (excluding windows & doors) Total:	LF	779	5.7	31.5	66.77	4.00	35.45
Floors: Total			14.0	62.8	165.21	10.36	71.73
Hardwood	SF	768	3.8	46.1[9]	102.68	2.69	51.84[9]
Resilient	SF	312		8.0[5]	26.04		9.06[5]
Tile (including kitchen drainboard)	SF	85	10.2[6]	8.7[7]	36.49	7.67[6]	10.83[7]
Roof Cover: Total:				43.0	66.55		48.37
Wood shingles	SF	1,810		43.0[8]	66.55		48.38
Stairs: Total:	BF	245		22.0	7.84		24.75
TOTAL			309.1	721.9	1,446.34	247.85	862.59

See footnotes after Table A-8

TABLE A-4: Detailed Cost Estimates for House IV, 1939

Operation	Material		Hours		Material Cost ($)	Labor Cost ($)	
	Unit	Quantity	Laborer	Skilled		Laborer	Skilled
Footings: Total:			15.6	13.2		10.96	14.85
Excavation (including backfill)	CY	3.05	4.6			3.25	
Forms	SF	330	11.0	13.2		7.71	14.85
Framing: Total:			25.2	74.5	173.41	17.70	83.90
Mudsill (including bolts) beam	BF	194	0.8	2.4	11.10	0.55	2.73
Floor joists, blocking, bracing	BF	980	3.9	9.8	31.36	2.74	11.02
Subfloor	BF	700	3.5	5.6	22.40	2.45	6.30
Studs, plates, blocking, bracing	BF	1,390	6.9	29.2	44.48	4.86	32.84
Ceiling joists, blocking, bracing	BF	473	1.9	4.7	15.14	1.32	5.32
Rafters, Cripples, ridge pole, blocking	BF	624	3.7	15.6	19.97	2.62	17.55
Roof Sheathing	BF	905	4.5	7.2	28.96	3.16	8.14
Exterior Walls: Total:			38.9	71.0	130.98	35.30	91.57
Wall sheathing	BF	1,170	5.3	12.3	37.44	3.68	13.81
Stucco - grounds, building paper	SF	1,045		6.5	8.15		7.37
- lathing	SY	116		11.0[2]	23.91		13.77[2]
- plaster	SY	116	33.6[3]	41.2[4]	61.48	31.62[3]	56.62[4]
Interior Walls & Ceilings: Total:			27.2	71.5	50.23	25.57	92.31
Plaster grounds	BF	170		13.0	5.76		14.62
Lath	SY	272		21.8[2]	18.63		27.20[2]
Plaster	SY	272	27.2[3]	36.7[4]	25.84	25.57[3]	50.49[4]

TABLE A-4: Detailed Cost Estimates for House IV, 1930 cont.

Operation	Material Unit	Material Quantity	Hours Laborer	Hours Skilled	Material Cost ($)	Labor Cost ($) Laborer	Labor Cost ($) Skilled
Windows: (Including trim & hardware) Total:	PC	8		28.0	45.97		31.50
Doors: (including trim & hardware) (including closets) Total:	PC	6		18.7	70.66		21.01
Inside trim: Total:	LF	520	3.9	21.4	22.00	2.73	24.13
Floors: Total:			4.0	11.9	46.29	2.82	13.57
Softwood	SF	574	2.9	9.3[9]	38.57	2.01	10.50[9]
Resilient	SF	60		1.5[5]	4.96		1.72[5]
Tile (kitchen drainboard)	SF	6	1.1[6]	1.1[7]	2.76	0.81[6]	1.35[7]
Roof Cover: Total:				9.7	52.12		10.91
Composition shingles	SF	970		9.7[8]	52.12		10.91[8]
TOTAL			114.8	319.9	591.66	95.08	383.75

See footnotes after Table A-8

TABLE A-9: Detailed Cost Estimates for House I, 1965

Operation	Material Unit	Material Quantity	Hours Laborer	Hours Skilled	Material Cost ($)	Labor Cost ($) Laborer	Labor Cost ($) Skilled
Footings: Total			3.6	10.6	26.40	15.01	57.33
Excavation	CY	6.9		2.0[10]			11.00[10]
Forms			3.6	7.2		15.01	38.88
Reinforcements	LB	240		1.4	26.40		7.45
Concrete Floors: Total:	SF	880	6.6	7.0[1]	187.35	27.65	35.98[1]
Framing: Total:			54.1	295.8	1,810.50	225.51	1,597.76
Beam, mudsill (including bolts), pier blocks	BF	264	0.3	13.7	49.20	1.42	73.93
Floor joists, blocking, bridging (one floor)	BF	2,719	10.9	35.3	271.90	45.37	190.89
Subfloor (one floor)	BF	2,588	3.9	14.2	318.00	16.18	76.84
Studs, sole plates, top plate, blocking, bracing (two floors)	BF	4,140	24.9	124.2	420.00	103.75	670.68
Ceiling joists, ceiling beams, blocking, bracing	BF	1,954	11.7	58.6	195.40	48.87	316.55
Redwood T & G, roof sheathing	SF	1,836	2.4	49.8	556.00	9.92	268.87
Outside Walls: Total:			18.2	55.6	483.95	92.02	307.25
Felt, redwood sawn rustic siding	SF	1,016	3.0	13.4	330.69	12.72	72.36
Stucco - lathing	SY	194		11.7[2]	60.14		67.86[2]
- plastering	SY	194	15.2[3]	30.5[4]	93.12	79.30[3]	167.03[4]
Inside Walls & Ceilings: Total:				91.0	734.25		491.07
Insulation	SF	666		6.7	39.29		35.96
Sheetrock	SF	6,482		57.7	337.96		311.47
Cherry plywood siding	SF	700		26.6	357.00		143.64

TABLE A-5: Detailed Cost Estimates for House I, 1965 cont.

Operation	Material Unit	Material Quantity	Hours Laborer	Hours Skilled	Material Cost ($)	Labor Cost ($) Laborer	Labor Cost ($) Skilled
Windows: (including solid glass) Total:	PC	18		43.9	542.34		237.06
Doors: (including trim) Total:				23.7	460.28		127.98
Exterior and interior	PC	12		12.0	266.97		64.80
Wardrobe	PC	5		8.7	133.50		46.98
Garage	PC	1		3.0	59.81		16.20
Inside trim: Total:				33.8	94.51		182.91
Baseboard, picture mold	LF	774		23.2	69.66		125.40
Window trim	LF	355		10.6	24.85		57.51
Floors: Total:				97.7	510.98		537.86
Resilient	SF	583		11.9[5]	251.28		61.78[5]
Hardwood	SF	1,330		85.8[9]	259.70		476.08[9]
Roof Cover: Total:				11.9	130.88		59.58
Tarn and Gravel	SF	1,636		11.9[11]	130.88		59.58[11]
Cabinets: Total				8.0	740.00		43.20
Kitchen, vanity, wardrobe drawer units, linen	LF	74		8.0	740.00		43.20
Stairs: Total:	BF	173		8.0	70.94		43.20
TOTAL			82.5	687.0	5,792.38	360.19	3,721.18

See footnotes after Table A-6

TABLE A-6: Detailed Cost Estimates for House II, 1965

Operation	Material: Unit	Material: Quantity	Hours: Laborer	Hours: Skilled	Material Cost ($)	Labor Cost ($): Laborer	Labor Cost ($): Skilled
Footings: Total:			9.8	23.5	35.97	40.87	126.99
Excavation	CY	7.7		2.0[10]			11.00[10]
Forms	LF	490	9.8	19.6		40.87	105.84
Reinforcement	LB	327		1.9	35.97		10.15
Framing: Total:			85.7	293.9	2,190.54	357.54	1,589.61
Beam, mudsill (including bolts), pier blocks	BF	328	0.3	18.1	77.23	1.42	97.59
Floor joists, blocking, briding (2 floors)	BF	4,994	20.0	64.9	499.40	83.32	352.62
Subfloor (2 floors)	SF	2,638	7.9	23.7	527.52	33.03	128.19
Studs, sole plate, top plate, headers, blocking, bracing, (2 floors)	BF	5,340	32.0	106.8	545.34	133.56	576.72
Ceiling joists	BF	1,446	6.5	20.2	144.60	27.15	109.30
Rafters, ridge board, ribbons, bracing, blocking	BF	1,293	7.8	32.3	129.30	32.36	174.53
Roof sheathing, plancher board	SF	2,790	11.2	27.9	267.15	46.70	150.66
Outside Walls: Total:			16.6	94.7	948.58	82.82	517.70
Stucco - lathing	SY	168		10.1[2]	52.08		58.75[2]
- plastering	SY	168	13.2[3]	26.4[4]	80.64	68.64[3]	144.62[4]
Redwood siding, felt, blocking	SF	2,087	1.7	49.2	778.43	7.26	265.95
Drip Molding	LF	160					
Box eves	SF	416	1.7	9.0	37.43	6.92	48.38
Inside Walls & Ceilings: Total:				51.7	317.69		279.40
Sheetrock	SF	4,648		43.5	244.25		235.17
Birch Siding	SF	216		8.2	73.44		44.23

TABLE A-6: Detailed Cost Estimates for House II, 1965 cont.

Operation	Material Unit	Material Quantity	Hours Laborer	Hours Skilled	Material Cost ($)	Labor Cost ($) Laborer	Labor Cost ($) Skilled
Windows: Total:	PC	14		7.5	280.70		40.50
Doors: (including trim) Total:				16.1	267.66		86.94
Exterior and interior	PC	10		10.0	157.94		54.00
Wardrobe	PC	5		6.1	109.72		32.94
Inside trim: Total:				14.5	33.95		78.57
Baseboard	LF	285		8.5	19.95		46.17
window trim	LF	200		6.0	14.00		32.40
Floors: Total				67.5	368.72		370.25
Resilient	SF	1,134		13.3[5]	183.66		69.16[5]
Hardwood	SF	974		54.2[9]	185.06		301.09[9]
Roof Cover: Total:				32.4	446.67		174.29
Wood shakes	SF	2,395		28.3[8]	446.67		156.84[8]
Prestocking	SF	2,395		4.1[12]			17.45[12]
Cabinets: Total:				6.0	570.00		32.40
Wall, base, counter top, drawer units	LF	27		6.0	570.00		32.40
Stairs: Total	BF	428		18.0	119.24		97.20
TOTAL			112.1	625.8	5,579.72	481.23	3,393.85

See footnotes after Table A-8

TABLE A-7: Detailed Cost Estimates for House III, 1965

Operation	Material Unit	Material Quantity	Hours Laborer	Hours Skilled	Material Cost ($)	Labor Cost ($) Laborer	Labor Cost ($) Skilled
Footings: Total:			5.9	27.1	43.01	24.44	146.54
Excavation	CY	7.6		2.0[10]			11.00[10]
Forms	LF	586	5.9	23.4		24.44	126.58
Reinforcement	LB	391		1.7	43.01		8.96
Concrete Floor: Total	SF	469	3.3	3.7[1]	92.44	13.68	19.16[1]
Framing: Total:			10.5	136.7	1,302.09	43.78	739.09
Mudsill (including bolts), pier blocks & posts	BF	390	0.4	4.8	70.98	1.50	25.81
Girders, rim joist	BF	1,005	1.0	10.0	108.72	4.17	54.27
Subfloor (T & G)	SF	1,679		13.4	306.25		72.52
Studs, sole plate, top plate, headers, blocking, bracing	BF	4,568	9.1	50.2	439.49	38.11	271.35
Ceiling joists	BF	1,259		15.5	115.83		83.97
Rafters, ridge boards, purlins, bracing	BF	1,341		16.6	123.37		89.42
Roof sheathing (spaced)	BF	1,494		26.2	137.45		141.75
Outside Walls: Total:			16.9	50.1	230.40	87.78	279.85
Stucco - lathing	SY	288		16.4[2]	89.28		95.06[2]
- plastering	SY	288	16.9[3]	33.7[4]	141.12	87.78[3]	184.79[4]
Inside Walls & Ceilings: Total:				46.3	293.29		250.29
Insulation	SF	1,324		11.2	64.54		60.75
Sheetrock	SF	4,473		35.1	228.75		189.54

TABLE A-7: Detailed Cost Estimates for House III, 1965 cont.

Operation	Materials		Hours		Material Cost ($)	Labor Cost ($)	
	Unit	Quantity	Laborer	Skilled		Laborer	Skilled
Windows: Total:	PC	13		3.2	315.78		17.55
Doors: (including trim) Total:			1.9	12.5	488.30	7.92	67.50
Exterior, interior, sliding, bifold, pocket	PC	16	1.6	8.0	370.50	6.67	43.20
Wardrobe	PC	3	0.3	1.5	57.99	1.25	8.10
Garage	PC	1		3.0	59.81		16.20
Inside trim: Total:				14.7	45.40		79.38
Baseboard	LF	360		9.0	21.60		48.60
Window trim	LF	230		5.7	13.80		30.78
Floors: Total				73.6	700.85		402.97
Resilient	SF	348		6.9[5]	107.25		36.09[5]
Carpeting	SF	772		8.6	361.20		44.72
Hardwood	SF	859		47.8[9]	158.24		265.51[9]
Slate	SF	82		10.3[7]	74.16		56.65[7]
Roof Cover: Total:				35.1	485.65		189.86
Wood Shakes	SF	2,604		30.7[8]	485.65		170.55[8]
Prestocking	SF	2,604		4.4[12]			19.31[12]
Cabinets: Total:				4.0	704.50		21.60
Kitchen, bathroom, vanities, shelves	LF	50		4.0	704.50		21.60
TOTAL			38.5	407.0	4,701.71	177.60	2,213.79

See footnotes after Table A-8

TABLE A-8: Detailed Cost Estimates for House IV, 1965

Position	Material Unit	Material Quantity	Hours Laborer	Hours Skilled	Material Cost ($)	Labor Cost ($) Laborer	Labor Cost ($) Skilled
Footings: Total:			3.9	18.7	28.71	16.30	101.45
Excavation	CY	6.1		2.0[10]			11.00[10]
Forms	LF	391	3.9	15.6		16.30	84.46
Reinforcement	LB	261		1.1	28.71		5.99
Concrete floors: Total:	SF	396	2.8	3.2[1]	78.05	11.55	16.20[1]
Framing: Total:			7.3	91.1	980.40	30.19	491.98
Mudsill (including bolts), pier blocks, posts	BF	258	0.3	3.4	47.10	1.08	18.58
Rim joists, girders	BF	676	0.7	6.8	61.61	2.84	36.50
Subfloor	SF	1,138		9.1	197.81		49.14
Studs, sole plate, top plate, headers, blocking, bracing	BF	3,148	6.3	34.6	293.65	26.27	187.00
Ceiling joists	BF	933		8.9	85.03		47.84
Rafters, ridge boards, ties, perlins, braces	BF	1,096		10.4	99.89		56.21
Roof sheathing	SF	2,132		17.9	195.31		96.71
Outside Walls: Total:			8.3	24.7	113.60	43.26	137.99
Stucco - lathing	SY	142		8.1[2]	44.02		46.86[2]
- plastering	SY	142	8.3[3]	16.6[4]	69.58	43.26[3]	91.13[4]
Inside Walls & Ceilings: Total:				37.4	227.40		201.80
Insulation	SF	823		7.0	33.54		37.80
Sheetrock	SF	3,835		30.4	193.86		164.00

TABLE A-8: Detailed Cost Estimates for House IV, 1965 cont.

Position	Material Unit	Material Quantity	Hours Laborer	Hours Skilled	Material Cost ($)	Labor Cost ($) Laborer	Labor Cost ($) Skilled
Windows: Total:	PC	7		1.7	112.95		9.45
Doors: (including trim) Total:			1.4	10.0	286.31	5.84	54.00
Exterior, glass sliding interior	PC	8	.8	4.0	150.47	3.34	21.60
Wardrobe closet	PC	6	.6	3.0	83.65	2.50	16.20
Garage	PC	1		3.0	52.19		16.20
Inside trim: Total:				9.8	23.64		53.19
Base molding	LF	280		7.0	16.80		37.80
Window trim	LF	114		2.8	6.84		15.39
Floors: Total:				49.1	173.85		271.05
Resilient	SF	169		3.4[5]	33.63		17.58[5]
Hardwood	SF	820		45.7[9]	140.22		253.47[9]
Roof cover: Total:				15.4	170.56		81.90
Composition shingles	SF	2,132		12.6[8]	170.56		69.82[8]
Prestocking	SF	2,132		2.8[12]			12.08[12]
Cabinets: Total:				4.0	458.50		21.60
Kitchen, bathroom vanities	LF	49		4.0	458.50		21.60
TOTAL			23.7	265.1	2,653.97	107.14	1,440.61

See footnotes after Table A-8

Footnotes to tables in Appendix A.

Hours and dollar costs in the laborer column without a footnote reference refer to Building Laborer; in the skilled column, they refer to Carpenter.

[1]Cement finisher

[2]Lather

[3]Hod carrier

[4]Plasterer

[5]Linoleum layer (1930); Carpet-linoleum layer (1965)

[6]Tile helper

[7]Tile setter

[8]Shingler

[9]Hardwood floorlayer

[10]Excavation machine operator

[11]Roofer

[12]Teamster

APPENDIX B

Data Obtained from Building Permit Survey

in

Alameda County, California

TABLE B-1

Number of Builders by Size-Class of Permits Filed,
Alameda County, California,
1940, 1950, 1955, and 1960

Size-class of permits filed	Number of builders						
	1940	1950		1955		1960	
	50 per cent sample	50 per cent sample	100 per cent sample	50 per cent sample	100 per cent sample	50 per cent sample	100 per cent sample
1-5	359	580	10	579	49	173	24
6-19	29	14	9	28	32	3	22
20-49	5	0	4	1	32	0	22
50-99	0	0	4	1	19	0	8
100-199	0	0	6	0	12	0	6
200-299	0	0	1	0	0	0	5
300-499	0	0	2	0	1	0	0
500 or more	0	0	1	0	1	0	0
Permits on which builders name excluded	297	15	0	19	0	0	0

Source: Building permit records, issuing offices, Alameda County.

Note: The 50 per cent sample is for builders filing one permit. The 100 per cent sample is for builders filing two or more permits. See Table 1, p. 19, for comparable 1930 and 1965 data.

TABLE B-2

Number of Houses by Size-Class of Builders, Alameda County, California, for the 100 Per Cent Sample, 1950, 1955, and 1960

Size-class of builder	Number of houses		
	1950	1955	1960
1 - 5	26	92	72
6 - 19	99	266	231
20 - 49	170	851	722
50 - 99	248	1,452	580
100 - 149	244	1,066	549
150 - 199	706	680	345
200 - 299	221	0	1,255
300 - 399	711	330	0
400 - 499	0	0	0
500 - 599	0	0	0
600 - 699	702	842	0
Total	3,127	5,579	3,754

Source: Building permits, issuing offices, Alameda County.

Note: See Table 1, p. 19, for comparable 1965 data.

TABLE B-3.1

Distribution of Single-Family Dwellings
by Building Permit Value,
Alameda County, California,
1930 and 1940

Building permit value ($)	Number of dwellings	
	1930	1940
Less than 2,000	40	16
2,000 - 3,999	320	1,122
4,000 - 5,999	288	1,088
6,000 - 7,999	96	168
8,000 - 9,999	46	54
10,000 - 11,999	16	22
12,000 - 13,999	4	16
14,000 - 15,999	6	4
16,000 - 17,999	4	6
18,000 - 19,999	4	2
20,000 - 21,999	4	0
22,000 - 23,999	0	2
Total	828	2,500

Source: Building permit records, issuing offices, Alameda County.

Note: From 50 per cent sample. Sample number doubled to get total population.

TABLE B-3.2

Distribution of Single-Family Dwellings by Building Permit Value, Alameda County, California, 1950, 1955, 1960, and 1965

Building permit value ($)	Number of dwellings							
	1950		1955		1960		1965	
	50 per cent sample	100 per cent sample	50 per cent sample	100 per cent sample	50 per cent sample	100 per cent sample	50 per cent sample	100 per cent sample
Less than 6,000	279	139	102	40	12	3	10	3
6,000 - 7,999	494	2,640	200	2,660	68	71	8	5
8,000 - 9,999	378	305	308	2,549	94	565	18	118
10,000 - 11,999	294	43	240	243	134	1,634	28	373
12,000 - 13,999	170	0	270	65	200	894	46	777
14,000 - 15,999	112	0	176	19	166	349	58	696
16,000 - 17,999	36	0	100	1	188	154	98	629
18,000 - 19,999	56	0	80	0	100	34	112	432
20,000 - 21,999	30	0	42	1	88	26	88	397
22,000 - 23,999	16	0	28	1	44	9	86	78
24,000 - 25,999	23	0	11	0	52	15	122	44
26,000 - 27,999	4	0	6	0	30	0	60	11*
28,000 - 29,999	8	0	6	0	6	0	66	--
30,000 - 31,999	10	0	16	0	12	0	64	--
32,000 - 33,999	6	0	8	0	12	0	46	--
34,000 or more	10	0	48	0	28	0	94	--
Total	1,926	3,127	1,641	5,579	1,234	3,754	1,004	3,563

Source: Building permit records, issuing offices, Alameda County.

*This number is for houses $26,000 or more.

Note: For the 50 per cent sample, the sample number was doubled to get the total population.

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