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RESIDENTIAL CONSTRUCTION AND PUBLIC POLICY: A PROGRESS REPORT

BY

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CENTER FOR REAL ESTATE AND URBAN ECONOMICS
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I. INTRODUCTION

Public concern with housing in the United States has both efficiency and distributional bases. Because housing expenditures are such a large fraction of consumers' budgets, and because poor households have such small budgets, a series of Federal programs to provide "adequate" housing for "poor" households has evolved, beginning with the Public Housing Act of 1937. On narrow efficiency grounds, however, there has also been increasing concern about public policy and its effect upon the production and distribution of housing services. It is alleged that residential construction is a "backward" industry, characterized by a low rate of technical progress and that supply prices for new construction are higher than would be indicated by efficiency in production. Concern is with the effect of existing policies upon the structure of the market and with the design of public policies to foster technical progress, reduced costs, and increased output of housing services.

In any practical context, of course, these distributional and efficiency considerations are hardly separable. Nevertheless, a reading of the reports of two presidential commissions established in response to inadequate living conditions of the urban poor (the Douglas and Kaiser Commissions[1]) indicates widespread dissastisfaction with the economic health of the construction sector as distinct

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[1]See National Commission on Urban Problems (Douglas Commission, 1969) and President's Committee on Urban Housing (Kaiser Committee, 1969).

from the delivery of basic services to the needy. The reports of these commissions, incorporated into the language of the Housing and Urban Development Act of 1968, indicated that the goal of "a decent home and a suitable living environment for every American Family"[2] required two types of public policies: policies to increase the flow of newly constructed, unsubsidized dwellings at affordable prices; as well as subsidy policies to improve the quality of existing dwellings and to increase the housing consumption of the poor.

This paper considers public policy and the efficiency of the residential construction sector. Section II below records basic facts about the industrial structure and relative performance of the housebuilding sector. It summarizes post-war empirical research about changes in productivity and the costs of construction, and describes briefly some of the more important innovations in materials and techniques. It also assesses, largely on the basis of interview data and expert opinion, the magnitude of cost savings attributable to some of these innovations. Section II also notes the relationship between reductions in labor and materials inputs and their effects upon the supply cost of housing services and costs occupancy for housing consumers. Finally, limited and suggestive information is presented about the nature of private research and development activity.

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[2]The goal of a "decent home" was originally espoused by the Housing Act of 1949; similar language appears in the acts of 1954 and 1959.

Section III discusses three aspects of industry structure and its relationship to public policy. This section investigates the cyclical sensitivity of the housebuilding sector, the fragmented nature of the industry and its regulatory environment, and the federal role in supporting research and development and technical innovation.

Conclusions are presented in section IV.

II. SECTORAL PERFORMANCE AND INDUSTRIAL STRUCTURE

A. Productivity Measures

Throughout the 1960s the conventional wisdom held that productivity trends in housebuilding lagged behind other sectors of the economy. Underlying all comparisons of the rate of technical progress in this sector are at least four methodological and measurement problems: 1) appropriate adjustment for quality changes; 2) consistent definitions of inputs; 3) adjustments required by variations in the mix of site and off-site activity; 4) disaggregation of construction activities into the residential and nonresidential sectors. Although analogous methodological problems are inherent in the measurement of technical progress in all sectors of the economy, there are indications that these issues present more difficulties in the analysis of the construction sector (Sims, 1969).

For example, Rosefielde and Mills (1979) have argued that more appropriate adjustments for quality improvements in contract construction would lead to substantially larger productivity estimates for the sector (Presumably, however, a more refined measurement of quality change would lead to higher productivity estimates in other sectors as well).

Nevertheless, a consensus seems to exist that housing was a "backward" sector of the economy through most of this century. For example, by comparing independently derived indexes of building costs and new home prices, Grebler, Blank and Winnick (1956) concluded that productivity in residential construction had remained relatively constant from the turn of the century through the mid-1950s. Applying a similar methodology to nonresidential contract construction led the authors to conclude that "productivity has increase significantly in heavy construction, but more less so in residential building" (Grebler, Blank and Winnick, 1956, p. 357). Denison's (1962) analysis of economic growth found an absolute decline in input productivity in the construction sector during the 1930-1960 period. Dacy's analysis of price trends and productivity during the 1947-1960 period similarly concludes "[contract] construction productivity lagged considerably behind the average for the economy and even behind total services" (Dacy, 1965, p. 406). Kendrick's exhaustive study of postwar productivity trends (1973) provides estimates of total factor productivity during the period 1948-1969. Of thirty-four industry groups considered, the average productivity change in contract construction ranks thirty-first.

Table 1 provides a summary of postwar productivity studies, indicating estimates of average annual productivity growth in construction ranging between a 0.5 percent per year and 2.8 percent, depending upon the methodology employed and the period of analysis. In all comparisons, productivity growth estimates for contract construction are lower than for the rest of the economy.

Raw productivity change measures for the more recent period are presented in the bottom part of table 1. During the fourteen year period 1966-1979, productivity increases in contract construction were smaller than increases observed in the overall economy or in the manufacturing sector in twelve of the years. Productivity changes in contract construction exceeded those elsewhere in the economy in two years. In 8 of the past 14 years, moreover, the raw productivity index (measured as constant dollar output per worker hour) actually declined. The period as a whole indicates a modest decline in productivity in contract construction activity.

B. Input and Output Cost Measures

The available evidence does not permit a refined analysis of productivity in residential construction. The trends reported for contract construction include all residential, commercial and industrial building as well as highway and

Table 1

Postwar Productivity Trends in Construction

A. Estimates of Annual Growth in Productivity in Percent

Author	Time Period	Contract Construction	Residential Component	Manufacturing	Private Domestic Economy
Sims	1947-1966	2.3			
Gordon:	1948-1965	1.4-2.8		3.4	
Dacy:	1947-1963	3.0			
Domar:	1948-1960	2.0		3.4	2.6
Ball:	1962-1969		1.5*		
UN:	1953-1967	0.5			3.6
Alterman:	1947-1955	2.5			3.6@
Cassinatis:	1947-1967	1.6-2.8			
	1952-1965	1.5#			
CEA:	1947-1966	1.9			2.8
Clague:	1948-1953	2.7			
Haber:	postwar	1.5			
Kendrick:	1948-1966	1.5#		2.5#	2.5#
	1948-1953	3.6#		2.9#	2.8#
	1953-1957	2.8#		1.5#	1.9#
	1957-1960	1.1#		2.0#	2.3#
	1960-1966	-1.0#		3.2#	2.9#

B. Average Annual Change in Productivity 1966-1979.

Author	Time Period	Contract Construction	Manufacturing	Private Domestic Economy**
Chase:	1966	-3.5	2.2	0.4
	1967	11.0	4.8	3.8
	1968	-7.1	3.2	1.2
	1969	-9.8	-0.3	-1.6
	1970	7.3	0.0	3.3
	1971	4.0	5.1	2.8
	1972	2.8	4.2	4.5
	1973	-16.2	1.1	-2.7
	1974	-4.5	-2.5	-2.2
	1975	9.3	5.6	5.6
	1976	1.0	3.4	2.4
	1977	-0.2	0.4	-0.3
	1978	-7.0	3.1	-0.1
	1979	-5.5	1.3	-1.5

TABLE 1 (continued)

Notes:
* Single family housing
**Private non-farm sector
Total factor productivity
@ Total private economy

Sources: Evsey Domar, et al., "Economic Growth and Production in the United States, Canada, United Kingdom, Germany, and Japan in the Post-war Period," Review of Economics and Statistics, Feb. 1964, p. 36.

Douglas C. Dacy, "Productivity and Price Trends in Construction Since 1947," Review of Economics and Statistics, Nov. 1965, pp. 406-411.

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Robert J. Gordon, "A New View of Real Investment in Structures," Review of Economic Statistics, Nov. 1968, p. 423.

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United Nations, Economic Commission for Europe, Economic Survey of Europe in 1969: Part I, Structural Trends and Prospects in the European Economy (New York, 1976), p. 92.

John W. Kendrick, Postwar Productivity Trends in the United States (NBER,1973), pp. 77-85.
Chase Econometrics, Current Data Bank, September 1980.

Jack Alterman and Eva E. Jacobs, "Estimates of Real Products in the United States 1947-1955," in Input, Output, and Production Measurement (NBER, 1961), pp. 246-249.

Peter J. Cassinatis, The Economics of the Construction Industry, (National Industrial Conference Board, 1969), pp. 76-88.

Council of Economic Advisors, Economic Report of the President: 1968 (USGPO, 1968), pp. 120-124.

Ewan Clague and Leon Greenberg, "Discussion of Employment," Automation and Technological Change, (American Assembly, 1962), p. 120.

William Haber and Harold M. Levinson, Labor Relations and Productivity in the Building Trades,(University of Michigan Press, 1956), p. 203.

Chase Econometrics, Current Data Bank, September 1980.

Julian E. Lange and Daniel Quinn Mills, eds., The Construction Industry, (Lexington Books, 1969), pp. 88-90.

heavy construction. In recent history, the residential component has varied between 30 and 48 percent of the total.[3]

A number of input cost measures for residential construction are available from the postwar period. Table 2 presents a summary of trends in four of these indices. Inferences about the relationship between productivity and variations in these indices depend quite specifically on their definitions.

None of the four indices presented includes land input prices. The Engineering News-Record index (EN-R) combines construction labor and materials input prices in fixed proportions. Since input prices are not adjusted for changes in productivity or technology, this index ignores technological change within the sector. The Boeckh index weighs materials and equipment prices for brick and frame residences by wage rates, adjusted to reflect variable labor efficiency in each of twenty locales. Consequently, some technological efficiency gains are implicit in its values. The Turner index is computed from bid estimates returned to the Turner Construction Company of the cost of standardized projects. Presumably, each firm fully accounts for inputs and labor efficiency changes in its bids, so technological advance should be fully reflected in this cost index. Unfortunately only a few of the standard projects which underlie this index

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[3]See, for example, Federal Reserve Bulletin, Vol. 65, No. 1, January 1979.

Table 2

Average Annual Growth of Construction
Cost Indices: 1947 - 1977

Period	EN-R	DCCI	Boeckh	Turner
1947-52	6.0%	4.6%	2.7%	5.0%
1952-57	4.1	2.0	2.7	3.3
1957-62	2.7	-0.1	0.5	1.1
1962-67	2.9	2.0	2.7	2.7
1967-72	9.2	6.7	6.6	9.0
1972-77	9.9	8.1	9.4	8.1

Source: Computed from U.S. Department of Commerce, Industry and Trade Administration, Construction Review, v. 25, n. 11, December 1979.

are residential in nature. Finally, the Department of Commerce Composite Index (DCCI) incorporates a number of construction cost indices (including the Engineering News-Record, Boeckh and Turner indices). Some of its component indices account for technological change and some do not; thus it reflects, in some part, productivity advances.

A comparison of the Boeckh or the Turner index with the EN-R index implies that actual construction costs in the residential sector rose less throughout the three decades than they would have if technology were stagnant. However, the comparisons from 1967 on suggest a reversal and a decline in residential construction productivity. A comparison of these two indices with the DCCI (which implicitly accounts for some technical change) supports the same inference.

A comparison of output prices is presented in table 3 for the same period. The wholesale price index (WPI) for industrial commodites reflects general trends in the manufacturing and mineral products sectors of the economy. The consumer price index (CPI) measures price movement among food and beverages, housing, apparel, transportation, medical services, entertainment and other services. Two components of the CPI's housing class also appear in table 3. The rent/residential component (CPI-R) incorporates price trends both for apartment rent and for imputed rent of homeowners

Table 3

Average Annual Growth of Various Output
Price Indices: 1947 - 1977

Period	WPI	CPI	CPI-R	CPI-H	NRS	BOC
1947-52	3.5%	3.5%	4.5%	na	4.5%	na
1952-57	2.1	1.2	2.8	2.2%[a]	1.3	na
1957-62	0.3	1.4	1.5	1.5	0.2	na
1962-67	1.1	2.0	1.2	2.6	1.5	1.9%[b]
1967-72	3.4	4.6	3.6	7.0	5.6	5.7
1972-77	10.6	7.7	5.2	7.9	9.9	9.6

a. 1953-57.
b. 1963-67.

Source: WPI, CPI, CPI-R and CPI-H are from U.S. President, Economic Report of the President, 1978, (G.P.O.); NRS is from U.S. Department of Commerce, Bureau of Economic Analysis. The National Income and Product Accounts of the U.S., 1929-74; Statistical Tables, (G.P.O., 1977), and Survey of Current Business, v. 57, n. 7, July 1977 and v. 58, n. 7, July 1978; BOC is from U.S. Department of Commerce, Industry and Trade Administration, Construction Review, v. 25, n. 11, December 1979.

(based on sales prices of new and existing homes). The homeownership portion of the CPI's housing class (CPI-H), introduced in 1953, combines a home purchase element with various operating and maintenance cost elements. Also presented is the implicit price deflator for purchases of new residential structures (NRS) computed by the Commerce Department and the recent Bureau of the Census price index for new single-family homes, exclusive of lot value (BOC). Presumably the latter index is the best indicator of output price trends.

A comparison of the NRS and the WPI or the CPI may suggest that homebuilding efficiency equalled or surpassed economy wide performance until about 1967. Since 1967, however, the relative price increases of new residential structures (NRS) or new single family homes (BOC) have exceeded economy wide price increases. Inferences based upon CPI-R or CPI-H are more ambiguous, since they include transactions on used homes and include the land component. Any such comparison of output prices assumes that demand fluctuations do not change the relative prices of goods; the comparison does, however, measure the entire economy's efficiency in producing housing--increases in productivity in input suppliers as well as builders.

Recent work by Ferguson and Wheaton (1979), who analyzed the raw data underlying the BOC index, presents disaggregated trends in output prices for newly constructed dwellings in four components: changes in the unit price of land; changes in the quantity of land; changes in the characteristics of housing structures; and changes in the price of a "standardized" structure. A comparison of the latter two components indicates that improved quality accounted for almost one fourth of the observed increase in the costs of residential structures during the period 1972-1978.

On balance, the productivity and price evidence suggests a pattern of modest improvements in productivity in residential construction from 1947 through the mid-1960s, although construction seems to have lagged behind manufacturing activity. During the more recent period, the evidence suggests little or no improvement in productivity and a more substantial decline relative to other sectors of the economy.

C. <u>The Costs of Housing Services</u>

A comparison of costs and productivity in the construction of residential structures may give a misleading picture of the importance of technical change and improved technique in the costs of supplying housing services to consumers. Table 4 presents "typical" distributions of the total costs of providing newly constructed housing services as reported to the Kaiser Commission. As of 1968, only about 55 percent of the costs of new construction of single family homes consisted of labor and materials costs. For multifamily units, about 60 percent of the cost of producing housing services is attributable to purchased inputs and labor.

Table 4

Distribution of Costs of Housing Service Provision
for "Typical" Developments in 1968

	Single family detached house	Apartment in multifamily medium-rise building
Development Costs	31%	25%
Land	10	9
Development	15	4
Miscellaneous	6	12*
Construction Costs	69	75
Materials	37	38
On-site wages	18	22
Overhead/profit	14	15
Total	100%	100%

*including architects' fees

Source: McGraw Hill Co., "A Study of Comparative Time and Cost for Building Five Selective Types of Low Cost Housing," The Report of the President's Committee on Urban Housing: Technical Studies, Vol. II, (USGPO, 1968), p. 9.

Development costs, including land, consist of 25-30 percent of the costs of production.

Table 5 presents a "typical" distribution of the costs of consuming housing services as of 1968. The occupancy cost comparison (at 6 percent mortgage interest rates) appears quaint from the perspective of the 1980s. It reveals quite starkly, however, the importance of debt retirement in the monthly cost of consuming housing services. Even at the typical mortgage rates of the 1960s, carrying charges represented 40-50 percent of occupancy costs. A comparison of tables 4 and 5 reveals that a given reduction in the cost of materials and labor would reduce the total costs of producing housing services by only about half as much. This would presumably be reflected in occupancy costs by reductions in the face value of mortgages. As any recent purchaser of housing knows, however, even large reductions in the face values of mortgages are easily offset by small changes in carrying costs.

Table 6 illustrates the relationship between innovations which reduce the costs of labor and materials in housing construction and the interest rates. For a hypothetical $100,000 home financed with a conventional 30 year mortgage, it indicates the productivity increase in construction which is offset by a 1 percent increase in the interest rate. Labor and materials are only a fraction of construction costs (and face values of mortgages), and level payments on conventional fixed term mortgages are sensitive to interest rates. Thus, it would require quite substantial

Table 5

Distribution of Occupancy Costs of Housing Services
for "Typical" Developments in 1968

	Single family detached house	Apartment in multifamily medium-rise building
Debt retirement	53%*	42%**
Taxes	26	14
Utilities	16	9
Maintenance and repair	5	6
Administrative and similar costs		13
Vacancies and bad debts		9
Profit and reserves	___	7
Total	100%	100%

*based on a 94.5% 30-year mortgage at 6% interest.

**based on an 85% 35-year loan at 6% interest

Source: McGraw Hill Co., "A Study of Comparative Time and Cost for Building Five Selective Types of Low Cost Housing," The Report of the President's Committee on Urban Housing: Technical Studies, Vol. II, (USGPO, 1968), pp. 8-12.

Table 6

Relationship Between Productivity Gains in Construction and Occupancy Costs for Consumers:

productivity increase in percent required to offset a one percent increase in interest rates*

interest rate	labor and materials as a fraction of construction costs				
	40%	50%	60%	70%	100%
8%	23.8%	19.0%	15.8%	13.6%	9.5%
9%	22.5%	18.0%	15.0%	12.9%	9.0%
10%	21.3%	17.0%	14.2%	12.1%	8.5%
11%	20.0%	16.0%	13.3%	11.4%	8.0%

*assuming a $100,000 house financed by a 30 year, level payment mortgage efficiency gains in construction to offset the additional occupancy costs associated with modest increases in interest rates.

Tables 4 and 5 are also suggestive of the importance of exogenous factors in the production and occupancy costs for housing services. Increased land rentals or site values observed during the past decade increase production costs, even if there are substitution possibilities between capital and land in production. A decade of increases in property taxes make occupancy costs larger, even if more services are provided in the bargain.

It appears that variations in the total costs of supplying housing services are less sensitive to technological changes in the production process per se than in many sectors of the economy. The costs of consuming these services are also less sensitive to cost reductions in labor and materials.

D. The Structure of the Housebuilding Industry

The residential construction industry is characterized by a relatively small scale of production as measured by gross receipts or by numbers of units completed annually. Table 7 reports the size distribution of multifamily and single-family builders as of 1972. For single-family builders, less than a third of the firms reported gross receipts of one million dollars or more, or a volume of more than about 100 units; almost forty percent of the firms reported volumes of fewer than about twenty units per year.

Table 7

Distribution of Gross Receipts by Size of Builder, 1972

Total receipts (000)	Estimated number of units	Single family builders	Multifamily builders
$0-50	0-5	8.9%	1.8%
50-99	5-10	14.6	4.1
100-249	10-20	14.8	5.6
250-499	20-40	14.7	9.0
500-999	40-100	15.6	15.3
1000-2499	100-200	8.4	15.6
2500 +	200 +	23.1	48.7
		100%	100%

Source: U.S. Bureau of the Census, 1972 Census of Construction, Washington, D.C., USGPO, 1974, p. 206.

In the multifamily sector, slightly less than half the firms produced an annual volume greater than 200 units and an eighth of the firms produced fewer than about 20 units in multifamily dwellings. The annual volume of the typical builder of either single family or multifamily dwellings is quite low.

Even this description overstates the numerical concentration of builders by volume, since it only includes firms with payrolls. It is reported that, in 1967, about a third of the 110,000 home-building firms in current operation did not have a regular payroll (Baer, et al., 1976, p. L-13).

Information on trends in firm size is somewhat more elusive. Table 8 presents trends on the size distribution of single family builders based on membership in the National Association of Home Builders (NAHB). Inferences drawn from this table are tenuous, since NAHB has about a one third annual turnover in its membership, both very small and very large builders are likely to be underrepresented, and the distribution of units by scale of production may vary over the business cycle. In any case, the raw data indicate a decline in the scale of the building industry during the decade of the 1960s.

Trends since 1969 reveal an apparent increase in the size and scale of homebuilders. For example, it is reported

Table 8

Size Distribution of NAHB Builders

Units constructed	Percent of single family builders 1959	1964	1969	Percent of total units constructed 1959	1964	1969
1-25	57.5	64.4	69.5	10.2	15.8	21.5
26-100	29.8	27.6	24.3	25.7	32.7	36.0
101-250	8.1	5.5	4.6	21.8	22.2	23.6
250+	4.6	2.5	1.6	42.3	29.4	19.0

Source: National Association of Home Builders, A Profile of the Builder and His Industry, Washington, D.C., 1970, p. 108.

that the number of firms with greater than $10 million in annual sale increased from 119 in 1968 to 369 in 1972 (figures are unadjusted for inflation).[4] The Bluebook of Major Homebuilders (1973) reports that the market share of builders with annual volumes in excess of 200 units rose from 17.2 percent of total units to 28 percent between 1969 and 1972.

Table 9 presents the latest information on the size distribution of housebuilders. As measured by the number of establishments, firms with less than 20 employees comprised almost 98 percent of "General Contractors-Single Family Homes," 87 percent of "General Contractors-Residential Buildings," and 94 percent of "operative builders." In terms of gross receipts in the industry, however, such firms comprised 78 percent, 31 percent, and 50 percent of the three industries.

The bottom part of the table indicates that firms with gross receipts in excess of a half a million dollars account for almost half of total receipts among single family general contractors. Such firms account for almost 85 percent of receipts among operative builders.

Beyond the increasing share of the market accruing to larger firms, there is some evidence of increasing merger activity among the larger firms, at least through the mid-1970s. Merger and

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[4] The Professional Builder as cited in: U.S. Department of Housing and Urban Development, Housing in the Seventies, October 1973, pp. 7-20.

Table 9

Size Distribution of Residential Construction Firms
in 1977 (SIC 1521, SIC 1522, SIC 1531, 1977)

	total	number of employees							
		1-4	5-9	10-19	20-49	50-99	100-249	250-499	500+
		a. percent of establishments							
SIC 1521	100,993	72.0%	19.1%	6.6%	1.8%	0.2%	0.1%	0.0%	0.0%
SIC 1522	4,775	52.8	20.6	13.4	9.3	2.3	1.1	0.5	0.0
SIC 1531	23,477	64.1	20.7	9.5	4.0	1.1	0.4	0.2	0.0
		b. percent of total receipts							
SIC 1521	$21.9B	33.3	25.7	19.2	12.3	4.6	2.3	0.9	1.4
SIC 1522	$ 4.5B	8.0	10.2	13.1	24.4	14.4	16.9	13.1	
SIC 1531	$22.9B	20.0	15.1	15.1	17.6	11.3	8.6	8.6	3.7
		gross receipts (in thousands)							
		0-24	25-49	50-99	100-249	250-499	500-999	1000-2499	2500+
		a. percent of establishments							
SIC 1521	100,993	14.7	15.1	21.6	27.4	12.5	5.8	2.3	0.6
SIC 1522	4,775	7.0	8.7	13.6	23.0	14.5	11.4	9.7	7.6
SIC 1531	23,477	4.7	5.6	11.7	23.4	19.9	16.4	11.9	5.7
		b. percent of total receipts							
SIC 1521	$21.9B	0.9	2.6	7.2	19.9	19.8	18.1	15.5	16.0
SIC 1522	$ 4.5B	0.1	0.3	1.1	3.9	5.4	8.4	15.8	65.0
SIC 1531	$22.9B	0.0	0.2	0.9	4.1	7.2	11.9	18.7	56.9

Source: U.S. Department of Commerce, Bureau of the Census, 1977 Census of Construction Industries: Industry Studies, SIC 1521, SIC 1522, SIC 1531, CC 77-1-1, 2, 3, US GPO, 1980.

Note: SIC 1521: General Contractors: Single Family Houses
SIC 1522: General Contractors: Residential Building
SIC 1531: Operative Builders

acquisition activity among the largest publicly held homebuilders has provided product line diversification, geographic expansion, and in one fourth of all cases, some vertical integration.[5]

The rapid and sustained growth of U.S. Home, the largest American housebuilding firm since 1972, has been through merger and acquisition. Between 1969 and 1972, U.S. Home acquired 18 companies, increasing sales from $3.7M to $205M in less than three years.[6] U.S. Home merged with Homecraft in 1977, and in 1978 issued $15M in mortgage backed securities through a wholly owned subsidiary.[7]

Despite any trends towards increased scale, however, the economic concentration of the housebuilding industry is quite low. The 25 firm concentration ratio in the industry is six tenths of one percent.

There is little recent evidence on the relation between scale of production and the costs of production. Maisel's (1953) analysis compares production costs of builders in three size classes. He estimates that production costs, including profit and overhead, for the typical single family dwelling are 2.6 percent lower for firms producing 25-99 units than for smaller builders, and are 7.9 percent lower for firms producing more than 100

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[5]U.S. Department of Housing and Urban Development, October 1973, pp. 7-15.

[6]"U.S. Homes Management Revolution," Fortune, Vol. 98, No. 7-13, December 4, 1978, pp. 68-78.

[7]These mortgages are currently rated AAA by Standard and Poors.

units. More recent evidence by Cassinatis (1969) suggests that for those firms producing 200 or more units, labor and materials costs for a typical dwelling are about 12 percent lower than the costs of firms producing fewer than 50 units. C. Cook concludes on the basis of this evidence that significant economies of scale do exist. The magnitude of the relationship between scale of production and the occupancy costs for housing services does not seem to be terribly large, however. Popular descriptions of the homebuilders suggest that there may be significant scale economies arising from production scheduling, improved x-efficiency, and vertical integration, at least among the industry giants. For example, Fortune reports the increased stability in annual production made possible by high capitalization among the giants (e.g., Centex, Ryan Homes, and Kaufman and Broad), by mortgage backed securities, and by increasing "professionalization" of management.[8]

One difference in production techniques by firms at the largest annual volumes is their reliance on prefabricated parts, or the output of the home manufactures industry. For example, the Department of Housing and Urban Development's analysis of 511 major homebuilders revealed that the 25 largest builders used "major" prefabricated parts in 52.3 percent of units completed. For other builders, the

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[8]See: "U.S. Homes Management Revolution," Fortune, December 4, 1978, pp. 68-78; and "Defying those Interest Rates," Fortune, November 3, 1980, pp. 6-9.

proportion of units with "major" premanufactured parts ranged between 27.2 and 35.9 percent.[9]

A comprehensive survey of the home manufacturers industry is reported by Field and Rivkin (1975). They estimate that by 1970, national production of manufactured homes (including significant use of pre-cut, panel, or modular construction) was more than 310,000 units, and included about 21 percent of the market for new units.

For 1978, it was estimated that manufactured housing output was at about the same level, 304,000 units and a somewhat smaller market share (Mahaffey, 1979). Home manufacturers tend to operate at a larger production scale than conventional builders, but even among these firms, about 30 percent produce fewer than 100 units annually (Field and Rivkin, 1975, p. 23).

There are at least four detailed comparisons of the relative costs of housing production using conventional and home manufacturing techniques.

Weiner (1968) considers production costs for a typical single detached house with 1000 square feet of living space. He compares conventional production at a volume of 150-200 units with off-site modular construction at differing scales. According to engineering estimates, excluding land and development costs,

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[9] U.S. Department of Housing and Urban Development, Housing in the Seventies, chapter 7.

off-site modular construction at a scale of 5000 units a year would reduce costs by 15 percent.

Several estimates were prepared for the Douglas Commission for "typical" single family houses (McGraw-Hill, 1968). It was estimated that the off-site production of panel walls reduces costs by less than 4 percent. Off-site construction of sectional and modular components is estimated to reduce costs, again according to engineering assumptions, by as much as 20 percent.

Rowland (1969) compared production costs for low-rise garden apartments. The cost savings attributable to fully modular construction, comparing a production scale of 12 conventional units with 1200 manufactured units, amounts to 9.3-13.7 percent, again excluding land and development costs. Finally, a comparison of high rise construction using pre-cast walls and partitions with similar construction using masonry and dry wall partitions indicates a labor and materials cost saving of 16 percent (Rothenstein, 1969).

The cost savings estimated in these studies arise from two sources, the reduction in the number of worker hours required to complete a given component of the final product and the substitution of cheaper and lower skilled labor. The nature of costs reductions is thus similar to technical progress in other sectors of the economy. However, the magnitude of cost savings depends crucially upon the benchmark for wage comparisons. These estimated cost savings arise from a comparison between the unionized construction sector and the industrialized sector, not between the existing construction sector and other industry. For the construction of single family dwellings, for example, it has been estimated that less than a third of the labor input is unionized (C. Cook, 1976, p. 6-20).

Whether these cost savings are large or small depends upon one's perspective. First, these comparisons are based upon engineering estimates and extrapolations, not upon a comparison of actual production runs. Second, as noted previously, labor and materials inputs into structures account for roughly 40-60 percent of the cost of producing housing services. Third, these comparisons were made more than a decade ago. Field and Rivkin, who are firmly convinced of the potential for cost reduction through home manufacturing, admit: "We must take it on faith that economies will result from industrialization of home building because conclusive evidence of lower costs does not exist. Presumptive evidence from other industries that have undergone industrialization implies that [manufactured] home building will produce substantial savings in cost . . ." (Field and Rivkin, 1975, p. 10).

E. Innovation and Research

Some inconclusiveness in the importance of home manufacturing as an alternative technique to "conventional" home building does not imply that these latter methods have been static.

Industry observers believe the current usage of "major" industrialized housing components in conventional construction is already quite high. When such components as pre-hung doors and pre-assembled windows are included, it has been estimated that about 90 percent of all new dwelling units built by conventional builders include major industrialized housing components compared to an insignificant fraction just after World War II. In addition, it is observed that before World War II, labor comprised 70 percent of on-site construction costs compared with roughly 30 percent today.[10]

Besides the substitution of pre-assembled and manufactured components for on-site techniques, innovation in construction includes new materials, new techniques for assembling materials on site, new tools for implementing given techniques, and perhaps improved management x-efficiency.

Engineering changes in residential construction methods have been relatively minor, in terms of their overall incidence or their contribution to cost reduction.[11] The use of brick for both structural and veneer purposes has increased since

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[10]Both these statistics are cited without attribution in at least two sources: U.S. Department of Housing and Urban Development, October 1973, p. 7-23; and Johnson (1968).

[11]Much of this discussion is based upon Gillis, B.A., "Interview Notes," with Ron J. Morony (HUD), March 11, 1980; Lee Fisher (NAHB), March 13, 1980; John Eberhard (NBS), March 13, 1980; Tom Faison (NBS), March 13-15, 1980; Joan Finich (BRAB), March 12, 1980

World War II as has the proportion of post-and-beam "California-style" construction. Better engineering knowledge about concrete products have allowed single slab (basement-less) homes to appear more frequently in cold Northern climates, where they were previously unknown. Electrical wiring has been moved from baseboard raceways to the interiors of framed walls (largely because better insulation materials have made the practice safe).

These process changes do not appear to have resulted from innovation in construction methods. Wider use of brick has apparently stemmed from a shift in the relative price of brick and wood products. Post-and-beam construction is among the oldest known structural engineering methods; its increased use is attributable to changing tastes--consumer preference for "open" houses--and to the development of double-glazed insulaing glass. The Northward **filtration of** slab-built homes has resulted from better materials, stronger and lighter concrete products, not from construction-method innovation.

Two other postwar innovations in construction methods _per se_ do entail substantial efficiency gains: the use of 2" x 3" rather than 2" x 4" studs and plates in non-load-bearing partitions, and the employment of a 24-inch framing module instead of the traditional 16-inch one. Adoption of a 24-inch module allows a somewhat less than one-third reduction in the number of studs and a corresponding decrease in the labor required for wall framing. The use of 2" x 3" lumber decreases the cost of interior partitions by about twenty-five percent. As with the other changes in building method, these innovations do not represent fundamentally new assembly concepts. Instead, they stem from the fairly recent development of lumber quality grading (supervised by the Commerce Department's American Lumber Standards Committee) and from better engineering knowledge about lumber stress characteristics, which has established that these new practices entail little or no added safety risk (Mayer, 1978). Interestingly, the 24-inch framing module may represent better engineering than the 16-inch module because joists can be placed directly over studs.

Somewhat more important than innovation in construction methods, according to industry sources, have been the improvements in power tools and the greater use of heavy equipment during the past two decades. Circular handsaws, powered mechanical hoists, compressed-air jackhammers and nailguns have all increased the productivity of laborers. Though no estimates of the cost savings attributable to tool improvements have been found, one conjecture is that nailguns alone decrease framing time by about twenty percent. Power handsaws may have generated savings of similar magnitude. Bulldozers, backhoes and other heavy equipment have decreased the time and cost of site preparation and excavation.

It appears that the most important technical changes in residential construction have been innovations in materials and the pre-assembly techniques discussed earlier. When three industry experts were each asked to list the five most important postwar cost saving innovations in construction,[12] only one response (the use of 2" x 3" studs) did not involve new materials or pre-assembly. The other responses were:

> prefabricated roof trusses (3 responses), plastic drain, waste and vent piping (3), other prefabricated components (2, both of the respondents mentioned roof trusses separately first, then cited other components: pre-hung doors and windows, prefabricated stairways and panellized construction), speciality plywood (2), gypsum wall board (2), insulating materials (1), heat pumps (1), molded bathroom facilities (1).

The importance of materials and pre-assembly innovations in technical change is emphasized by other industry experts. Johnson's enumeration of "important innovations" in residential construction during the two decades after World War II includes some 120 items, more than 70 of which are materials improvement or pre-assembly. The most important innovations noted by Johnson [1968] include:

- gypsumboard
- improved plywood and plywood products
- particleboard
- prefinished siding and floor and wall coverings
- light gage steel I-beams and adjustable columns
- plastic piping
- molded plastic bathroom fixtures
- washerless and single-level faucets

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[12] Interviews with Messers Morony, Fisher and Faison.

- improved electric heat pumps
- improved gas, oil and electric furances
- ready mix concrete
- insulating glass
- polyethylene vapor barriers
- improved construction hardware
- acoustical ceiling tile
- indoor-outdoor carpeting

In addition to improvements in wood products--particleboard, plywood, etc.--the introduction of plastics into homebuilding has reduced total costs. The most well-known products are ABS (acrilonitrile-butadiene-styrene) and PVC (polyvinyl-chloride) plastic drain, waste and vent piping. Industry sources suggest that ABS and PVC piping are employed at cost savings of about 25 percent. Polyethylene is widely used as a vapor barrier under slabs. It is estimated that this practice has a 40 percent cost advantage over the former technique, hot-mopped felt (Johnson, 1968). Molded plastics have found increasing use in one- and multi-piece bathroom components, "significantly" reducing costs.

Hard evidence on the cost savings or increased output attributable to these innovations does not exist, and any numerical estimates are merely well-informed opinion.

How well do the details of industry innovation correspond to the aggregate productivity trends of the sector? To the extent that these innovations represent cost savings on small individual tasks and that, in the aggregate, these tasks amount to less than half of the costs of producing housing services, the effect of technological change may be rather small indeed. However, since output quality at this level of detail is quite impossible to standardize, some fraction of the returns to innovation may not be fully reflected in productivity measures at all.

Innovation in housebuilding arises from formal and informal research and development which may be undertaken by housebuilders, suppliers, trade associations and government.

Individual housebuilding firms conduct little in the way of research and development activity. Moreover, it is reported that "there is great reluctance on the part of builders and even housing manufacturers to experiment with new products and techniques, since innovations are perceived to be risky under many market conditions."[13]

The number of research scientists and engineers employed in the construction sector suggests that resources devoted to R & D is quite small. In 1966, the Bureau of Labor Statistics reported 800 scientists and engineers (including those with bachelor's degrees) doing research in the construction sector, about 1.7% of all scientists employed in the sector. In 1970, the figure reported was 1800. The 1974 National Science Foundation survey of scientists and

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[13] US Department of Housing and Urban Development (October 1973), p 7-24.

[14] US Department of Labor (1973).

engineers reported that 409 individuals with doctorates considered themselves working "principally" on housing.[15]

Some measure of the research supported by trade associations (in this case, the National Association of Home Builders, NAHB) is provided by the scale of operation. Willis (1979, p. 244) reports that in 1978 the NAHB research foundation employed a staff of "fewer than 25 people, including secretaries, and that only one quarter of its work is for the general and that only one quarter of its work is for the general benefit of members, and that the other three quarters is proprietary work." Much of its work is testing products of suppliers to provide independent verification of their properties. Presumably the high turnover in NAHB membership contributes to its small scale of research.

It appears, therefore, that a large fraction of the innovation in housebuilding is the result of R & D activity by suppliers or by government. Public sector involvement is discussed in the next section. The fraction of R & D by manufacturers and materials suppliers devoted to housing is not known (and in many cases cannot be allocated). However, in contrast to other potential innovations in homebuilding, it appears that the economic returns to R & D are more easily appropriable by the innovator when they are in the form of identifiable materials and not improved techniques. Willis

[15]National Science Foundation (1976).

reports impressionistic evidence that suppliers' R & D efforts devoted to housing are low. For example, in interviews conducted in 1978, members of the Producers' Council (the trade association of manufacturers of building products) asserted that "very few of the large suppliers devote any of their R & D effort specifically to housebuilding." (Willis, 1979, p. 247). Research facilities of particular supplier associations such as the Brick Institute of America and the American Plywood Association, tend to be small.

Important to the profitability calculus of R & D in building, even by suppliers of new materials who can capture the returns to successful innovation privately, is the profile of market penetration of a successful product. It has been estimated that a potential innovator must be prepared to wait eight to ten years after product development before reaching an appreciable fraction of the market for new dwellings.[16] Presumably, the diffusion rate of new products is sensitive to their relative reduction in production costs. But if most potential innovations are evolutionary and reduce costs for a small component of the building production process, this suggests that the rate of adoption by builders will be low. This can be expected to affect the *ex ante* R & D decisions of suppliers and their level of investment in innovative activity.

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[16] US Department of Housing and Urban Development, (October 1973); see also Falk (1976)

III. PUBLIC POLICY, COSTS, AND EFFICIENCY

A. Cyclical Sensitivity and Organization

The position of the residential construction sector as a large but volatile component of total investment activity has provoked much analysis of the transmission of that volatility and of its impact upon the economy as a whole. Until recently, however, there has been little analysis of the relation between instability in final demand and the micro-behavior of firms. Two recent works have related the cyclical sensitivity of the sector to the organization of competition and the performance of the sector.

A short paper by Manski and Rosen (1968) presents a verbal analysis of the micro-economics of an industry characterized by large random variations in demand. The authors deduce five general propositions based on the general assumption that: those conditions for profit maximization--relating to production technology, output size, market area, and choice of output product itself--which are optimal when demand is stable are different from those that are optimal when demand is unstable.

First, given a choice between a production technology that is efficient within a narrow range of output and is quite inefficient outside that range and a production technology that is "reasonable" over a wide band of output, but best at no output level, there will be a tendency for firms to choose the latter process if demand is unstable.

Second, given a choice between hiring labor on a long term basis and hiring workers by the job, there will be a tendency to choose the latter when demand is unstable. (Presumably if demand is unstable, firms will also be less likely to invest in on the job training for workers, even if it is specific training.)

Third, given a choice between producing, at equivalent cost, a high quality perishable product and a lower quality storable product, the latter choice will be made if demand is unstable.

Fourth, given a production choice between an output which performs a narrow range of functions well and others poorly, and an output which performs a broad range of functions "adequately," the latter choice will be made if demand is unstable as long as net fluctuations can be dampened.

Fifth, given a choice between developing a small market intensively and operating in a less concentrated manner in a larger area, the latter choice will be made if net fluctuations can be reduced.

The basic conclusion of the Manski-Rosen analysis is that demand instability, under these conditions,creates a tradeoff between static economic efficiency and flexibility in response to temporal variation. Flexibility and diversification makes the individual firm more able to mitigate the shocks of random changes in demand.

The model indicates that, when demand is unstable, the average price paid by consumers is higher. Importantly, however, the profits of an individual firm need not be lower in a world of demand instability than in one of perfect stability--since instability raises costs for all firms and the industry demand curve need not be perfectly elastic. Thus, while demand instability may be costly to consumers as a group, it need not be costly to any single producer.

Manski and Rosen discuss this view of cyclicality in demand in the context of six telephone interviews with suppliers to the residential construction industry. They conclude with the remarks: "The contribution of industry studies to an understanding of the behavioral implications of instability is more potential than actual. Studying the detailed structure and operations of specific industries should offer a direct and fruitful approach to the question of instability. Unfortunately, we know of no industry studies which have tried to grapple with the instability question in a major way." (1968, p. 224).

Thus, it is worth noting the international comparison of residential construction and housebuilding recently completed by Mark Willis [1979]. Willis develops a simple model of the firm facing unstable demand which is a direct extension of the Manski-Rosen analysis. Instead of postulating an industry populated by identical firms, however, Willis considers the entry and exit of marginal firms as demand increases and declines. This model predicts, for residential construction, that: the industry will be highly fragmented, with a large number of in-and-out firms; firms will use non-specialized inputs in the construction of new dwellings; construction firms will be unlikely to use production processes with high fixed costs; and that the industry will oppose public programs that would jeopardize current market shares. Willis interprets his results as implying that fewer resources will be devoted to R & D, that the selection of R & D projects will be distorted, and that firms will resist new products and processes of a labor saving variety.

Of more interest than the theoretical refinements of this model, however, is the empirical evidence presented by the author. Willis presents a detailed comparison of aggregate housebuilding characteristics in the United States, England and France, and the results of a series of interviews with builders and suppliers in the three countries.

Because housing starts have been more stable in England than in the United States and have been more stable in France than in England, a detailed international comparison provides some evidence about the link between demand conditions and industry structure. Willis' rich statistical and anecdotal evidence does indicate that firm sizes tend to follow the anticipated pattern, that French firms tend to be more capital intensive than English or U.S. firms, and that productivity trends in construction show that increases in output per worker hour have been significantly larger in France than in England, and somewhat larger in England than in the United States.

Willis also presents sketchy evidence on private R & D activity in the three countries. Although this evidence is far from satisfactory, the author concludes that resources devoted to R & D are relatively lower in the United States.

Willis presents a persuasive argument that these, and other comparisons of performance, are causally related to demand instability. In considering the evidence presented, however, it must be recognized that both the extent of public housing and the relative size of contracts for public housing is larger in France than in England or the United States; moreover the historical pattern of French regional planning activity has facilitated the growth of a few large firms. Finally, for the essential inferences between demand stability and the progressivity of residential construction the analysis has two degrees of freedom.

Historically, Savings and Loan Associations (S & L's) have provided 40 to 60 percent of new home mortgage funds, and maximum interest rates offered by S & L's have been limited by regulation Q. As a result, when market interest rates have exceeded ceiling rates, there have been substantial outflows of funds from S & L deposits to other forms of savings. Indeed, during the period 1965-1980, net flows into savings and loan associations have been strongly and negatively correlated with the "spread" between passbook and regulation Q ceilings.

Thus, in some part, the extreme sensitivity of mortgage lending and new construction to interest rates has been the result of public regulation. It is worth noting, therefore, that this source of cylicality in housebuilding will be removed by the Depository Institutions Deregulation and Monetary Control Act (PL96-221) signed into law on March 31, 1980. Under Title II of the act, regulation Q and other limitations on S & L activity will be phased out over the next six years.[17] Although the impact of interest rates on new construction activity depends more directly on the interest elasticity of demand than on specific regulation, it is forecast (indeed, it is intended by the act) that the reforms of 1980 will increase the flows of deposits into savings and loan associations and will make mortgage lending more stable.

The arguments of Manski, Rosen, and Willis indicate that the indirect effect of these reforms will be to foster productivity gains in residential construction and to stimulate innovative activity.

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[17] These implications of regulatory reform are discussed in "The Depository Institutions Deregulation and Monetary Control Act of 1980," Federal Reserve Bulletin, June 1980, p 444-453.

B. Geographical Fragmentation and Local Regulation

Because transport costs are an important component of materials costs, because the average size of building firms is small, and because (it is often alleged) local tastes vary, the geographic market served by most firms is quite small. Among the giant firms, the geographic coverage is not large. HUD's survey of the 25 largest builders revealed that they operated, on average, in 6 states, while a sample of smaller firms (26th through 100th in sales volume) operated in 3 states.[18] Today, the largest single builder, U.S. Homes, operates in 17 states compared with 10 in 1977.

In any case, the production process is, as a result, affected by a diverse set of public policies, highly localized in nature, with differential impacts across smaller firms and with more complicated effects within the markets served by larger firms.

These local regulations, derived from the police powers of the individual states, and justified in terms of health and safety responsibilities delegated to local authorities, include: zoning controls, growth control and environmental regulations, subdivision regulations, and building code provisions.

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[18] US Department of Housing and Urban Development, (October 1973, p 7-17.

1. Zoning, growth control, environmental and subdivision regulations.[19]

The classic justification for zoning regulation, which allocates particular land uses geographically, is to internalize any spillover effects arising from nuisance land uses. The spatial allocation of land uses achieved by zoning removes or reduces these externalities, increasing land values in the residential sector (and perhaps in non-residential uses as well).

However, since most locally raised revenues are derived from property taxes, the fiscal motive for zoning in suburban jurisdictions may be quite strong. If public services are provided on a basis of rough equality per household, local authorities have an incentive to insure that the marginal dwelling provides more housing services (and hence local property tax revenues) than the average house. Thus, in practice, zoning regulations often specify minimum lot sizes or floor areas for single family housing and regulate or prohibit multifamily dwellings.

The effect of such regulation on housing costs per unit of output depends upon the impact of local ordinances on the cost of land as an input into housing, as well as any additional administrative or holding costs incurred. If

[19]A more detailed treatment of some of these issues appears in Katz and Rosen (1980) and Dowell (1980).

zoning does reduce the allocation of land to residential uses, then raw land costs may be expected to rise.

Theoretical analyses of the effect of zoning upon land allocation and input prices to housing have been undertaken by Burstein [1975], Stull [1974], Hamilton [1976], and Ohls et al. [1974]. Not surprisingly, the impact of zoning upon raw land prices depends upon the amounts of developable land in residential and non-residential sectors, the demand for development in alternative uses, and, most importantly, on the substitutability of demand across civil divisions with differing regulations. To the extent that the metropolitan-wide system of land use regulation does reduce the supply of developable land relative to demand, we may expect prices of land inputs into housing to increase.

Empirical evidence on the effect of zoning regulation on land prices is broadly consistent with the hypothesis of land price escalation. Numerous studies have concluded that zoning ordinances increase the value of otherwise identical dwellings. In many cases, however, this effect of zoning may be attributable to the externality impact of regulation.[20]

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[20]For example, Stull's (1974) analysis of jurisdictions in Boston metropolitan area indicated that house values were higher, ceteris paribus, in jurisdictions limiting or excluding various forms of non-residential activity. Lafferty and French (1978) and Peterson (1974) report similar results; in all cases the methodologies relate the value of single family housing to a collection of housing, neighborhood and (in some cases) public service characteristics--and measure of the zoning attributes of jurisdiction.

These qualitative results of the impact of zoning are by no means unanimous, however. For example, Maser, et. al. (1979) found no evidence that zoning affected the allocation or price of resources in upper New York State.

Of more importance to the supply cost of new housing, however, is the effect of density restrictions on the price of vacant land or new housing. Sternlieb and Sagalyn's [1972] analysis concluded that large lot (low density) zoning increased the unit price of land for new single family housing built in New Jersey suburbs. Gleeson's [1979] analysis of Brooklyn Park, Minnesota estimated that two thirds of the intra-city variation in land prices (about $1500 per acre) was attributable to zoning designation and density restriction. Peterson's [1974] analysis of Northern Virginia suburbs found that density restrictions had a significant and quite large effect upon land prices. Peterson's results are consistent with land price a premium in response to zoning restrictions which varies with accessibility to downtown. At a distance of 10 miles from Washington (Fairfax County, Va.), for example, parcels zoned 1/2, 1, 2, and 10 units per acre were selling for $5,800, $7,900, $13,700, and $32,000 per acre respectively in 1974.

Reliance upon complex environmental and growth management programs has increased substantially in the past decade. For example in 1973, one jurisdiction in the San Francisco-Oakland area had growth control regulations; three years later thirty-one civil divisions had such regulations. (Dowell, 1980). Dowell reports an increase of 1200 percent in the number of communities imposing environmental and/or growth management restrictions in California during the period 1972-1977 (Dowell 1980, p. 113).

Growth control and environmental management pograms include "open space" set asides, growth timing ordinances, urban service areas, permit limitations, building moratoriums, and environmental impact review and compliance procedures. Localities typically justify these controls in terms of the benefits of environmental quality, lower municipal service and capital costs, lower property taxes, and the preservation of community "character."

Ellickson's [1977] analysis of growth management restrictions is similar conceptually, to the analysis of zoning. He concludes that any effective growth management policy is likely to reduce the supply of new construction, to increase the price of vacant land, and to increase values of existing properties. Some empirical evidence is available on the magnitude of price increases. Case studies of San Jose, Santa Rosa and Petaluma, California all conclude that the prices of existing standardized dwelling units have increased with the adoption of such ordinances (Katz and Rosen, 1980). More important for our purposes is the effect of such tools on the supply prices of newly constructed dwellings. The San Jose analysis estimates that during the 1968-76 period the price of one builder's standard unit increased by 121 percent and 43 percent of this increase is attributable to growth control (Katz and Rosen, 1980, p. 26).

Clearly the effect of such restrictions varies with the metropolitan wide level of their imposition and with the level of demand for new units. Thus it is worth nothing that a recent survey of the San Francisco area, where housing demand has been increasing rapidly, indicates that half of the jurisdictions surveyed had imposed some type of absolute moratorium on new construction at some point since 1970 (Gabriel, et al., 1980).

In addition to the effects of such ordinances on land input prices in construction, there may be substantial administrative and carrying costs imposed on developers and builders by such regulation. For example, Frieden [1979] reports that, by 1965, more than half the states imposed some form of environmental impact review for new construction. The environmental impact statement is typically the responsibility of the developer, and is often prepared by consultants engaged by the developer. If the developer has purchased the land and has engaged in planning studies (as Frieden claims is typical), then a lengthy review process imposes overhead and property tax costs as well as the carrying costs for land. Mueller and James [1977] estimate that the costs of report preparation and time delays amount to 4-7 percent of total cost of new units (Dowell, 1980). In Hawaii, comparable figures are $325-450 per unit per month of delay (Rands, et al., 1980). Delay costs for Edmonton were estimated at $700-900 per month.

Subdivision regulations can also increase the unit costs of producing new housing. Subdivision ordinances often require a complex package of off-site investments by developers including streets, paths, lighting, landscaping, and sewers. For the San Francisco metropolitan area, Rands et al., (1980) report a range of development fees of $800 to $5919 for a single detached unit in 1979 and a range of $3948 to $15,301 for a seven unit multifamily dwelling. In the San Francisco area, Gabriel et al. (1980) report that median development fees were $1907 per unit in 1979. Rands et al., (1980) report a median development fee for single family houses of $2800 (or 3.5 percent of median new home prices). The private provision of public open space, bike paths, bus shelters, parking and lighting are often the rule.

Finally there is some evidence on the costs of delays implied by development review procedures. It is estimated that, in Houston, the process adds between $400 and $600 to the cost per dwelling unit (Dowell, 1980).

The net effect of this pattern of local regulation upon efficiency in the production of a standardized unit of residential services depends upon several factors.

First, to the extent that zoning removes or mitigates harmful externalities, increases in land values reflect higher levels of residential services consumed.

Second, to the extent that fiscal zoning is successful, new housing costs per unit of service are increased and resources are redistributed toward owners of pre-existing residential capital.

Third, to the extent that environmental and subdivision regulations increase land and development costs by providing additional amenities in accordance with willingness to pay, output of residential services is increased.

Fourth, to the extent that these regulations add costs beyond those required for health and safety, or beyond those reflected in consumers' evaluations, they increase unit housing costs. It has been frequently alleged that the overall effect of these latter regulations is excessive; indeed one estimate suggests that "unnecessary improvements" increased development costs by almost $900 per unit or about 2.5 percent in Northern New Jersey (Seidel, 1972).

Fifth and last, in residential construction interest costs and carrying charges are enormously important. Thus the real costs imposed by delays in lengthy compliance reviews and increases in the elapsed time of production add to the unit cost of new housing services and are deadweight losses to society.

2. Building codes.

Despite the existence of a model building code (or perhaps due to the existence of at least five "model" building codes), there is only a modest level of uniformity among the approximately 8000 local ordinances which set standards for the construction of residential housing. In addition to differences among the codes themselves, there are differences in the administrative application, enforcement procedures, and the discretion given to building officials, as well as the avenues of appeal to review boards and arbitrators. Local building codes include three types of information: definitions; licensing requirements; and standards. Definitions specify, for example, what constitutes plumbing, while licensing provisions specify who may install plumbing. Finally standards specify the minimum quality or physical characteristics of plumbing materials or their performance characteristics.

One role of local building ordinances, therefore, in addition to the promotion of health and safety, is the promotion of job security or competition among labor groups. In addition, however, local codes ratify innovative activity by permitting new techniques, materials, or equipment to be used in construction. For the evaluation of new products and techniques, testing laboratories (such as Underwriters' Laboratories) play a key role, but no testing results are binding. Thus approval by any testing laboratory need not imply product acceptance by any jurisdiction. The difficulty of specifying performance standards instead of input standards means that the innovator must, in principle, submit his product for testing at the local level. The criteria for acceptance may vary with the statutory provisions of the code and with the competence of local officials. As a result, it may be a long time before a cost-saving or quality-enhancing innovation achieves wide usage in the market.

A number of states have, however, adopted mandatory state codes for some types of construction. For 11 years the state of Connecticut, for example, has had a uniform code, and has required that local building officials be certified by the state. There is, however, considerable anecdotal evidence that enforcement is far from uniform. It should also be noted that some strides in uniformity of state codes has been made in the area of industrialized and prefabricated parts. For example, in California a prefabricated unit that receives certification under state law at the factory is deemed to satisfy any local requirements in the state.

Nevertheless, to the extent that the pattern of permissable materials and techniques at the local level lags behind best-practice technology, increased unit costs of housing result.

There is conflicting evidence on the magnitude of excess costs attributable to variations in building codes. Several studies have suggested that the <u>direct</u> effect of building codes upon construction costs is small. For example, Maisel's (1953) early study of the San Francisco housing market concluded that an increase of less than one percent in the costs of newly constructed housing was attributable to "known code inefficiencies."

Burns and Mittelbach (1968) in their report to the Kaiser Committee, analyzed a survey conducted by House and Home (the leading trade journal) in 1958, and suggested that if the 10 most "wasteful practices" required by building codes were eliminated, the average cost saving for single family housing would be from 5 to 7.5 percent. "By assuming the provisions (of building codes) are randomly distributed and by taking account of their varying role in communities," the authors conclude that" . . . the estimates represent from 1.5 to 3 percent of the price of an average house" (Burns & Mittelbach, 1968, p. 102).

Several other analysts have come to different conclusions, however. In expert testimony presented to the Kaiser Commission, Johnson (1968, p. 57) concludes that" . . . in large urban areas, it may be possible to achieve on the order of a 10 to 15 percent reduction in direct construction costs [or 5 to 8.25 percent of selling price by Johnson's calculations] . . . if the constraints of codes and restrictive labor practices are removed and if the industry is allowed to produce as efficiently as it knows how." Survey evidence gathered by the Douglas Commission (1968, p. 262) indicated some real cost reductions achievable by mass production under more uniform building codes. The estimates indicated that if twenty-one "excessive requirements"--not all of which are necessarily in effect in any particular jurisdiction--were eliminated, $1838 would be cut from a typical $12,000 FHA insured house. This represents a 15.3 percent reduction in construction cost (or roughly 13 percent in sales price, if one-fifth of selling price is the land component). The commission report also noted the problems of one home manufacturer who estimated that producing a standard product acceptable to the jurisdictions within his six-state market area would increase costs by $2492 or almost 21 percent.

Information on the cost increases attributable to excessive code provisions gathered more recently is also inconclusive. On the one hand, Muth and Wetzler presented regression estimates relating prices for newly constructed dwellings to a dummy variable indicating a locally modified building code. Their results suggest that the average effect of local code variation on housing prices is only about two percent. On the other hand, Babcock and Bosselman (1973), on the basis of interviews with builders in Ohio, concluded that codes could more than double the cost of producing residential structures.

An analysis of the diffusion of innovation in homebuilding was undertaken by Oster and Quigley (1977). For a sample of jurisdictions, they considered the provisions of local codes which permitted or barred a number of construction practices--all of which were generally agreed to be "best practice" (included were 2" x 3" studs and 24" framing in non-load bearing partitions discussed earlier). Their analysis indicated that many proxies for the competence of local officials and for the importance of local interest groups affected the speed of diffusion greatly. In an earlier version of this paper(Oster and Quigley, 1976), they estimated logistic diffusion paths for several innovations. These curves suggested that the interval of time between the year when 10 percent of jurisdictions permit an innovation and the year when 90 percent grant permission, may be as long as thirty years.

More important than the static excess cost inefficiencies of building regulation, therefore, may be the dynamic effects of these barriers upon the aggregate level of R & D effort and its allocation. With relatively long payback periods and with important local interests at stake, the <u>ex ante</u> profitability of research in building materials is probably reduced, when compared to other research activities, and the allocation of activity between labor-saving and capital-saving innovation may be affected.

It is difficult to estimate the aggregate effect of these types and patterns of local regulation upon the supply cost of housing. To some extent, the overall pattern of these regulations, no doubt, promotes health and safety or reflects willingness to pay for improved housing services. To that extent, associated increases in housing costs represent, not inefficiency, but increased output of housing services. To a large extent, however, these regulatory patterns represent attempts at redistribution from new residents and/or construction firms to owners of existing properties or to other local interests, such as craft labor.

To the extent that this redistribution is successful, it increases construction costs and generates additional losses through excess carrying costs. Finally, it may affect both the level and distribution of private research and development activity.

C. Federal Support of R & D Activity

As late as 1960, the Housing and Home Finance Agency, the direct predecessor to the Department of Housing and Urban Development, had an annual research budget of $15,000 (Nelkin, 1971, p. 76). The Building Research Advisory Board (BRAB) had been in existence for 11 years. BRAB, a committee of the National Research Council (NAS) had been established in 1949 as a non-governmental agency to stimulate and coordinate research and technology in the construction industry. One reason for BRAB's establishment, it is asserted, was to limit any federal role in housing research contemplated as a result of the 1949 Housing Act (Nelkin, 1971, p. 22). The 1949 Housing Act had authorized research on housing codes and technology, but following industrial opposition, appropriations were suspended in 1953. By 1960, some small fraction of the activities of the National Bureau of Standards was also devoted to building-related activities.

In 1962, the Civilian Industrial Technology Program (CITP) was proposed by the Kennedy administration--a Department of Commerce effort to foster technical change in lagging industries, notably housing and textiles. Congressional and industry opposition prevented the CIPT program from being adopted, but from BRAB's opposition to CIPT came a proposal for an expanded role for building research in the National Bureau of Standards (NBS). The present Center for Building Technology, a division of the Institute for Applied Technology, NBS, is a descendent of the BRAB proposal.

The Center for Building Technology is the closest thing to a U.S. national research laboratory for the construction and housing industries, analogous to national laboratories in Scandinavia, France and England. The principal difference is that the U.S. testing facility in NBS has no authority to promulgate or enforce standards itself. In 1978 the Center employed a staff of 250, including 170 professinals, had a budget of $14 million, and was engaged in a limited variety of testing and research activities (Willis, 1979, p. 89).

Currently, the standards evaluation and testing role of NBS is supplemented by the National Institute of Building Sciences, a non-governmental advisory board authorized by the Housing Act of 1974, but not established until 1976. (P. Cook, 1976).

Before the establishment of HUD in 1965, federal research on building technology was virtually non-existent. By 1969, HUD's research budget was less than $.5 million; in 1970 it increased twenty fold, and by 1980 it is at a level of $53 million.[21] Only a small fraction of these funds are allocated to building research, per se. In FY 1977, for example, the largest fraction of HUD's research budget was spent on housing assistance research (principally on housing allowances themselves and on analyses of the behavior of recipients); 17 percent was allocated to community development and neighborhood preservation research, and 11 percent was spent on state and local government research. Roughly a quarter of the budget is spent on housing energy conservation, safety, standards, management, and maintenance research.

Table 10 indicates the level and distribution of HUD administered federal research funds from FY 1974 through 1980.

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[21]U.S. Department of Housing and Urban Development (1980).

Table 10

Level and Distribution of HUD Administered Federal
Research Funds 1974-1980

	1974	1975	1976*	1977*	1978	1979*	1980*
housing assistance research	$16.2	$15.6	$15.6	$15.8	$12.6	$9.8	$9.8
safety and standards	2.9	4.1	4.8	6.1	3.7	3.2	2.9
state and local government and research	7.8	8.1	5.4	8.6			
program evaluation and support		2.7	3.8	4.3	5.3	5.9	8.6
other HUD research	33.3	36.6	32.3	36.2	39.7	39.0	31.7
total HUD research	$60.2	$56.6	$61.9	$71.0	$61.3	$57.9	$53.0
energy conservation and standards (DOE transfer)					32.5	21.7	6.4

*estimated

Source: Department of Housing and Urban Development, HUD Statistical Yearbook, US GPO, 1974-1980.

HUD sponsored research has declined modestly in nominal terms, more substantially in real terms, during the recent period. In contrast to other federal research acitivities, housing research has represented 0.22 to 0.25 percent of federal research funds. The HUD research budget is roughly 10 percent of the Department of Agriculture research budget; the Department of Denfense research budget is about 20 times as large.[22]

Of course, the HUD research budget does not represent the only federal resources devoted to residential construction technology. As noted in Table 10, substantial research on residential construction is funded by the Department of Energy and more limited research is sponsored by the Department of Defense (and the Corps of Engineers), as well as OSHA, EPA, CPSC, GSA and the National Science Foundation (P. Cook, 1976, pp. 253-259). The exact split between basic and applied research, between research on techniques, materials, and regulation is unknown, and in contrast to most Western European nations, there is no centralization of research activity.

It is instructive to consider the one major attempt by the federal government to foster an improved production technology, to rationalize regulatory standards, and to create a more stable environment for residential construction.

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[22]National Science Foundation (1976).

1. Operation Breakthrough[23]

The housing act of 1968 expressed as a goal the completion of 26 million additional dwelling units in a ten year period, an average annual figure that was forty percent larger than average annual number of housing completions during the previous fifteen years. In response to the report of the Douglas Commission, which had included optimistic projections on the possibilities for industrialized, mass produced housing, the act included Section 108 to "encourage the use of new [construction] technologies." This section authorized the Secretary to select plans for the development of housing using new technologies, to construct at least 1000 dwellings a year for five years using five different technologies, to evaluate the technologies, and to report the findings to Congress.

Governor George Romney became Secretary of HUD in January 1969, without a program, but with a clear mandate from the previous Congress to increase the supply of housing quickly. "Operation Breakthrough" was announced at a press conference in May 1969 and formed the basis for much of the new Secretary's testimony before the Senate that month.[24] Section 108 of the housing act had been written rather narrowly; it was intended to test whether economies of scale existed for certain promising technologies, and to report the results to Congress. According to the

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[23]Much of this material has been taken from four sources: National Academy of Sciences (1974); C. Cook (1976); Real Estate Research Co, et al (1976); and U.S. General Accounting Office (1976).

[24]See U.S. House of Representatives (1969).

Secretary's testimony, however, the design Operation Breakthrough was an attempt to use off-site factory methods--"new technologies"-- to increase aggregate housing production rapidly. Such a rapid increase in production required a thorough understanding of institutional factors--the cyclical nature of demand and the pattern of regulation--as well as a successful test for the presence of economies of scale along the way.

Operation Breakthrough "attempted to increase the efficiency of the market mechanism for housing output by reducing the institutional barriers among the various segments of the industry (localized building codes, zoning laws, etc.). Such action was ultimately intended to increase the market incentives for privately funded R & D, the results of which would permit the industry to respond in a timely and appropriate fashion to [secular] changes in supply or demand conditions. The breakthrough program gave heaviest emphasis to . . . the more specific R&D policy category" (C. Cook, 1976, p. L-28).

Operation Breakthrough would be implemented in three phases: Phase I, Design and Development, on cost-plus contracts with an expected duration of 2-4 months; Phase II, Prototype Completion, also on cost-plus contracts with production in another 12 months; and Phase III, Volume Production, to last indefinitely.

Initially, about 1000 design prototypes developed during Phase I were to be constructed during Phase II on widely varying geographic sites. These prototypes would serve as sales models for Phase III production. During this period as well, NBS would conduct laboratory and field tests to verify the acceptability of design prototypes. Certificates of acceptance would be issued, and the producers would then manufacture their systems for sale at a private profit. Originally, each producer would install 5 to 7 different housing systems to increase the chances of successful marketability.

Phase II construction required the selection of site planners, site developers, and site locations, as well as the selection of housing manufacturers. In addition, during Phase II, HUD would support state and local studies to identify sites for full scale production.

Note the design of this ambitious program. It would not be until several years after volume production had been underway, that the congressional mandate (to test economies of scale in the market) would have been fulfilled. Note also that the Operation Breakthrough program originally planned to subsidize only 1000 units before beginning volume production. Section 108 authorized instead a test of 25,000 subsidized units before submitting a feasibility report to Congress.

Apparently, Operation Breakthrough, as originally conceived, would produce: houses; and factories to produce houses;

and institutional regulatory reform; and research and development of new technologies; and, in addition, would provide a demonstration. Within HUD, the Office of Research and Technology was elevated to Assistant Secretary level and two former NASA officials were recruited to the program. The Research and Technology office emphasized community development, analysis of the entire delivery system, and the potential for modern management techniques.

Phase I Requests for Proposals (RFPs) were issued in June 1969. The RFP stated: " Operation Breakthrough has as its primary objective the establishment of self-sustaining mechanisms for rapid, volume production of marketable housing at progressively lower costs for people of all income levels, with particular emphasis on those groups and individuals which have had difficulty in obtaining satisfactory housing in the past."[25]

Firms had 90 days to respond. More than 600 proposals were submitted (instead of the 50-100 expected), and HUD had 5 months to evaluate their technical and cost characteristics.[26] The 22 winning firms, announced in February 1970 included several firms new to the housing industry (e.g., Republic Steel) and

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[25]U.S. Department of Housing and Urban Development (June 23, 1969), p C-2.

[26]Many of these designs are presented and discussed in: U.S. Department of Housing and Urban Development (1970); and U.S. Department of Housing and Urban Development (n.d.).

four aerospace contractors. Ten of the systems selected were of modular design, nine were panel designs, and three used component assemblies.

Eleven sites were selected for Phase II in response to 218 proposed by communities in 36 states. With the exception of New England, they represented broad geographical coverage. Funding cutbacks subsequently eliminated two of these sites. Finally, eleven site planners and developers were selected by June 1970.

At Secretary Romney's request, the appropriations of the Office of Research and Technology were increased twenty fold, from $.5 million to $10 million. Policy decisions to emphasize integrated community development increased design and evaluation costs for a fixed Operation Breakthrough budget of $60 million.[27]

With three months to respond to the Phase I RFP, it was clear that potential entrants were forced to rely on "off-the-shelf" technologies, which would then be tested and refined during the 2-4 month development effort. The development of evaluative criteria was entirely HUD's responsibility, since HUD's certificate of acceptance would certify health, safety, habitability, and (perhaps implicitly) marketability of the dwellings.

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[27] See C. Cook (1976) and National Academy of Sciences (1974) for a discussion of these budgetary decisions. The final cost of operating breakthrough was $72 million.

A hard-nosed decision to design appropriate performance specifications and to conduct tests relative to performance was required if the prototypes were to be marketed at all in other localities with restrictive code provisions, and if subsequent R & D was to be stimulated. This proved to be a difficult undertaking, requiring time and money, and ultimately, the redesign of more than half of the prototype plans. Phase I was scheduled for completion by August 1970, but was not, in fact, completed until one year later.

After issuing the RFP for phase I, HUD contracted with the National Bureau of Standards for the development of criteria to review, evaluate, and finally to accept the developed housing systems. The NBS development of performance based codes was reported in five volumes in December 1970. These codes, "Guide Criteria," contained novel provisions concerning the habitability and durability of dwellings. The performance standards in the codes necessitated some "reasonable engineering judgments," (much as building codes themselves often do in practice). Some ambiguity was introduced between the development/designer interpretations and the NBS interpretation. The National Academy of Sciences (1973b, pp. 7-8) review of the Guide Criteria indicated that the innovative set of standards "not written in the format and terminology customarily used in, and felt by many to be essential to, legally enforceable codes."

Moreover, "while many of the Guide Criteria provisions... could serve as a basis for furthering the development of existing regulatory documents, the process of translation and selection would have to be done with professional care if existing processes were not to be unnecessarily complicated." Finally, the review panel (National Academy of Science, 1973a, p. 7) concluded that "the Guide Criteria contains [sic] certain provisions that are not sufficiently clear and precise to avoid the need for excessive interpretation by the reader."

More important than the technical ambiguity of the standards, however, were the ambiguities introduced into the interpretations by FHA underwriters and potential leaders.

As precious time was lost during the initial phase (and as it was feared that more precious momentum would be lost with further delays), the strategy of parallel R & D was introduced. Parallel R & D had been successfully employed for a decade at NASA in producing pure hardware.

Apparently the strategy of parallel R & D proved very costly. Four divisions: technical, site planning, "market aggregation" (i.e., subsequent marketing under Phase III), and financing, each conducted development activities simultaneously. The relationship among these activities was not well-defined <u>ex ante</u>; the implications of alternative development activities in any one division upon the other three divisions were hardly understood. As a result, valuable "time was used up redesigning housing systems and reallocating them across sites to meet financial commitments arranged before the sites and systems had been completely designed and evaluated" (C. Cook, 1976, p. L-61).

Substantive changes had to be made in more than half of the housing systems, which increased costs and removed innovative components. More importantly, these changes left little time for dispassionate evaluation of the redesigned systems. By the time the implications of these changes were understood, it was simply too late; site development and mortgage financing for Phase II had been locked in.

Phase II contracts were signed with 21 of the 22 building firms and with the site developers. For legal reasons, these contracts were ultimately negotiated on a fixed-fee basis, which increased the risk to manufacturers. More importantly, however, HUD was in the position of being unable to acquire legally any comparative cost data from Phase II.

Given budgetary realities, Phase II could only be financed by private mortgage financing backed by FHA. FHA had already seen its primacy within HUD eclipsed by the elevation of the Office of Technology and Research. The Assistant Secretary for Housing Production and Mortgage Credit, a former president of the National Association of Home Builders, allegedly interpreted Operation Breakthrough as an attempt to "federalize" residential construction.[28]

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[28]This bureaucratic tension is discussed explicitly in C. C. Cook (1976, pp L-70-72) and implicitly in Real Estate Research Co. et. al., (1976).

In addition, however, housing components were designed to the new "Guide Criterion" performance standards, not the input-related (and FHA established) Minimum Property Standards (MPS). Finally, the MPS were themselves under review, and many in the industry were quite nervous that MPS would be replaced, in an instant, by the NBS performance criteria.

Industry comment on the performance standards indicated extreme concern about "the possible adoption of the Guide Criteria as a whole or of its more controversial provisions for regulatory purposes. . ." Industry spokesmen also objected to "the lack of opportunity provided during development of the Guide Criteria for contribution of knowledge and advice from the many capable individuals outside the federal government, including those who might be most affected by the use of the Guide Criteria" (National Academy of Science, 1973b, p. 9).

In any case, applications for financing Phase II and Phase III were not expedited at local HUD/FHA offices. FHA financing arrangements required complicated, lengthy, and costly procedures.

The first Phase II prototype (in Kalamazoo, the Secretary's home state) was completed in March 1972. Most of the other sites were about a year behind schedule. At this point, given the lengthy delays and the loss of momentum, it was decided to permit Phase II and Phase III operations in tandem, subject to the condition that Phase II prototypes be "sufficiently advanced." According to the NAS [1974, pp. 40 - 56] review, levels of quality assurance were quite low, especially when compared to the design tests which had been imposed in Phase I.

As Phase II and Phase III proceeded in tandem, federal rent subsidies and Section 236 subsidies were offered for Phase III units to speed production of Phase II prototypes. For the 17 producers who intended to proceed to Phase III, the inducement to complete the prototypes was quite strong. Section 236 set asides of 1000 units per producer were offered. For the other 4 producers, this provided no added inducement to complete the "experiment" in a timely fashion.

As a result of the difficulties with the FHA, HUD authorized the redesign of Phase III to accommodate local building codes and the MPS regulations.

On January 16, 1973, President Nixon imposed an indefinite moratorium upon new allocations of Section 236 subsidy moneys.

The rest, as they say, is "history." The original 1000 subsidy units per producer was honored, but no additional units were authorized. Producers were forced to substitute "standard" components and procedures for "innovative technologies" to comply with MPS, at increased site and off-site costs.

In all, about 25,000 Phase III units were completed in 150 different developments using Section 236 set asides. Only 1500 units were completed for unsubsidized occupancy at market interest rates (Real Estate Research Co., 1976).

By 1976, only five of the twenty-two Operation Breakthrough housing systems were still being marketed by their manufacturers (U.S. General Accounting Office, Nov. 2, 1976),

As of 1977, less than 7000 innovative units had been marketed outside of Operation Breakthrough by these firms at market interest rates.

No factory came close to completing a single volume run.

The cost to the federal government was $72 million or $12 million more than had been budgeted initially.

IV LESSONS FOR PUBLIC POLICY

The analysis presented in this paper documents the course of technical progress in the production of residential dwellings in the post-war period. The evidence indicates that there have been a large number of individual changes in the production process -- changes which have increased the quality of new construction at given costs or which have reduced the cost of dwellings of given quality. The course of technical progress in residential construction has been slow and incremental in nature. No single improvement in material or method has altered basic construction techniques or construction costs in a dramatic way. In comparison with other sectors of the economy, especially the manufacturing and agricultural sectors, the rate of technical progress in house-building has been slower, and aggregate resources devoted to research and development have been smaller. The overall level of public support for innovation has been quite modest and it appears that the *ex ante* profitability of innovation in the private sector is equally small, especially for innovations in building techniques.

In part, this pattern of technical progress may arise from factors inherent in the industrial processes. Labor and capital are small fractions of the total costs of producing new dwellings and are a smaller fraction of the occupancy costs by prospective consumers. In part, observed rates of technical progress may be attributed to the low capitalization of the industry and the predominance (at least historically) of small firms producing at low volumes. This pattern of market organization is seen to be a quite economical reaction to the sensitivity of the industry to monetary conditions and to cyclicality in the demand for newly constructed units.

In part, the structure of the industry and its lower level of capital intensity is an indirect consequence of aggregate financial policies and the regulation of depository institutions. As these federal regulatory constraints are removed over the next few years, one source of the cyclical sensitivity of new construction will be eliminated. Nevertheless, even when housing contruction is able to compete equally with other investment activities in the credit market, the level of new construction will surely remain sensitive to aggregate economic conditions. Unless housing construction activity were subject to explicit legislative control, or specific "counter-countercyclical" subsidy policies, the level of industrial activity will remain sensitive to monetary policy. It is, of course, hard to argue that productivity considerations in the housing sector are sufficiently important to warrant special treatment for housing during periods of monetary restraint.

The supply and occupancy costs of new housing have escalated as raw land prices have increased, as property taxes have risen, and as developers have assumed more of the responsibility for provision of infrastructure. In part, these increases in the costs of output have arisen from the conscious intent of local regulation based upon fiscal and "environmental" concerns. To the extent that metropolitan-wide land use controls are effective, the supply of land available for residential development is reduced and the input cost is raised. Further, to the extent that environmental regulation and subdivision restrictions affect the development process, there are three potential effects: A possible wealth transfer from new residents to prior residents; a possible increase in the residential quality of newly constructed dwellings; and a potential for large deadweight losses from time delays, bureaucratic negotiation and from the resulting "amenities" of new dwellings which exceed willingness to pay. Many developers do not hesitate to point out another consequence of a regulatory pattern which increases the costs and reduces the supply of newly constructed dwellings: monopoly rents to the builder who can offer newly constructed units on the market.

Given the importance of property taxes in local government finance and the land use powers delegated to local governments, there is little reason to expect these trends to be reversed. To the extent that reliance upon local property taxes can be reduced, we may expect reductions in the cost of newly constructed dwellings. The principal arguments for decreased reliance on the property tax, however, rest quite properly on other grounds - - progressivity of the tax structure, economy of administration, horizontal equity across individuals in different communities, etc. Reduced housing prices are merely a small indirect part of this larger issue.

It should be noted that the prohibition of land use restrictions, density requirements, etc., by local governments would have direct consequences in terms of stimulating housing output, reducing costs, and promoting economically integrated local communities. It is highly unlikely, of course, that these powers of local government will be withdrawn. However, it is worth noting that any weakening of these restrictions would have favorable effects upon housing - - mandatory "fair share" zoning requirements, required compensatory payments to land owners whose properties have been "upzoned" etc.

National experience with the federal "Operation Breakthrough" program provides several lessons for policy design.

First, despite the failure of the program to make rapid advances in construction technology or to increase housing output in a singificant way, the program provided some tangible benefits - - some improvement in coordination of building codes, especially preemptive legislation certifying manufactured housing components in several states; greater uniformity in state regulations governing transport of large and bulky loads, etc.

Second, the history of the program demonstrates the difficulty of conducting simultaneously a research, demonstration, and production program, especially one requiring a commitment over a reasonably long period of time. In part, the program illustrates the difficulties of coordinating the many interests in the building process, especially in the face of technical and financial uncertainties. In part, it illustrates the difficulty of providing a political commitment to housing production or innovation over an extended period including macro-economic change in the economy.

It does appear, however, that the history of operation breakthrough says practically nothing about the potential for rapid technical change in residential construction, or about the role of federal policy in fostering innovation. It would seem to be quite mistaken to interpret this history as evidence that a substantial public commitment to technical change in housing is doomed to "failure". On the contrary, the disappointing results of operation breakthrough says nothing about the innovative and experimental program authorized by Section 108 of the 1968 Housing Act. Such a program was never attempted, and it remains to be seen whether federally sponsored R & D in construction technique can lead to cost savings and marketable innovations. A federal commitment to produce, say, a thousand experimental dwelling units per year for ten years would be relatively cheap, even when viewed as a fraction of federally financed new construction under existing programs. A long term commitment would stimulate competitors to plan in advance and to submit truly experimental designs. Public sponsorship would facilitate the dissemination of experience and the diffusion of successful techniques. If combined with performance testing by a federal laboratory, described earlier, with statutory authority to certify improvements as meeting code standards, such a federal program could increase the potential market for improvements in methods and materials.

Such a small scale program would not answer two questions important to builders, developers and components manufacturers. It would not establish the extent of scale economics in the production of innovation housing and it would not establish the acceptance by consumers of design innovations. It would seem, however, that the profitability of housing innovations in the aggregate is best established by entrepreneurs in the marketplace.

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