

Chapter 2

The Development of the U.S. Housing Construction Industry

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The Development of the U.S. Housing Construction Industry

industrialized building techniques have grown in importance throughout the postwar period, and factory-built housing has gained a significant market share in many industrialized countries. However, inconsistencies in available data make international comparisons difficult to formulate. In the United States, 10 to 35 percent of all housing is now supplied from components produced largely in factories—25 to 50 percent, if “manufactured” (mobile) homes are included. Although “manufactured” (mobile) homes are virtually unknown outside the United States, several other countries produce a significant fraction of all housing in factories. Approximately 90 percent of Swedish single-family housing and 15 percent of all Japanese housing is factory-built; in Japan, the factory share is growing rapidly. Foreign developments will be discussed in more detail in chapter 4.

It is difficult to document the movement from “conventional” to “factory” construction techniques, due to the enormous variety of construction techniques now in use. Virtually all home construction employs some kind of factory-built component, such as prehung windows, doors, or roof trusses. On the other hand, even “modular” homes, which emerge from factories with bathroom fixtures in place and wallpaper on the walls, require some onsite work. The confusion over definitions has been compounded by the fact that the term “manufactured housing” is defined by statute to mean units more commonly called “mobile homes.”¹ In this text, the term “factory-built” will be applied to complete units constructed in a factory, to be erected as a package on a construction site. The term will not cover components such as trusses or wall panels. At the turn of the century, the term “industrialized housing” referred to use of framing lumber produced in a lumber mill, as opposed to the prevailing hand-crafted site assembly of logs. We now call that “stick-building,” and refer to factory-prepared housing as “industrialized.” The

variety of factory construction techniques now being used in the United States are described in box A.

Confusion over terminology translates into a statistical disparity, which raises questions about levels of industrialization within the industry. This can be seen by examining the two principal sources of information about factory construction in the United States (displayed in table 1). First, while the two estimates of total unit sales and total “manufactured” (mobile) home sales are close, estimates of sales in panelized housing differ by 350 percent. In modular/sectional housing, estimates differ by a factor of 2. Undoubtedly, most of the differences derive from conflicting definitions. Some of the “production builders” reported in *Automation in Housing* and the “industrialized builders” reported in *The Red Book* construct panels and subunits in their own facilities. Others build temporary “factories” near large-tract construction areas. Some simply use site-built construction techniques in warehouses, and then transport partially completed wall sections to the building. The two surveys document these activities in different ways.

The statistics also differ in that the *Automation in Housing* report presents a stratified sample of builders based on telephone surveys, while *The Red Book* data is derived from a mailed questionnaire. Using the *Automation in Housing* definitions and methods, nearly half of all U.S. homes are now constructed with factory-based techniques. Both data sets show that the share of “manufactured housing” (mobile homes) seems to be countercyclical, in that sales increase when the overall housing market declines. There was a significant drop in “manufactured” (mobile) home sales between 1972 and 1976, and sales also fell during the housing recovery of 1984 to 1985. The drop in sales during the early 1970s was due in part to the passage of statutes regulating “manufactured” housing at a national level. Use of other factory construction techniques, however, increases steadily in the *Automation in Housing* statistics, while *The Red Book* data indicate a decline in panelized housing.

¹Public law 96-399, Sec 308

Box A.—U.S. Factory Construction Techniques

- **Precut Systems.**—Precut systems involve the factory packaging of structural elements, material components, and finishes. The builder receives a "kit of parts" that fit together, and employ some components elements. The major U.S. precut systems manufacturers frequently provide interim financing of 2 to 3 years for their homes, citing the owner/builder's "sweat equity" as a partial downpayment. Permanent financing is arranged upon completion of the home.
- **Panelized Systems.**—In panelized systems, two-dimensional, factory-produced structural units are erected and joined together on the site. Composite panels for walls, roofs, and floors may be used, which often incorporate structure, insulation, and exterior finishes. Closed panel systems may include interior finishes, exterior sheathing, and exterior finishes, and incorporate building services and insulation during fabrication—preventing the onsite inspection allowed for by open panel systems. Elements like windows, doors, and exterior siding may be integrated at the factory. Panels may be built with a number of materials: wood framed, steel framed, foam or honeycomb cored, stressed-skin, precast concrete, or lightweight cellular concrete. A panelized system may use roof and floor panels, or wall panels with roof and floor trusses.
- **Manufactured Housing (Mobile Homes).**—These three-dimensional homes are assembled in the factory on a steel chassis, and must satisfy HUD building codes. Onsite, they rest on a temporary foundation and are connected to the site utilities. Manufactured homes may be either "single-wide," where the house is a single unit, or "multi-wide," where two or more units comprise the final house. Recently, "double-wide" units, or two units side-by-side, have been erected on permanent foundations.
- **Modular Systems.**—Modular systems resemble mobile homes: factory-assembled "boxes" compose the final building. However, they differ in that modular units are transported by external carriers, and modular buildings may take on any size or shape. Modulares are usually wood framed. Concrete, which has been employed for large-scale high-rise housing projects, has not proven to be cost-effective in the United States. Modulares must comply with conventional building codes, but are not subject to the Federal standards that govern mobile homes.
- **Wet Core Modules.**—A prefabricated element that can complement several building systems, the wet core module assumes a number of forms. It may contain bathroom, kitchen, and laundry facilities, with plumbing, stack fixtures, and interior finishes built in. Or, it may simply incorporate a plumbing wall with fixtures, but not necessarily the actual shells of rooms.
- **Wood Components.**—These two-dimensional structural parts of buildings—such as floor trusses, roof trusses, wall panels, beams, headers, and door and window assemblies—are used onsite by large-scale builders. Typically, up to 50 percent of a factory-built home may consist of pre-assembled wood components.

Table 1.—Factory Construction as a Percent of All Residential Construction in the United States

	1978	1979	1980	1981	1982	1983	1984	1985
Automation in Housing Survey:								
1 Production builders	63	74	75	75	55	48	51	52
2 Panelized	23	26	27	29	26	24	27	32
3 Modular	4	5	4	5	4	4	4	4
4 "Manufactured" (mobile)	14	16	17	21	23	17	17	18
5 Factory built (rows 2+3+4)	41	47	48	55	53	45	49	54

NOTES: Based on a stratified sample survey of subscribers to *Automation in Housing & Manufactured Home Dealer* and firms identified during earlier surveys. Subscribers produce about 90 percent of all housing units started in the United States each year. The sample does not include small custom builders some producers of high-rise structures. Production Builders are defined as large construction firms that sell products directly to customers. The Panel and Modular builders sell to builders/dealers. Some production builders use factory techniques for a part of their sales. Percent calculations use total private housing starts (U.S. Bureau of the Census, Construction Reports, C-20 Series) plus total "mobile" home production as the denominator.

SOURCE: *Automation in Housing & Manufactured Home Dealer*, January 1966, p. 14 & 16.

Table 1.—Factory Construction as a Percent of All Residential Construction in the United States—Continued

	1978	1979	1980	1981	1982	1983	1984	1985
Red Book Survey:								
One to four units:								
1 Precut	1	1	1	2	1	1	1	1
2 Panelized	6	6	7	5	4	3	4	4
3 Modular/sectional	2	2	2	3	3	2	3	3
4 Mobile homes	12	14	14	18	18	15	15	14
5 Industrialized home builders	10	10	10	10	13	13	14	13
6 Others	48	45	43	42	36	38	36	37
Five or more units:								
7 Factory made	1	1	1	0	1	1	1	1
8 Other	20	20	22	21	24	26	27	27
Factory (1+2+3+4+7)	22	24	25	28	27	22	23	23
Industrialized	10	10	10	10	13	13	14	13
Others (6+9)	68	66	65	63	61	65	63	63
Total	2,296	2,026	1,526	1,327	1,292	1,992	2,000	1,900

NOTES: Precut homes are defined as "a sales package for which the many parts are pre-cut but not preassembled. Although roof trusses may be included preassembled wall panels are not." Modular/sectional homes are "three-dimensional housing unit(s) produced in a plant and designed for erection on a permanent foundation with a minimum of on-site labor." Industrialized builders are "real estate developers and builders . . . using industrialized building techniques whenever they are cost effective."

SOURCE: "The Red Book of Housing Manufacturers," 1985

THE VARIOUS KINDS OF FACTORY-PRODUCED HOMES

"Manufactured" (Mobile) Homes

The structural box beam serves as the basic design principle of a "manufactured" (mobile) home. This integrated structural unit consists of four major subassemblies, into which are incorporated several mechanical service systems: the chassis, and the floor, wall, and roof systems. Nonstructural assemblies include such units as cabinets and windows. Figure 1 provides an exploded view of a "manufactured" (mobile) home, resting on a chassis.

Single-wide "manufactured" (mobile) homes are completed in the factory. However, multisection homes generally consist of three walls, a roof, and a floor, all of which are joined at the site. The arrangement of sections at the building site allows for greater flexibility in floor plan designs. Both single and multisection homes conform to maximum highway width loads—typically 14 feet. The Manufactured Housing Institute's 1985 publication *Quick Facts* reported that 29 percent of all "manufactured" (mobile) homes shipped in 1984 were multisection homes. Due to their large size, these homes may overlap markets for other types of industrialized housing.

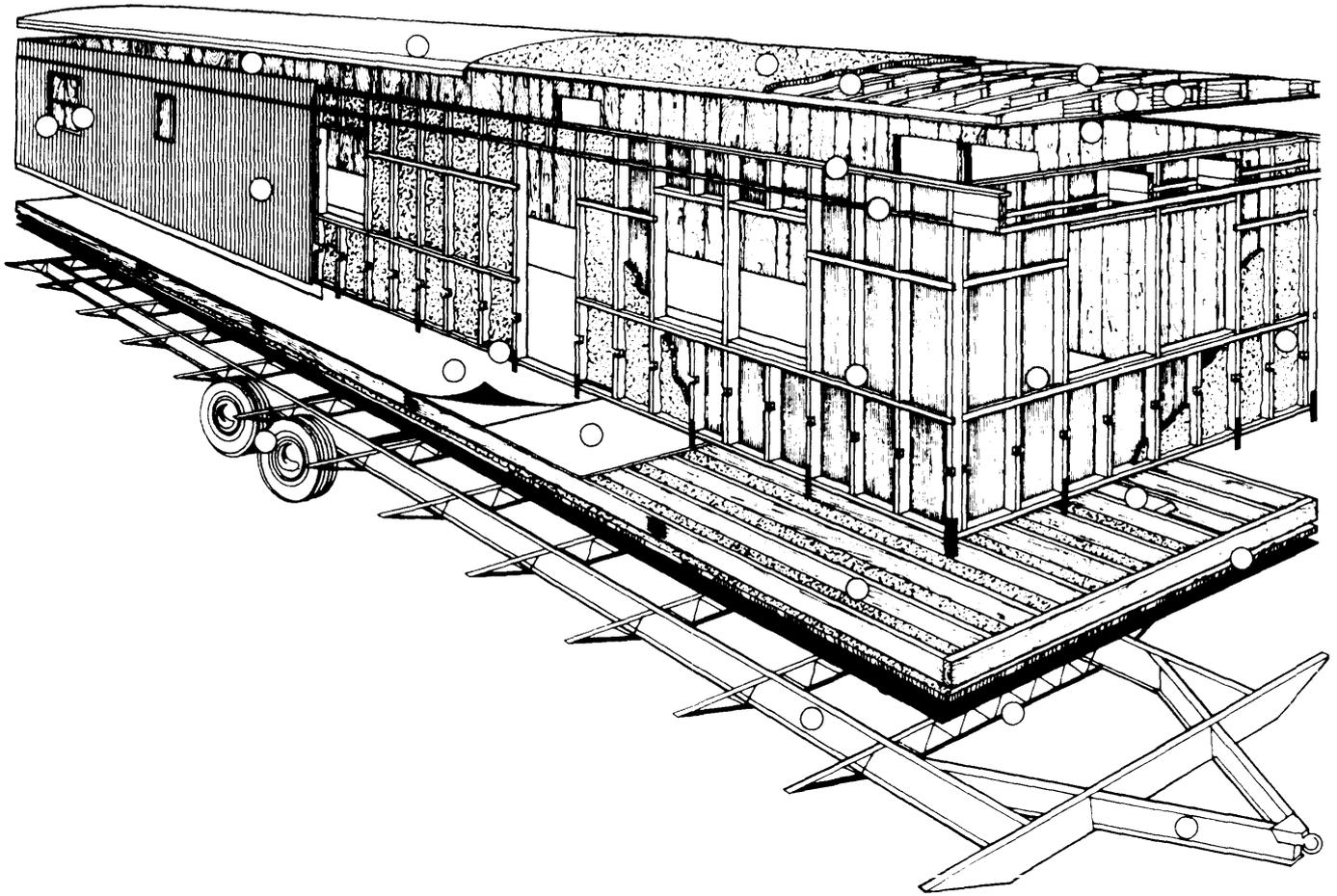
According to a recent study of the "manufactured" (mobile) home industry, construction processes for

these units can be divided into three basic activities: assembly, or the actual construction of product units; material storage of supplies, components, or product units until they are used in the production process or are shipped from the plant; and material handling, or the transportation of materials for storage, shipping, or use in assembly activities.² Each phase must be carefully coordinated and integrated within the production system in order to complete the unit successfully.

The typical "manufactured" (mobile) home plant is housed within a single-story "manufactured" metal building with an average floor area of 64,000 square feet. Normally, plant layouts and assembly lines fall into three different types: straight, L-shaped, and U-shaped. Subassembly and storage areas are located in designated areas around the periphery of the assembly lines. Units move along the assembly lines either end-to-end or side-by-side. The side-by-side placement method has become prevalent, as it permits more efficient factory space utilization. Furthermore, the side-by-side arrangement is desirable for producing multiunit "manufactured" (mobile) homes, since two or more units can be mated onsite to be

²Arthur D. Bernhardt, *Building Tomorrow, The Mobile/Manufactured Housing Industry* (Cambridge, MA: MIT Press, 1980).

Figure 1.- Exploded View of a "Manufactured" (Mobile) Home Resting on a Chassis



SOURCE" Arthur D. Bernhardt, *Building Tomorrow' The &40 bile/Manufactured Housing Industry* (Cambridge, MA The MIT Press, 1980)

assembled side-by-side, allowing for improved alignments and closer tolerances.

The Manufactured Housing Institute estimated that in 1983, approximately 185 firms shipped "manufactured" (mobile) homes from 410 factory sites. The average number of units shipped per plant was 582. With material costs accounting for 65 to 70 percent of the total cost per unit, more efficient material purchases can substantially improve the cost performance of a given production facility. Firms with many plants can realize even greater economies of scale.

Most "manufactured" (mobile) home plants follow a sequence of basic assembly operations. Production of the "manufactured" (mobile) home unit proceeds from the bottom up and from the inside out, beginning with the chassis frame and moving to the floor, wall, and roof assemblies. As the unit moves

along the main assembly line, subassemblies are added at the appropriate points. Some manufacturers purchase subassemblies and components from other companies. The extent to which subassemblies and components are fabricated in the plant depends on such factors as the availability of labor and materials, local shipping costs, and the proximity of suppliers.

Normally, 1 to 3 days are required to assemble a "manufactured" (mobile) home, depending on market demand, plant facilities, and unit specifications, with an average of 250 man-hours per unit. Most workers operate in crews, and are responsible for a specific assembly or fabrication operation on a rotating basis.

Once assembly operations are completed in the factory, the units are transported to the homesite,

to a builder/dealer's display lot, or to a storage facility. The units' chassis are attached to trucks, and can be transported within a radius of approximately 500 miles. From the manufacturer's point of view, however, the "feasible" shipping radius depends on market demand, transportation costs, and the location of competitors. The truck is the most economical means for transporting "manufactured" (mobile) homes, although several manufacturers have used rail and ship transport. The dealer installs approximately two-thirds of the units sold.

Upon reaching the site, the "manufactured" (mobile) home is positioned, unlatched from the transport vehicle, and stripped of its wheels. For multi-component "manufactured" (mobile) homes, sections must be positioned and joined. Finally, the unit is connected to utility and sewer systems. Less than 15 percent of the units installed between 1970 and 1976 had been moved from their original location by 1983.³ Approximately 7 percent of the owner-occupied units and 4.5 percent of the renter-occupied units are installed on permanent foundations, and another 12 to 15 percent are installed on a concrete pad. The remainder rest directly on blocks, without a concrete pad.⁴ Multisection units have declined in importance, after peaking at about 25 percent of all units sold in 1978. By 1983, they represented less than 15 percent of the units shipped.⁵

"Manufactured" (mobile) homes serve a relatively well-defined market niche. With an initial price per square foot of about 60 percent of a site-built house, they are the principal choice of families looking for housing with an initial cost of under \$50,000.⁶ Table 2, based on data published by the Manufactured

Housing Institute, indicates that in 1983, "manufactured" (mobile) homes captured 82 percent of the market for single-family homes valued at less than \$50,000—an absolute increase of 44 percent from the market share of 38 percent in 1977. This significant increase did not result from a surge in "manufactured" (mobile) home production; rather, the total number of site-built homes selling for under \$50,000 declined from 433,000 units in 1977 to only 65,000 units in 1983.

Figure 2 compares the income characteristics of families living in "manufactured" (mobile) housing with that of all families living in purchased or rented housing. In 1983, nearly three-quarters of all "manufactured" (mobile) homes were inhabited by families with incomes of less than \$20,000, while three-quarters of all housing was owned by families with incomes of less than \$35,000. In fact, a recent study conducted for the U.S. Department of Energy indicates that in 1980, the median income of "manufactured" (mobile) home residents was \$12,000, while that of other single-family detached homeowners was \$19,800.7 It is interesting to note, however, that "manufactured" (mobile) housing does have a significant market share in the higher income categories; in 1983, for example, 7,000 families with incomes **over \$100,000** per year reported that their principle residence was a "manufactured" (mobile) home.⁸

The real cost of a housing unit, of course, requires deeper analysis than the initial unit cost. Such research could consider the quality of the housing produced, the expected life of the unit, and the cost of operating and maintaining the unit. Some of these trade-offs will be discussed in chapter 3.

³Westat, Inc., "Analysis of the Annual Housing Data (AHS) Pertaining to the Durability of Manufactured Housing" (Rockville, MD 1986), p. 29.

⁴Ibid., p. 2.11.

⁵Ibid., p. 2-10.

⁶Manufactured Housing Institute; see table 8 in ch. 3.

⁷Pacific Northwest Laboratory, "Impact of Alternative Residential Energy Standards," November 1985, p. 33.

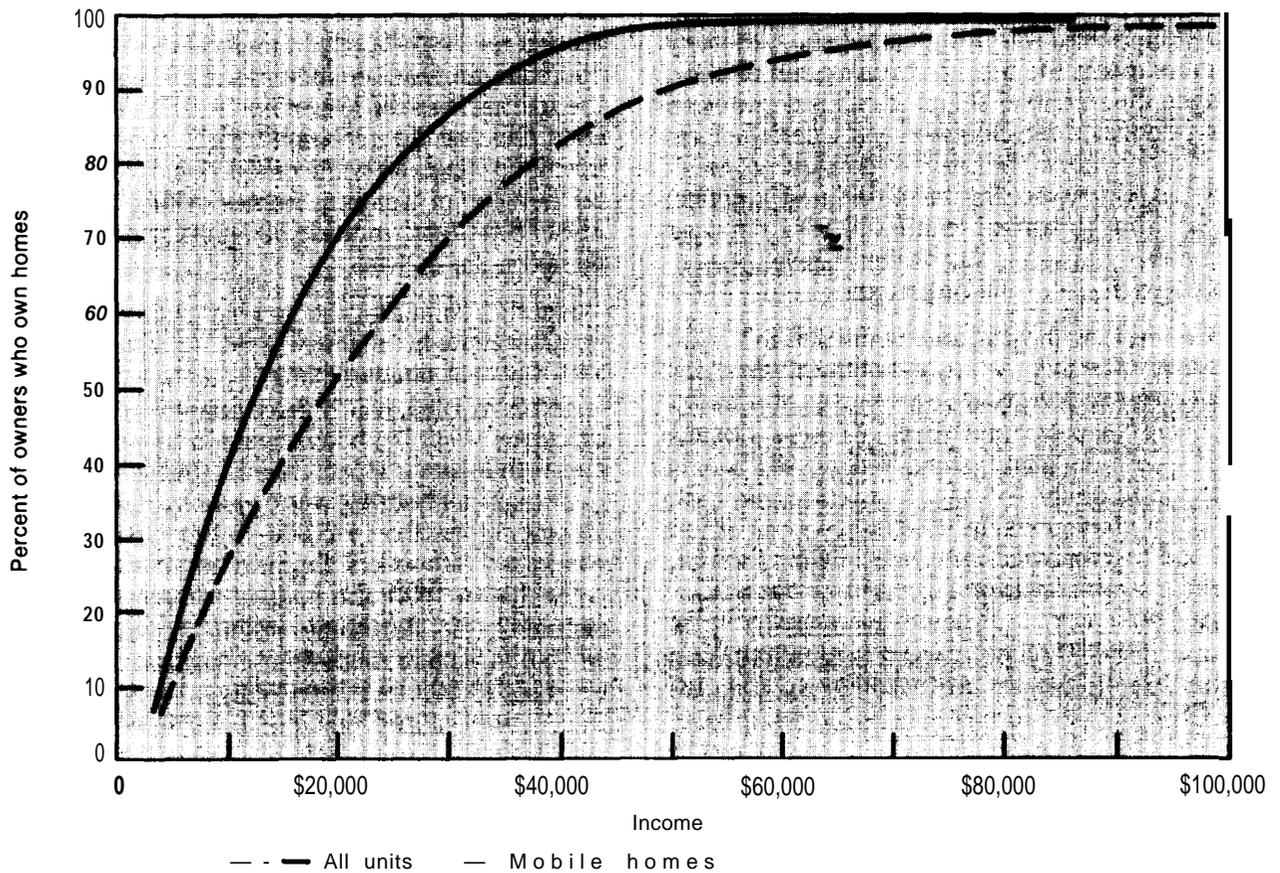
⁸U.S. Department of Commerce, Bureau of the Census "Annual Housing Survey: 1983," p. A-11.

Table 2.—Comparison of Mobile Home Shipments and Sales of Single-Family Site-Built Homes for Under \$50,000, 1977-83 (in thousands)

	1977		1978		1979		1980		1981		1982		1983	
	Number	Percent of total												
Site-built homes sold	433	62	316	53	184	40	137	38	88	27	67	22	65	18
Mobile homes shipped	267	38	276	47	277	60	222	62	241	73	239	78	295	82
Total new	700		592		461		359		329		306		360	

SOURCE: Manufactured Housing Institute

Figure 2.—Home Ownership by Income Cohort for 1983



SOURCE: Manufacturing Housing Institute.

Most manufactured housing plants are located in small rural communities, particularly in the sunbelt region. The rural areas provide both the principal consumer markets and favorable labor markets, due to the presence of low-skilled and non-unionized workers. Manufactured housing is concentrated in the South, which held 46.2 percent of the market in 1983; only 8.1 percent of all units are located in the Northeast.⁹ Approximately half of these units are sited individually or in clusters of 5 or fewer, while about one-quarter are situated in clusters with 100 or more units.¹⁰

⁹Westat, *op. cit.*, p. 2.2

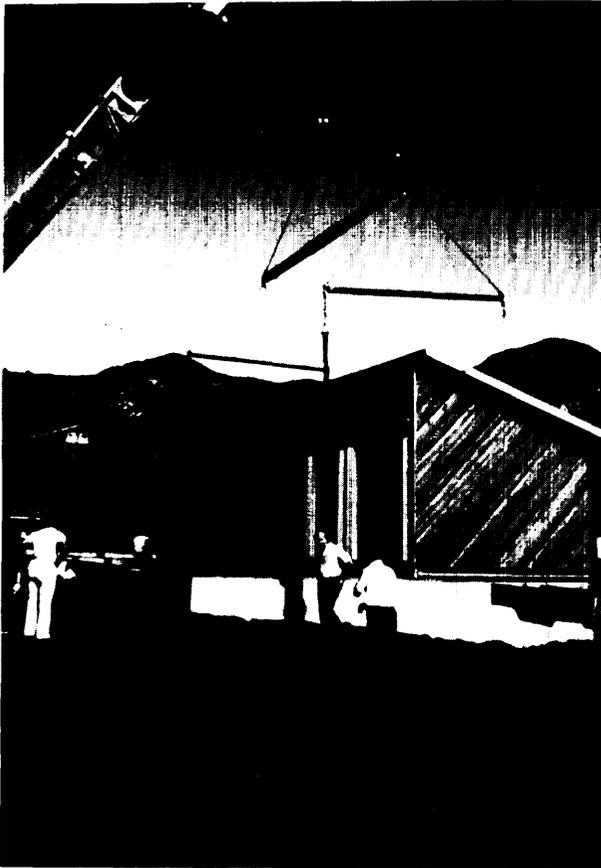
¹⁰*ibid.*, p. 2.6.

Modular Homes

Modular systems resemble “manufactured” (mobile) homes. The final building is composed of factory-assembled, three-dimensional “boxes” (see figure 3). However, modular units are transported by external carriers, and modular buildings—including small hotels/motels and commercial buildings—may be constructed from any number of boxes. These boxes can be stacked seven stories high to form multistory residential and commercial structures. Unlike “manufactured” (mobile) housing, which is regulated by the national HUD code, modular homes must satisfy State and local building codes.

Modulars are among the strongest of all light-frame residential structures. They are built with completed

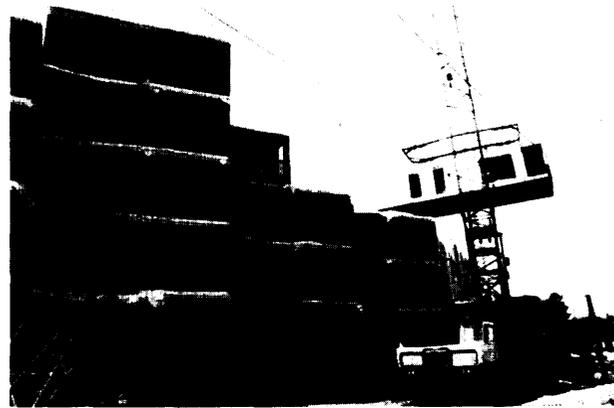
Figure 3 Double Wide Modular Home



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sheathing for roofs, sidewalls, and marriage walls with glue-nailed plywood, and employ heavier-than-normal construction techniques in wall and floor section framings. Modular housing units come in a variety of styles and sizes.

According to *Automation in Housing* magazine, 200 plants manufactured modular homes in 1983, with the typical plant building 350 homes per year and employing 109 persons. Factory layouts, machinery, equipment, and assembly processes for producing modular units resemble those described for "manufactured" (mobile) homes. However, since modular units are not built on a wheeled chassis, they either move through the production line on



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roller systems or are placed on a temporary trailer assembly. Electronic airlifts place the finished sections onto shipping vehicles for transportation to the site.

Generally, trucks transport modular sections to the site. Site cranes then remove and position the sections on a permanent foundation. Helicopters can be used for transporting the units when special problems arise, such as bridges or tunnels.

Again, because modular units lack a structural frame chassis, they rest on permanent foundations. This necessitates significant site preparation work before the unit's arrival. The recently developed "all weather wood foundation" (AWWF) systems, which cut costs and onsite assembly time when compared with traditional concrete foundations, are now used throughout the industry. AWWFs are assemblies of frame walls built of low-grade, preservative-treated lumber and plywood to create basement and crawl-space foundations. In comparison with conventional cement foundations, the AWWF can be erected quickly in extreme climates, which normally make concrete work difficult. As a result, they can extend construction seasons in many areas. This provides greater continuity in employment, and lowers costs in areas sensitive to "land factors." Furthermore, the development of prefabricated foundation systems has eliminated the setup or drying time encountered with cement foundations, and skilled labor is not required for their assembly.

When the modular unit is secured on the foundation, sectional joint work commences using specialized connector plates as well as pneumatically driven fasteners. Joints are then sealed and the utility and sewer systems are connected to the main lines. The sections are sealed together with moisture-proof barriers, to ensure consistent moisture protection and energy efficiency. The Swedes make sure that this is done, and take great care to train installers.

The market for modular homes has growth potential in the area of infill housing, or that which is constructed between two existing structures. Stacked modular units can satisfy the need for high-density, smaller sized housing units in urban areas around the country.

Panelized Homes

Like modular homes, panelized homes come in an array of types, sizes, and interior/exterior finishes. Panels may be produced in lengths of 2 by 8 feet or 4 by 8 feet that are erected by one or two workmen, in lengths of 10 to 16 feet that can be erected by four workmen, or in sizes of over 16 feet which require a crane for erection.

Automation in Housing reports that approximately 600 companies produced panelized homes in 1983. The panels themselves fall into two classifications, open and closed. Open panels refer to factory-assembled wall, floor, or roof panels that are open on one or both sides so that construction and/or enclosed mechanical, electrical, or plumbing equipment can be inspected onsite. An exterior open panel wall may have sheathing, doors, windows, and siding on the outside and insulation between the studs, but will lack finished materials such as drywall on the inside surface. In contrast, closed panels are enclosed on both sides, severely limiting access to onsite inspection. Panel factories typically contain linear production lines with automated sawing machinery and pneumatic panel nailers and staplers.

Panelized components can be loaded for shipping by truck or rail. Improved shipping techniques allow panelized home manufacturers to service greater market ranges than "manufactured" (mobile) or modular home producers.

A major disadvantage of panelized structures is the onsite labor required to assemble such systems. Poorly trained installers can increase costs and reduce quality. Although high-quality and tolerance standards exist in the factory, the ultimate quality of the structure depends on the skills and experience of the contractor who assembles the system at the building site. Currently, few U.S. panelized manufacturers provide their own building crews for on-site assembly operations. The Swedish discovered that quality assurance required them to have panels erected by either their own employees or teams trained by the manufacturing firm (see ch. 3). Swedish firms guarantee the installed product,

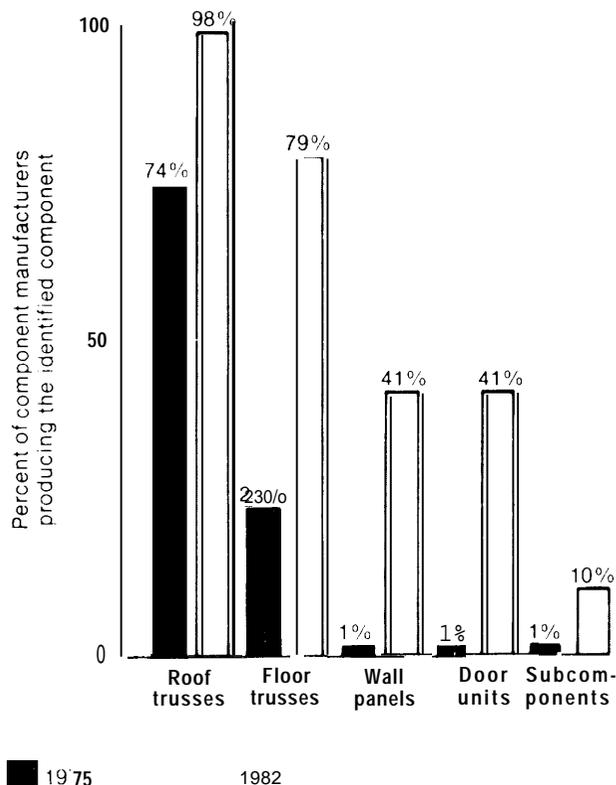
Precut Systems

Precut systems, which include log homes, dome houses, and precut frame houses, are produced in the factory and shipped to the site as packages. The builder receives a "kit of parts," such as framing envelope components, windows and doors. All elements are designed to fit together and are cut to size. These systems use certain individual components, such as roof trusses. Generally, the leading U.S. precut systems manufacturers provide 2- to 3-year interim financing for their homes, using the owner/builder's "sweat equity" as a partial downpayment. Permanent financing is arranged upon completion of the house. There are approximately 250 log-home manufacturers and 60 dome-house producers in the United States today.

Component Systems

Although not strictly a building system, manufactured building components play an important role in conventional construction. The invention of the metal truss connector plate was of enormous benefit to component manufacturers. This stamped metal plate that can join truss members, can splice chords of trusses, can join members of rough openings for doors and windows, or can fabricate other components. In 1982, virtually all of the Nation's 2,000 component manufacturers produced roof trusses, and nearly 80 percent produced floor trusses. Figure 4 provides a diversification trend chart depicting the component manufacturers' tendency to expand prod-

Figure 4.—Diversification Trends of Component Manufacturers



SOURCE *Automation in Housing* 1983

uct lines by including wall panels, door units, and other subcomponents. Recently, however, HUD announced that a significant number of roof trusses used in prefabricated industrialized housing had failed.¹¹ Careful regulation in this area could provide consumers with greater protection.

Over 90 percent of America's homes and apartments are built with roof trusses that have been connected by metal plates. Advances in computer technology have led to the widespread application of prefabricated truss assemblies in homebuilding operations. Roof trusses come in many configurations; computer software programs provide instantaneous design information concerning loading and stress factors, and indicate material and cost requirements associated with particular designs. Furthermore, roof truss assembly has become increasingly automated.

¹¹ Comment of the National Conference of States Building Codes and Standards, Inc. May 25, 1986

To move truss presses, the truss members and plate connectors sit on a conveyer, which moves the assembly under a roller that squeezes several joints at a time.

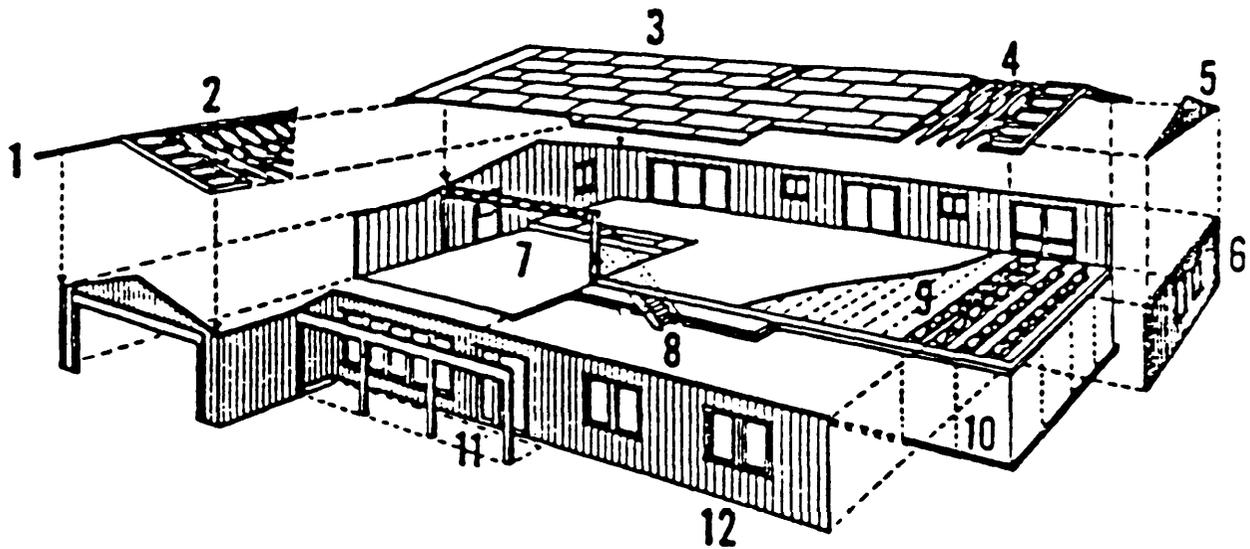
Roof trusses typically span a 32-foot wide house and are spaced up to 24 inches from the center. They can be set in place in minutes and, with the application of conventional 4 by 8 foot sheets of plywood as sheathing over the top chord, can close a house to the weather in less than a day.

After roof trusses, the 1970 invention of the floor truss represents the second major breakthrough for the American home building industry. These systems are made with 2-by-4 top and bottom chords placed flatwise with 2-by-4 webs, which are fastened with metal connector plates. Another advance came in 1976, with the invention of the metal web connected floor truss. This replaces all or portions of the 2-by-4 webs with a triangular metal web. Integral connector teeth protrude from each of the three points of the web, which is then attached to the outside edges of the chords. The floor truss assembly machinery operates on the same principle as roof truss assembly machines; the wood framing members are positioned on a truss machine, which presses the plate connectors onto the joints.

Component manufacturers also make prehung doors and windows; prefabricated stairs; and subcomponents like corners, tees, and headers (see figure 5). All segments of the housing industry use these wood components, largely because the light frame wood system that predominates in this country is an "open system." These components can be used by virtually all builders.

Some component manufacturers specialize in the production of wet core modules. Although not an actual building system, a wet core module is a prefabricated element that can fit with a number of building types. In its most developed form, it consists of a module containing the bathroom, kitchen, and laundry facilities for a home, with plumbing, stack, fixtures, and interior finishes built in. In a less developed form, it may incorporate fixtures into a plumbing wall, but not necessarily into the actual shells of the rooms. By industrializing a highly labor-intensive segment of the traditional housing construction process, these components can produce significant cost savings for the builder.

Figure 5.—Component Framing Assemblies



Newer component framing house part assemblies:

1. Ladder rake overhang assembly
2. Valley roof trusses
3. Roof sheathing
4. Engineered roof trusses

5. Gable end
6. Wall panels
7. Garage door header truss
8. Pre-assembled stairs

9. Engineered floor trusses
10. Wood foundation panels
11. Prehung doors
12. Prehung windows

SOURCE: *Automation in Housing*, 1983

INDUSTRY SEGMENTS

The housing industry includes producers, distributors, sellers of the end product, and other segments. The housing units that these segments produce—"manufactured" (mobile), modular, panelized, precut, and component systems—were presented in the preceding section.

Categories of housing producers are not entirely distinct from one another. Some firms manufacture more than one type of housing; for instance, several "manufactured" (mobile) housing producers make modulars as well. These producers try to maintain stability in an unstable market by retaining flexibility in their plants. When demand for one type of product, like single-family homes, declines, they emphasize another, such as multifamily units. This approach may become increasingly popular in the U.S. residential construction industry.

Production Builders

This segment consists of large and small volume site builders, who use factory-made housing components to construct large numbers of single-family houses or low-rise apartment buildings in subdivisions, or "tracts," near major metropolitan centers. Typically, their structures consist of prefabricated factory or onsite components. Often called "volume producers of housing," production builders do not use networks of builder/dealers, but sell homes directly to the consumer.

Increases in site-labor and construction loan costs have made production builders the principal consumers of prefabricated housing components. While some large production builders now operate their own component manufacturing systems, most still secure components from independent companies.

Builder/Dealers

“Manufactured” (mobile), modular, and panelized home manufacturers usually sell their products through networks of builder/dealers. These builder/dealers often operate from display lots, located within 700 miles of “manufactured” (mobile) and modular home manufacturing plants due to transportation constraints. Builder/dealers may sell for one or several manufacturers, and do most of their business in well-defined market areas. In addition to acting as salespersons, builder/dealers prepare the land, complete foundation and utility work, and supervise finishing work on the home after delivery.

Figure 6 illustrates the functional interrelationships among manufacturers, wholesalers, fabricators, builders, dealers, contractors, and consumers associated with the manufactured housing industry.

Small Builders

Small operators constitute the vast majority of American homebuilders—far too small, in terms of units produced per year, capital resources, and scope of operations, to handle the large capital expense of introducing new technologies.

Concerning output, the 1977 Census of Governments reported that 227,830 general building contractors, nearly 80 percent of all general contractor establishments, had receipts of less than \$250,000, which translates into 5 to 10 units per year. Similarly, the National Association of Home Builders (NAHB) states that the vast majority of its member firms produce fewer than 25 houses per year. And the 1977 Census of Construction concluded that one-fourth of all homebuilders operate in a single market area, and that less than 5 percent of all builders of single-family units worked outside their home States.

These small firms do exhibit a strong entrepreneurial nature. When market conditions change, they move out of homebuilding and into more promising construction endeavors. In the so-called “bad years” of 1967, 1974, and 1975, nearly 20 percent of member firms surveyed by the NAHB in 1977 switched to other businesses. Members switched at half this rate during periods of success.

Small producers often capitalize on short-term investments. They should be able to adjust finances quickly, so as to reinvest in new efforts according to market trends. Such producers can operate more flexibly and more economically with unskilled or semiskilled workers than with costly new machinery. Given these considerations, the large-scale, long-term capital requirements associated with technological innovation conflict with the needs and capabilities of most American builders.

U.S. Home: A Case History

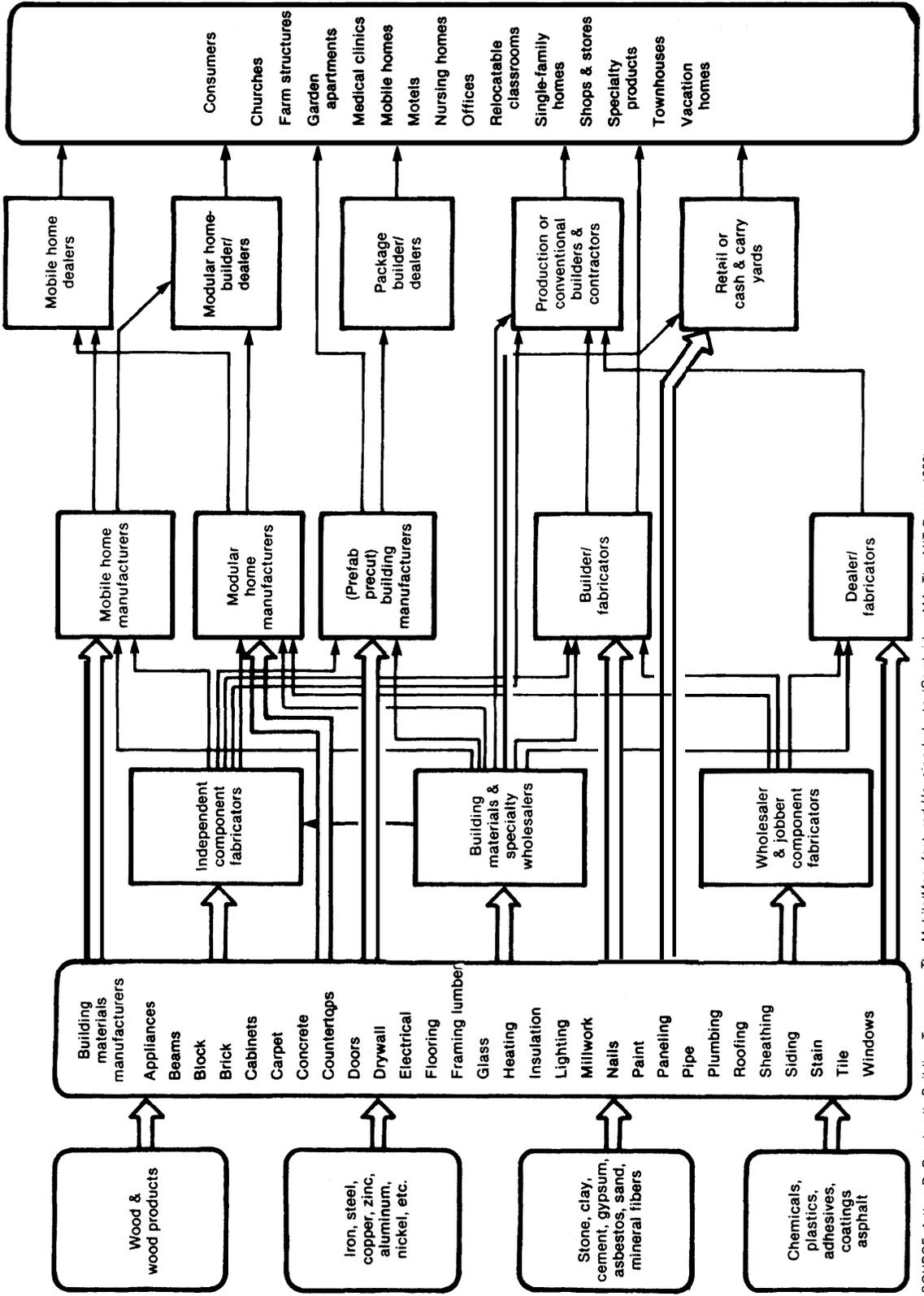
U.S. Home Corp., until recently the Nation’s largest homebuilding firm, serves as an example of a large company that has changed its market approach in order to satisfy housing demand—sometimes against its will. Started by New Jersey builder Robert Winnerman, this company produced an estimated 2,400 houses in 1968, generating revenues of \$58.3 million. U.S. Home became a national force the following year, when Arthur and Charles Rutenberg incorporated their separate Florida firms with that of Winnerman.¹² During the next 3 years, Winnerman acquired 14 other firms. By 1973, U.S. Home operated in 11 national markets; production had increased to 10,700 units, and revenues to \$351 million. Production peaked in 1980, at 15,821 units.

In 1982, U.S. Home delivered 12,599 units, down from its previous high, although it still enjoyed operating revenues of \$832 million. Over half of this production was situated in Texas, where the success of the oil industry had created an unusually high demand for housing. By 1983, U.S. Home had opened 74 divisions and 13 manufacturing plants in 25 States. They were building in 175 single-family detached communities, 109 condominium projects, and 9 retirement communities.

U.S. Home’s 1983 annual report indicates several actions taken by the company to protect and expand its market. It was the first major homebuilder to develop and issue “collateralized mortgage obligations” (CMO) funds. CMOS raise new mortgage credit by selling securities that are “collateralized” by loan payments made on previously sold homes; these funds are then earmarked to make loans to purchasers of

¹²Ned Eichler, *The Merchant Builder* (Cambridge, MA: The MIT Press, 1982), p.187.

Figure 6.—A Model of the Industry



SOURCE: Arthur D. Bernhardt, *Building Tomorrow: The Mobile/Manufactured Housing Industry* (Cambridge, MA: The MIT Press, 1980).

new homes. In 1983, U.S. Home learned of projections that the bulk of future demand for new housing would be in rural and small metropolitan areas. In order to adapt to the changing nature of the market, the company acquired Brigadier Industries Corp., one of the Nation's largest producers of "manufactured" (mobile) housing. This move was intended to improve U.S. Home's ability to operate efficiently in small markets, and to facilitate its pledge to offer housing at competitive prices.

However, U.S. Home did not anticipate the downside of the oil industry and the resulting decrease in housing demand. The firm had entered the "manufactured" (mobile) home market to capitalize on the immediate need for low-cost housing; in much the same way, it opened the largest industrialized housing plant in Salt Lake City during the overthrust drilling boom of the late 1970s and early 1980s.

When the oil market collapsed, U.S. Home was faced with a manufacturing capacity that outstripped demand by a large margin. The firm has confronted this problem by abandoning production of both "manufactured" (mobile) homes and modular units, and it is currently negotiating to sell off its Brigadier subsidiary.

Like many other producers of factory-built housing, U.S. Home has met with both success and failure in its attempts to operate within a volatile market. Because it has continued to profit from certain segments even during periods of financial duress, it has been able to overcome setbacks in a particular housing category. Its case history demonstrates the risks involved in adapting to industry developments as they occur, and the manner in which a company may readjust to the effects of such changes.

TRENDS IN INDUSTRIALIZED HOUSING

The Early Years

In the United States, prefabricated building technologies received widespread attention as early as the 1930s. Having witnessed the technological success of the automobile industry, the American public believed that mass production of houses would alleviate the Nation's chronic shortage of affordable housing. In 1932, *Fortune* referred to General Homes, Inc., which had just unveiled its prefabricated steel house, as "the General Motors of the new industry of shelter," commenting on the construction of General Homes' prefabricated steel house.¹³ By 1933, prefabricated housing companies were attempting to capture a share of the potentially vast market for mass-produced homes. Even industrial giants such as Armco Steel, American Rolling Mills, Wheeling Steel, Great Lakes Steel, and Goodyear—all of whom envisioned that mass-produced housing would generate profitable markets for their own building materials and components—began investing in home manufacturing operations.

But early dreams of capitalizing on the prefabricated home faded quickly. One housing analyst cites

three reasons: "the price of the prefabricated house was not competitive, public interest stopped short of purchase, and promised capital backing proved elusive."¹⁴ Inconsistent local codes and management errors also contributed to the problem.

Few U.S. firms mass produced prefabricated housing prior to World War II. As one study suggests:

Up until the Second World War, prefabricated housing accounted for only one half of one percent of total housing construction. The War radically changed that figure. The need for large scale production at minimum cost and maximum speed gave established prefabricators and would be prefabricators a golden opportunity. The Federal Public Housing Authority alone built some 116,000 prefab houses and about 80,000 more were built by other government agencies and by private operators.¹⁵

This rapid expansion of prefabricated housing production during the war also stimulated new business ventures within the field.

¹³"Housing: A Striking Answer," *Fortune*, August 1932, p. 60.

¹⁴W.D. Keating, *Emerging Patterns of Corporate Entry Into Housing* (Berkeley, CA: IURD Press, 1972).

¹⁵*Ibid.*

Following World War II, the United States experienced a housing crisis of unprecedented proportions. In response to a critical shortage of homes, President Truman appointed Wilson Wyatt as Housing Expediter. Wyatt had full privileges to use the War Powers Act and the War Mobilization and Reconversion Act, and had direct control of the Federal Housing Authority and the Federal Home Loan Bank Board. He presented the Veteran's Emergency Housing Program on February 7, 1946. This program:

... set a production target of 2.7 million units for the years 1946 and 1947. To reach this unprecedented goal, Wyatt intended to rely heavily upon prefabricated housing, 250,000 units in 1946 and 600,000 in 1947. Achievement of this goal would have increased the value of prefab production from \$100 million to \$2.5 billion.¹⁶

As it turned out, only 37,200 prefabricated units were constructed in 1946, and 37,400 in 1947. The Wyatt program died out by 1948, and cost the Federal Government approximately \$200 million. Many housing producers, including those with technically sound products, went bankrupt upon the withdrawal of Federal funding. Among these were the futuristic Dymaxion House of Buckminster Fuller, and Carl Strandlund's porcelain enamel and steel Lustron Home. Other companies managed to profit from the very weakness of this Federal initiative; Fortune concluded,

... the 1946 Wyatt program was almost entirely a private enterprise program, and a lot of private enterprises made a lot of money under its shelter.¹⁷

Operation Breakthrough

The next attempt by government and industry to infuse modern technology into the homebuilding sector came on May 9, 1969, when George Romney, Secretary of the U.S. Department of Housing and Urban Development, presented Operation Breakthrough. This proposal grew out of Section 108 of the Housing and Urban Development Act of 1968: "New Technologies in the Development of Housing for Low Income Families." The Section "authorized the (HUD) Secretary to select plans for the development of housing using new technologies, to construct at least 5,000 dwellings a year for five years using

five different technologies, to evaluate the technologies, and to report the findings to Congress."¹⁸ Ultimately, Operation Breakthrough exposed builders to the benefits of modern technology, and encouraged more uniformity within and between State building code systems; however, it failed to create widespread support for its programs in the American marketplace, where local factors tended to delay implementation.

Romney proposed a three-phase implementation of Operation Breakthrough: Phase I, Design and Development; Phase II, Prototype Completion; and Phase III, Volume Production. In June 1969, HUD requested proposals for the project. The department stated that:

Operation Breakthrough has as its primary objective the establishment of a self-sustaining mechanism for rapid, volume production of market housing at progressively lower costs for people of all income levels.¹⁹

HUD received proposals from 236 firms. Commenting on the unexpectedly high response rate, one study observed:

On the heels of the urban riots, many of the Nation's big corporations wanted to devote some of their money and skills to solving social problems—especially if money could be made at it. The list is long: American Cyanamid, General Electric, Inland Steel, CNA Insurance, Phillip Morris, Boise Cascade, Warner Communications . . . From every specialty, these wise kings came with their gifts to help the infant housing industry in its muddy manger.²⁰

In February 1970, HUD selected 22 Operation Breakthrough finalists. Of the proposed housing systems, 10 were made of modular design, 9 were of panel design, and the remaining 3 used component assemblies. Initially, HUD selected 11 demonstration sites. Budgetary constraints later reduced the number to nine.

Operation Breakthrough lost its early momentum when the participants encountered costly delays in securing financing during Phases II and III. These

¹⁸John M. Quigley, "Residential Construction and Public Policy: A Progress Report," IBER Working Paper, Berkeley, CA, 1983.

¹⁹Ibid.

²⁰artin Mayer, *The Builders* (New York: W.W. Norton & Co., Inc., 1980).

¹⁶Ibid.

¹⁷"The Industry Capitalism Forgot," *Fortune*, 1947, vol. 36, No 2, p. 67.

delays, which arose from having to satisfy a multitude of local codes before a given design could be implemented, caused many financiers to lose interest in the program. In an effort to remedy the problem, HUD allowed Phase II and Phase III operations to proceed simultaneously, and “federal rent subsidies and section 236 subsidies were offered for Phase III units to speed production of Phase II prototypes.”²¹

The final blow to Operation Breakthrough came on January 16, 1973, when President Nixon announced an indefinite moratorium on new allocations of Section 236 subsidy funds. In the end, only 14 of the original 22 Operation Breakthrough participants built Phase III projects. Some housing producers did not participate due to the problem of code compliance. Others cited “cost and other production problems, corporate marketing policies, and bankruptcy” as reasons for avoiding the project.²² Summing up the results of Operation Breakthrough, “about 25,000 Phase III units were completed in 150 different developments using Section 236 set asides. Only 1,500 units were completed for unsubsidized occupancy 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 initially been budgeted.”²³

While Operation Breakthrough is now looked on as a mismanaged Federal housing program, the effort did expose builders to new housing construction technologies. Furthermore, it led many States to reevaluate their building code systems, encouraged uniformity between State standards, fostered new methods for evaluating housing construction, tested new labor arrangements for structure assembly operations, and introduced American builders to innovative European practices. However, few HUD-sponsored building systems actually reduced the cost of housing as a result of the technology that came out of Operation Breakthrough.

After Operation Breakthrough

Since 1973, significant large-scale public, private, or joint venture projects encouraging the use of new

²¹Quigley, op. cit.

²²U.S. General Accounting Office, Comptroller General, “**Operation Breakthrough—Lessons Learned About Demonstrating New Technology**,” Washington, DC, 1976.

²³Quigley, op. cit.

homebuilding technologies have failed to materialize. While the “Joint Venture on Affordable Housing” initiated by HUD in several cities in 1982, has had limited success, most Federal efforts have related new technologies to energy consumption, not construction. The 1982 U.S. Comptroller General’s report to Congress, “Greater Use of Innovative Building Materials and Construction Techniques Could Reduce Housing Costs,” cited a number of factors in government and industry that “impede the use of available technological innovation and the development and introduction of new ones.”²⁴ These included:

- a low level of effort by the Department of Housing and Urban Development and the National Institute of Building Sciences to encourage the development and use of innovative technology, except for that related to reducing energy costs;
- builders’ reluctance to accept risks associated with the use of technology whose long-term performance is not proven;
- restrictive and inconsistently administered local building codes; and
- builders’ lack of technical information on the results of using innovative technology.²⁵

The National Institute of Building Sciences had been created by Congress in 1974 under Public Law 93-383, and was intended:

. . . to encourage all sectors of the building industry to develop a more efficient way of introducing technology into housing by encouraging a more rational building regulatory system through simplification and harmonization of building criteria, standards, and other technical provisions, and evaluating existing and new technology to facilitate its introduction and acceptance at the Federal, State, and local levels.²⁶

Due to internal organizational problems, the National Institute of Building Sciences did not become fully operational until 1979. It has still not assumed the active role called for by the statute, primarily due to a shortage of financial resources.

²⁴U.S. General Accounting Office, Comptroller General, “Greater Use of Innovative Building Materials and Construction Techniques Could Reduce Housing Costs,” Washington, DC, 1982.

²⁵Ibid.

²⁶Ibid.

Summing up the scenario since Operation Break-through, the Comptroller General's 1982 report stated that "the statutory authority given to HUD and the National Institute of Building Sciences to encourage the development and use of innovative technology in homebuilding has been receiving only limited attention by HUD and the Institute."²⁷ Given the past performance records of both HUD and the Institute, it appears unlikely that either party will vigorously promote the research, development, or use of innovative technologies or materials to reduce housing costs, unless funds are earmarked specifically for this purpose.

The Future

Industry analysts generally agree that the postwar movement toward factory-built housing will continue, and may even expand. However, despite substantial interest on the part of leading industrial firms, as well as government backing for prefabricated housing under Presidents Truman and Nixon, large-scale mass production of homes in American factories has not materialized. Why should today's forecasts be more reliable than previous ones?

First, virtually all segments of the residential housing industry now depend on factory-based technologies to a certain degree. Until the Second World War, few firms were involved in mass producing houses, and a mere 0.5 percent of total housing construction was factory-built. Clearly, factory construction plays a more important role today.

Second, computer technologies are extending the inherent efficiency of factory-based production. Computers facilitate many individual operations involved in industrialized housing, from the initial design stage, to the building's final assembly. This improves quality control, saves time and money, encourages uniformity of parts, and enhances design flexibility. As new computer applications emerge and software is developed to meet the specific needs of the residential construction industry, factory-based technologies should become more attractive to homebuilders as well as homebuyers.

Third, the big builders are growing. The emergence of "superbuilders," and particularly the ex-

pansion of the largest firms among them (see table 3), has brought about the combination of capital and concentrated land markets necessary to justify long-term investments in plant and equipment. It is difficult to distinguish between cause and effect, because factory-based mass production, especially of the more profitable product lines, may also give firms a competitive edge to expand. In any case, some production builders have already indicated their intention to expand their production of housing, through continued acquisition of construction facilities.

Fourth, Japanese and European technological innovations, coupled with the growing threat of competition from foreign concerns acting in joint ventures with large domestic firms, has already inspired a combination of interest, emulation, and even fear within the industry.

Table 3.—Top 25 Homebuilders by Units Produced, 1983

1	Fleetwood Enterprises, Inc. (III)	37,746
2	U.S. Home Corp. (I, II, IV)	22,855
3	Champion Home Builders Co. (III)	21,715
4	The Commodore Corp. (II, III, IV)	16,274
5	Skyline Corp. (III)	16,118
6	City Investing Co. (1,111)	15,590
7	Redman Homes, Inc. (III)	15,403
8	Lincoln Property Co. (1)	12,734
9	Pulte Home Corp. (1)	12,008
10	The National Housing Partnership (1)	11,701
11	Tidwell Industries, Inc. (III)	11,010
12	Liberty Homes, Inc. (III)	10,565
13	Fairmont Homes, Inc. (III)	9,779
14	Kaufman & Broad Home Systems, Inc. (1,111)	9,570
15	Jim Walter Homes, Inc. (1)	8,706
16	Ryan Homes, Inc. (1)	8,503
17	Horton Homes, Inc. (III)	7,018
18	National Homes Corp. (II)	6,842
19	Cardinal Industries (IV)	6,754
20	Zimmer Corp. (III)	6,321
21	Canter Corp. (1)	6,299
22	Ocilla Industries, Inc. (III)	6,000
23	The Ryland Group, Inc. (I, II, IV)	5,491
24	Weyerhaeuser Real Estate Co. (1)	5,000
25	Conner Homes Corp. (III)	4,964
Top 25 total		295,686
Top 100 total		377,983
Top 25 as percent top 100		78

Legend:

(1) = production builder; (II) = panelized home manufacturer, (III) = mobile home manufacturer; (IV) = modular home manufacturer.

SOURCE: "Automation in Housing," 1984

²⁷Ibid.

MARKET CONCENTRATION

The 1978-83 market share percentages, numbers of units produced, and sales volumes of the top 100 U.S. builders indicate the extent of market concentration within the residential construction industry. These 100 home producers captured 24 percent of the industrialized housing market in 1983, a decline of 2.7 percent from the 26.7 percent figure of 1982;²⁸ this can be attributed to the increasing presence of small builders in the revitalized housing market. Still, production levels and sales volumes for the top 100 builders increased between 1982 and 1983. *Automation in Housing* magazine's 1984 annual report indicated that "the largest U.S. firms accounted for 377,983 units in 1983. Their sales volume soared 35.7 percent to 12.019 billion compared with the 8.859 billion they put on the books in recession-battered 1982."²⁹

Table 3 presents the top 25 homebuilders, ranked by number of units produced. The table also describes the product-types manufactured by each company. These 25 companies produced 78 percent of all units built by the top 100 homebuilders, and almost 20 percent of all housing produced in 1983. Ranking these companies according to their dollar volume of sales, the top five—U.S. Home Corp., Pulte Home Corp., Ryan Homes, Inc., City Investing Co., and Centex Corp.—all boasted 1983 sales in excess of \$500 million; U.S. Home posted a sales volume of \$932.7 million. Of these superbilders, 29 had sales in excess of \$100 million.

Implications for Small Builders

As the industry becomes more concentrated, the role of the small builder may change. New technol-

ogy has the potential to drive out small builders, or at least to give them a different role. Use of factory-produced structural elements has already made the small builder more of an assembler than a craftsman. But it has also created many new opportunities for specialized firms, in areas like site preparation and crane operations. Will the small builder's future role be limited to pouring a foundation and assembling a set of modules or panels? Will the small builder become a captive of major production houses? Or will the small builder become an entrepreneurial specialist supplier to larger homebuilders?

"Manufactured" (Mobile) Homes

The "manufactured" (mobile) home industry is the most concentrated area of factory-based housing. Of the 169 firms engaged in the production of "manufactured" (mobile) home units in 1983, the top 25—as shown in table 4—accounted for 74 percent of the total production volume of 295,000 units. The top 10 companies produced 54 percent of all "manufactured" (mobile) homes, and the five leading manufacturers reported sales volumes greater than \$250 million.

This oligopolistic industry structure has resulted from a series of mergers and acquisitions following the enactment of the Manufactured Home Construction and Safety Standards Acts. Many firms that could not comply with HUD's standards were acquired by larger "manufactured" (mobile) home producers. Table 4 also indicates that only 4 of the top 25 are private firms, the remainder being publicly traded corporations. Many of the public homebuilders have established mortgage banking subsidiaries to originate, underwrite, sell, and service home mortgages.

²⁸*Automation in Housing*, various issues,

²⁹*Automation in Housing*, 1984

Table 4.—The Nation's Top Producers of Mobile Homes

Company name	Headquarters address	1984 housing units
Champion Home Builders Co. ^a	Dryden, MI	22,795*
Fleetwood Enterprises, Inc. ^b	Riverside, CA	21,613*
The Commodore Corp. ^c	Syracuse, IN	20,580 ^o
Skyline Corp. ^d	Elkhart, IN	16,892*
Redman Homes, Inc. ^e	Dallas, TX	15,732
Guerdon Industries, Inc. ^f	Denver, CO	13,000
Liberty Homes, Inc. ^g	Goshen, IN	12,075
Fairmont Homes, Inc. ^h	Nappanee, IN	11,815*
U.S. Home Manufactured Housing Corp. ⁱ	Houston, TX	10,179*
Tidwell Industries, Inc. ^j	Haleyville, AL	9,636*
Zimmer Corp. ^k	Boca Raton, FL	8,500
Kaufman & Broad Home Systems, Inc. ^l	Los Angeles, CA	8,164*
Schulte Homes Corp. ^m	Edenton, VA	7,200
Horton Homes, Inc. ⁿ	Boaz, AL	6,623
River Oaks Homes, Inc. ^o	Dallas, TX	6,000
Palm Harbor Homes, Inc. ^p	Newport, NC	5,554
Conner Homes Corp. ^q	Greensboro, NC	5,460
Oakwood Homes Corp. ^r	Knoxville, TN	4,800
Clayton Homes, Inc. ^s	Indianapolis, IN	4,489
DeRose Industries, Inc. ^t	Madison, WI	4,000
Wick Building Systems, Inc. ^u	Double Springs, AL	3,433
Winston Homes, Inc. ^v	Santa Ana, CA	3,350
Golden West Homes ^w	Arlington, TX	3,250 ^o
Fuqua Homes, Inc. ^x	Moultrie, GA	3,018
Destiny Industries, Inc. ^y	Atlanta, GA	3,000
Vintage Homes ^z	Bartow, FL	2,880
Home of Merit, Inc. ^{aa}		2,702

*Figure estimated by RED BOOK editor.

^aFirm also produces motor homes.

^bFirm also produces travel trailers and motor homes.

^cFirm is a publicly held corporation (Am@). Firm also manufactures modular/sectional and panelized units as well as commercial mobile units.

^dFirm also manufactures travel trailers and mini-motor recreational vehicles.

^eFirm is a subsidiary of Redman Industries, Inc.

^fFirm is a subsidiary of City Investing Co., New York, NY, as is Wood Brothers, Denver, CO, and General Development Corp. of Miami, FL.

^gFirm also produces modular/sectional units.

^hMajor subsidiaries are Brigadier Homes (mobile homes) and Interstate Homes (modular/sectional homes). Centurion Homes is a subsidiary of Brigadier Homes.

ⁱFirm also produces modular/sectional homes. Shelter Resources-Winston Industries was purchased by Tidwell Industries.

^jFirm is a wholly owned subsidiary of Kaufman & Broad, Inc., Los Angeles, CA.

^kFirm also produces modular/sectional units.

^lFirm is a subsidiary of River Oaks Industries, Inc.

^mConner Homes Corp. acquired Breck Homes Inc. and Haverlock Homes Corp.

ⁿManufacturing conducted through Homes by Oakwood, Inc., a wholly owned subsidiary.

^oFirm also manufactures panelized homes.

^pFirm is a subsidiary of Tidwell Industries, Inc.

^qFirm also produces modular/sectional homes.

^rFirm is a subsidiary of Fuqua Industries, Inc., Atlanta, GA.

^sFirm is a subsidiary of Vintage Enterprises.

SOURCE: Office of Technology Assessment.