LOCAL BUILDING CODES AND THE USE OF COST-SAVING METHODS

by Richard Duke

A Staff Report

of the

Bureau of Economics

to the

Federal Trade Commission

December 1988

LOCAL BUILDING CODES AND THE USE OF COST-SAVING METHODS

by Richard Duke

A Staff Report

of the

Bureau of Economics

to the

Federal Trade Commission

December 1988

Federal Trade Commission

DANIEL OLIVER, *Chairman*
TERRY CALVANI, *Commissioner*
MARY L. AZCUENAGA, *Commissioner*
ANDREW J. STRENIO, JR., *Commissioner*
MARGOT E. MACHOL, *Commissioner*

Bureau of Economics

John L. Peterman,
Director
John R. Woodbury,
Associate Director for Special Projects
Ronald S. Bond,
Deputy Director for Operations and Consumer Protection
James Langenfeld,
Deputy Director for Antitrust
Paul A. Pautler,
Deputy Director Economic Policy Analysis
Denis A. Breen,
Assistant Director for Antitrust II
Robert T. Brogan,
Assistant Director for Antitrust I
Gerard R. Butters,
Assistant Director for Consumer Protection

ACKNOWLEDGMENTS

This study benefited from the contributions of many individuals. Of those within the Federal Trade Commission, the greatest credit goes to Gerard Butters, who supplied ideas, econometric expertise, and editing. Keith Anderson, Edward Gallick, John Hilke, James Langenfeld, John Mooney, Michael Goldenberg, Russell Parker, Douglas Webbink, Alan Mathios, and Thomas Stanton (formerly with the Federal Trade Commission) made helpful suggestions.

Outside the Federal Trade Commission, Steven Allen of North Carolina State University at Raleigh graciously contributed the results of his survey of unionization in the construction trades. Several people at the National Association of Home Builders Research Foundation contributed help. Robert Stroh supplied data on home builders, and he, Lee Fisher, and Donald Luebs were a constant source of information about building practices. Officials of the major model code organizations were also exceedingly helpful, especially Richard Lawes of the Building Officials and Code Administrators International, Raymond Whalen of the Southern Building Code Congress International, and Donald Watson of the International Conference of Building Officials. Donald Pinkerton and Robert Wible of the National Conference of States on Building Codes and Standards also provided assistance.

Others within the FTC provided valuable help. John Hamilton, Allen Jefferson, and Michael Hunter furnished computer assistance. Patricia Cahill, Sharon Johnson, and Robert Pollock ordered copies of building codes from various cities.

John C. Weicher of the American Enterprise Institute reviewed the manuscript and contributed several helpful comments.

Executive Summary

Previous studies concluded that locally-drafted building codes increase construction costs for single-family houses. Using more recent information, this study finds that locally-drafted building codes no longer significantly increase building costs. There are two reasons for this finding. First, almost all localities now have either adopted one of three national associations' model codes or are covered by a state code based on one of these model codes. Any restriction on building practices now result from model codes, not from locally-drafted ones.[1] Second, many builders do not use cost-saving techniques permitted by the model codes. Purchasers of new homes apparently believe that houses built with the older techniques are of higher quality, substituting newer techniques only when cost saving are substantial.

---

[1] This study does not attempt to determine the appropriateness of the restrictions contained in the model codes or any of the codes incorporated into the model codes, such as the National Electrical Code. Thus, we cannot rule out the possibility that building code regulation remains overly restrictive because of the conditions imposed by the model codes.

In addition, we do not consider the possibility that some building practices are not permitted by local building officials, even though they would satisfy the standards, particularly performance standards, contained in the model code used by the locality.

Model Codes Have Almost Entirely Replaced Locally-Drafted Codes

To determine whether local building codes are currently restricting construction practices, the study examines building code regulation of single-family housing construction in 162 U.S. cities during 1981. The study finds that building codes are not written locally in 97 percent of these jurisdictions. Virtually all these cities have adcpted model codes or are covered by state codes based on a model code. Thus, the model codes determine acceptable building practice.

A comparison of our findings with those of earlier surveys shows that many cities appear to have adopted model codes during the late 1960's. In 1964 only 47 percent of jurisdictions were covered by model codes. This proportion increased to about 90 percent in 1970 and to 94 percent by 1976.

The Federal government and private lawsuits appear to have played major roles in the spread of the model codes. During the 1960's, the Federal government required cities to adopt a model code in order to qualify for urban renewal funds. Courts also began to overturn highly restrictive local building codes.

Many Builders Do Not Use Cost-Saving Techniques Permitted by Building Codes

Based on an examination of six cost-saving techniques,[2] it appears that many builders do not employ newer techniques permissible under current codes.[3] The six cost-saving practices range from innovations in roof support systems, such as wider spacing of rafters and the use of trusses rather than rafters, to the use of plastic panels rather than ceramic tile around bathtubs. They include wider spacing of studs in walls, substituting 2x3's for 2x4's as studs in partition walls, and using pre-assembled pipes for bathroom plumbing (plumbing trees) and pre-wired electrical panel boards.

These practices are generally regarded as progressive and technologically proven. Several of them have been cited by critics as examples of the kinds of innovations whose use is retarded by restrictive building codes. Estimated cost-savings associated with these techniques range from approximately $575 per house using roof trusses spaced 24 inches apart to

---

[2] The data come from a 1981 survey of builders' practices conducted by the National Association of Home Builders Research Foundation.

[3] While the techniques appear to be permitted by wording of the codes, we have not determined whether local building inspectors would, in all cases, readily agree that they are acceptable.

$50 or less per house from using of 2x3s in partition walls, plumbing trees, or pre-wired electrical panel boxes.[4]

While approximately two-thirds of builders used innovative roof support systems in 1981, the other techniques were used much less frequently. About one-quarter of builders used plastic panels around the bathtub; and about 20 percent used one of the cost-saving methods for partition walls. Only about five percent of builders used plumbing trees or wider spacing of studs in load-bearing walls.

The sample shows that innovative techniques will not be adopted by all builders, even after the building codes permit their use. To a large degree, it is the market, rather than government regulation, that limits the acceptability of these techniques.

Cost-Saving Techniques Are Used More Frequently When the Savings Are Significant or When Consumers Do Not Strongly Prefer Older Methods

Given that the sample of newer techniques are not prohibited by building codes, the report analyzes reasons why these techniques have not been universally adopted. It finds that, while the six newer techniques would reduce the cost of building a house, they may also lower its value. For example, a house which has roof trusses rather than rafters

---

[4] The cost savings are estimated for an illustrative house, which is a two-story house with dimensions of 24 feet by 30 feet with a single bathroom. See Appendix B for more detail on the estimation of the savings.

has less usable attic space, and closer spacing of wall studs provides greater rigidity to the house. In addition, consumers may find ceramic tile around the bathtub more attractive than plastic panels.

Looking at the pattern of utilization of the innovative techniques in the sample, those older techniques which are used most frequently appear to add more to the value of a house than to the cost of construction. In particular, the data show that the greater the resulting cost savings, the more likely it is that an innovative technique will be used. For example, roof trusses, which reduce costs by more than $500, are used more frequently than plumbing trees, which save only about $50.[5] Plastic panels around bathtubs save approximately $100 per bathroom, which is less than the saving from roof trusses but more than the saving from plumbing trees. About one-fourth of the builders use plastic panels in their new house construction, less than the number using roof trusses and more than the number using plumbing trees.

Other cost-related evidence also suggests new home buyers and builders perform a quality-cost trade-off when evaluating new cost saving technologies. For example, the cost savings

---

[5] More than sixty percent of builders either use roof trusses spaced 24 inches apart or use roof rafters with 24 inch spacings, while plumbing trees are used by only about five percent of builders. The main exception to this pattern is the use of 24 inch spacing of studs in load-bearing walls. While we estimate that wider spacing would save about $125 per house, it was used by only 6.1 percent of the builders.

from some techniques may be greater where many houses are built with the same floor plan, because some factory production time is lost whenever the design of a plumbing tree or a roof truss is altered. Similarly, it is less costly to use a crane to install roof trusses when many comparable houses are constructed at the same site. Therefore, large builders should be more likely to use these techniques, because they are in a better position to realize the cost savings and pass them on to consumers. The report finds that large builders are indeed more likely to use innovative roof support systems and plumbing trees, as well as being more likely to use wider stud spacing in both load-bearing and partition walls.[6]

In addition to these cost-related indications that buyers and builders perform a trade-off in deciding whether to use newer techniques, there is evidence that consumers are

---

[6] Some of the evidence is ambiguous about whether the magnitude of the cost savings is the key determinant of buyers and builders adopting an innovation. Innovative techniques might be used more frequently where they would lead to large labor or materials cost reductions -- i.e. high wage-rate or high material cost sections of the country. We find the use of plastic panels around the bathtub and of plumbing trees is greater in areas with higher wage rates. However, the other techniques were not used more frequently in high wage areas, and no significant relationships were found between the use of the various techniques and regional materials costs.

The strength of labor unions might also affect the use of innovative techniques, either because restrictive union work rules increase the cost savings from use of the innovative techniques or because the unions use their power to keep the techniques from being used. However, we find no significant relationship between use of the techniques and union membership.

willing to pay more for particular older building techniques. For example, if wealthier home buyers demand higher quality construction, then cost-saving techniques will be employed less frequently in higher-priced homes. In the sample, a smaller proportion of higher priced homes use four of the techniques studied, suggesting that the older techniques are perceived as representing higher quality.[7]

Model Codes And Other Alternatives To Local Building Codes

The model codes that have replaced most local building codes are generally viewed as improvements over the local codes.[8] However, this study does not consider whether the model codes are more restrictive than they should be. Some evidence suggests that, on occasion, model codes have been slow to adopt innovations. For example, plastic pipe had been available for 18 years before its use for drain, waste,

---

[7] The main exception, plumbing trees, is the only technique in the sample for which there is no obvious quality difference between the new and the old technique. Pre-wired electrical panel boards are not discussed here because they were used by only 0.4 percent of builders.

[8] For many aspects of house construction, model codes tend to be performance oriented and allow builders to choose from a range of techniques that meet structural and safety requirements. (The primary exceptions are the plumbing and electrical systems of a house where the codes still mandate the use of specified techniques.) The local building codes that model codes replaced frequently specified particular techniques and materials, presumably limiting the innovation and use of least cost techniques. In addition, older local building codes were updated only infrequently, further limiting the use of innovative techniques.

and vent pipe was approved by any model code association. Further, the Federal Housing Authority had approved the use of plastic pipe six years before it was first approved by a model code group. Regulation-induced delays of innovative techniques can impose significant costs on those consumers who would buy homes with these innovations.

Given these delays, building codes may not be the best way to ensure that consumers get at least the minimum quality they desire in a house. Alternatives include private insurance and requirements that builders disclose the use of new or unproven techniques. These approaches are less likely to limit new and beneficial techniques than building codes, although they may present other problems. The study does not evaluate these other less regulatory approaches, but suggests they should be considered as alternatives to the current scheme of codes.

TABLE OF CONTENTS

TABLES

I. Introduction

It is widely believed that locally-drafted building codes significantly retard the adoption of innovative cost-saving construction methods and thereby increase the cost of housing. Builders are supposedly discouraged from using new construction methods because city officials charged with writing building codes, influenced by labor unions or material suppliers threatened by an innovation, resist approving their use. In the extreme case, the building code itself is thought to allow only a single tried and true method of construction.

However, the evidence on these issues comes from studies that use relatively old data and that do not directly examine the extent to which contractors employ innovative methods when they are permitted.[1] In this study, we use more recent data to examine the effects of building code restrictions and we seek to determine whether building code regulation actually prevents builders from using less costly construction techniques than they would otherwise employ. Toward this goal, we obtained copies of the building codes used in 1981

[1] The earlier studies were based on the published surveys of building codes conducted by Field and Ventre in 1970 and by Seidel in 1976. (See Field and Ventre (1971), Oster and Quigley (1977), Seidel (1978), and Noam (1983 and 1984).) The only study we know of that gathers systematic evidence on builders' actual practices, a report of the General Accounting Office (1978), shows that builders often use more expensive methods than required by the building code, and that builders rarely cite building codes as a reason for not using cheaper methods. Studies such as the Report of the National Commission on Urban Problems (1968) and the President's Commission on Housing (1982), which have concluded that building code regulation is highly restrictive, have relied only on anecdotal evidence of builders' practices.

in 162 building code jurisdictions throughout the United States. We also obtained data on builders' construction practices from a survey conducted by the National Association of Home Builders Research Foundation.

We found that 97 percent of the jurisdictions we surveyed no longer used a locally-drafted code, but instead had adopted a model code. In addition, the four locally-drafted codes in our sample had provisions very similar to the model codes. We also checked specific provisions of these building codes and verified that a number of cost-saving construction methods that had apparently been prohibited by many building codes in the past are now almost universally accepted. To the extent that our sample is representative of the U.S. as a whole, it would appear that local drafting of highly restrictive building code provisions is now at most an isolated problem.

We also found that builders frequently did not adopt cost-saving methods even when they were explicitly permitted by the code. Specifically, cost-saving methods were used less than 20 percent of the time in four of the six aspects of construction that we examined. This result indicates that even in the past the impact of restrictive codes was probably less than some investigators have estimated. If few builders wish to use certain cost-saving methods even when they are allowed, prohibition of these methods will have little practical effect.[2]

---

[2] The finding that builders frequently choose not to use cost-saving methods suggests an explanation for the results of Muth and Wetzler (1976), who could not find statistically significant differences between housing prices in jurisdictions with locally drafted building codes and jurisdictions with model building codes. (Their point estimate of the difference was 1.7% of the value of the house.) In contrast, other studies have concluded that local building codes have a greater impact upon construction costs. (See The National Commission on Urban Problems (1968); The President's Commission on Housing (1982); Field and Rivkin (1975); Seidel (1978); and Noam (1983).)

In seeking to explain builders' practices of often using more costly methods than the building codes require, we found that builders were responding to a combination of consumer preferences and potential cost savings from new techniques. Many of the more costly, older techniques appear to represent higher quality construction, and consumers appear to be willing to pay the higher prices necessary to construct houses using these techniques. One example of higher quality is the greater strength and rigidity gained by spacing wall studs and floor joists closer together than required by the model codes. Another example is the greater usable attic storage space produced by the use of roof rafters instead of roof trusses.

Our results appear consistent with a benign view of building code regulation: (1) local building codes no longer prohibit the use of cost-saving construction techniques, and (2) even if local building codes were restrictive in the past, the cost of these restrictions was low, since most home buyers probably would have been willing to pay extra for more costly, higher quality construction techniques. However, caution dictates that we temper this view in several respects. First, "model codes" may be too slow in allowing new construction methods or materials to be used. For example, the National Electrical Code may well have delayed the approval of electrical conduit made from polyvinyl chloride.[3] While examination of this issue is beyond the

---

[3] Specifically, the largest producer of steel electrical conduit has been held to have prevented the acceptance of electrical conduit made from polyvinyl chloride in the 1981 edition of the National Electrical Code. (Electrical conduit is hollow tubing used as a raceway to contain electrical wires inside walls and floors.) This plastic electrical conduit was approved in the next edition of the code in 1984 only for use in buildings of three floors or less, and was not approved for use in all buildings until the subsequent edition in 1987. (See *Allied Tube & Conduit Corp. v. Indian Head, Inc.*, No. 87-157 U.S. Supreme Court, June 13, 1988.)

(continued...)

scope of this study, it is a potentially serious concern. Second, even when progressive codes are used, much is left to the discretion of local building officials in the enforcement of the codes. We cannot rule out the possibility that the opposition of local building officials is part of the explanation for the infrequency of adoption of cost-saving construction techniques. Third, we have not investigated more radical alternatives to the current system of building code regulation (such as a liability system or disclosure requirements) that might conceivably allow more flexibility in building practices and a more rapid development and introduction of technical improvements. These caveats are explored further in the conclusion.

The remainder of this report consists of three parts. In section II, we sketch the recent history of building code regulation and attempt to identify the major factors responsible for the shift to model codes. In section III, we document the extent to which various cost-saving methods are actually employed by builders. In section IV, we analyze builders' decisions to use cost-saving techniques.

II. The Evolution Towards Uniform Model Codes

Since World War II the regulation of building construction in the United States has evolved from a pattern of differing local regulations toward greater use of more uniform model codes. Before World War II, state governments and the Federal government had little, if any, role in regulating

---

[3](...continued)
Another example of delay in model code approval of an innovative construction technique involves the use of plastic pipe for drain, waste, and vent purposes. Plastic pipe had been available for 18 years before its use was approved by any model code association. Further, the Federal Housing Authority had approved the use of plastic drain, waste, and vent pipe six years before it was first approved by a model code group. (See Seidel (1978) for a discussion of delays in the approval of plastic pipe.)

building practices. Local governments decided whether to regulate building construction, determined the provisions of their codes, and established the methods of enforcement. Consequently, there were substantial differences in building codes among local jurisdictions. After the war, however, changes in economic conditions, the creation of new model codes by professional associations of building code officials, and pressures from Federal and state governments have led to the increasing use of three similar model codes. These model codes allow substantially more choice of materials and methods of construction, and are widely considered to be less restrictive in practice than older, locally-drafted codes. Judging from our sample of 162 local jurisdictions, the shift to the use of these model codes is now almost complete.

We begin our sketch of the evolution to model codes by identifying the major model codes and stating the principles on which they are based. We then summarize the conclusions of previous studies which show that locally-drafted codes have tended to be more restrictive than model codes. Third, we describe the forces that have fostered the acceptance of model codes. Finally, we describe our sample of 162 building codes in effect in 1981.

A. The Origin and Function of Model Codes

The first model code was issued in 1905 by the National Board of Fire Underwriters, an association of property insurance companies. The purpose of this code, which was issued in response to catastrophic fires in several major cities, was to reduce fire hazards. Called the National Building Code, it was drafted as a set of regulations suitable for adoption by cities. The code was maintained and revised over the years by the association and its successors. It has not been revised since 1976 because the American Insurance

Association, the latest form of this organization,[4] believes the objectives of the code are being accomplished by the three model code organizations.

In 1927 the International Conference of Building Officials (ICBO) became the first model code organization to issue a code. A second model code was issued in 1946 by the Southern Building Code Congress, and the third major model code was issued in 1950 by the Building Officials and Code Administrators International (BOCA). A regional pattern has developed in the adoption of these codes: the BOCA code is used primarily in the Northeast and Midwest; the Southern code in the South; and the ICBO code in the West. The ICBO code has also been adopted by many jurisdictions in Michigan and by Indiana as its state code.

Finally, the three model code associations and the American Insurance Association have collaborated to form a single code specialized for residential construction: the One and Two Family Dwelling Code, first issued in 1973.[5] The purpose of this code is to achieve national uniformity by eliminating conflicts and duplications among the model codes. Jurisdictions that adopt a model code typically adopt the One and Two Family Dwelling Code at the same time. Builders in these jurisdictions have the option of filing their plans under the standards of either model code.

A pattern of state building codes also developed during this

---

[4] The American Insurance Association was formed by a merger of the National Board of Fire Underwriters with the Association of Casualty and Surety Companies and the old American Insurance Association.

[5] The third edition of this code, identifies it as *One and Two Family Dwelling Code*, Third Edition, 1979, Under the Nationally Recognized Model Codes: Basic Building Code, Standard Building Code, and Uniform Building Code. The code is copyrighted by these three code organizations.

period.[6] Seven states had adopted a building code by 1970, and 30 states had adopted a building code by 1981. Every state code is based upon one of the model codes developed by the three model code associations, except for the New York State code.[7] Twenty-one of these 30 state codes set mandatory minimum or maximum standards for local building codes in the state; the other nine state codes were purely voluntary in 1981. (New York's code changed from voluntary to mandatory in 1984.) Fifteen of the mandatory-code states prevented local jurisdictions from making their codes more restrictive than the state code either by setting maximum standards or by requiring state approval of local amendments. Eight of these states imposed both mandatory minimum and maximum standards, thus allowing no variation in codes without explicit state approval.- Similarly, in five of the nine voluntary-code states, if localities chose to adopt the state code, they were required to obtain state approval for any amendments to the code.

Building codes cover all aspects of construction, from foundations and walls to plumbing and heating. The plumbing, mechanical, and electrical codes are usually recorded in separate documents, but are incorporated by reference in the primary building code. The model codes all use the National Electrical Code.

In many aspects of house construction, model codes allow builders discretion in the choice of building materials and methods subject to the constraint that the techniques employed must satisfy the performance standards contained in

---

[6] The material in this paragraph is taken from a directory published by the National Conference of States on Building Codes and Standards (1982).

[7] Since the New York State code has provisions very similar to those of the model codes, we classify all state codes as being "model codes".

the codes.[8] A conservative builder can follow the detailed specification guidelines contained in the code, which describes acceptable building practices down to the number and type of nails which must be used to attach the wallboard to the studs. Alternatively, builders can use any materials and construction methods they wish, as long as they demonstrate to the satisfaction of the building inspector that they are satisfying the performance criteria specified in the code. Of course, only those materials and methods that are consistent with the performance standards in the code can be employed and thus the model codes can still restrict innovation.

When a builder uses unconventional construction techniques, the burden of proof is on him to demonstrate that they satisfy the performance standards of the code. The building code inspector may require the builder to present test evidence of the soundness of his methods at his own expense, and ultimately the inspector has wide discretion in accepting or rejecting the builder's plans. Some inspectors simply accept a research report from the National Association of Home Builders or a professional engineer's stamp as adequate proof that a construction design is sound. Other inspectors may set the burden of proof so high that builders do not find it cost-effective to use innovative techniques. However, if an inspector unreasonably persists in disallowing the use of novel but safe construction methods, his decisions are ultimately subject to court review and possible reversal.

Model codes provide a compromise between the need to tailor building regulation to local conditions and the objective of having uniform building regulation so that builders need not use different construction methods when

---

[8] One exception to this is the electrical aspects of house construction, which are governed by the National Electrical Code. The National Electrical Code uses specification standards rather than performance standards. Another exception is plumbing, which is generally governed by codes using specification standards.

they build in different jurisdictions. The codes set forth uniform design principles by which the construction is to be evaluated, but allow the stringency of the standards to vary according to local conditions. For example, codes specify how to measure the ability of a structure to resist vertical and horizontal loads, but allow the standards of strength required to vary depending upon local snow, wind, soil, and seismic conditions. Thus, if a builder chooses a construction technique that will stand up to the most severe conditions in the areas he wishes to build, he can be assured that it will pass the codes of every jurisdiction using the model code. Alternatively, the builder can simply choose to use construction methods that pass the specification standards of the One and Two Family Dwelling Code, which are very widely accepted.

B. Differences Between Model Codes and Locally-Drafted Codes

Previous research has uniformly come to the conclusion that local building codes are more restrictive than model codes and have therefore led to substantial increases in housing prices. Several studies have concluded that a common effect of local building codes was to restrict the use of new or non-traditional building materials or techniques.[9] Surveys of cities by the National Commission on Urban Problems (the "Douglas Commission") (1968) and by Field and Ventre (1971) found that locally-drafted codes were more prohibitive of 14 advances in construction techniques than either state codes or model codes.

Many of the studies of the effects of building codes have produced estimates of the increase in housing prices attributable to the use of restrictive locally-drafted codes

---

[9] The President's Commission on Housing (1982); U. S. Congress, House Subcommittee on Housing and Community Development (1981); Nutt-Powell (1982); Keating (1981).

instead of model codes.[10] The Douglas Commission estimated the extra costs of home construction due to individual requirements in local codes that exceed those in model codes and in the Federal Housing Administration minimum property standards. The extra costs attributed to each of the 21 most frequently encountered requirements ranged from $25 to $640. It was estimated that if a builder of manufactured houses were forced to abide by every one of these requirements, the builder's cost of construction would be increased by 15.3 per cent. Noam (1983), using regression analysis, estimated that in 1970 housing prices in jurisdictions with extremely restrictive local building codes were 4.9 percent higher than the national average.

One reason local codes are more restrictive than model codes is the greater weight likely to be given to local interests. Field and Ventre (1971) assert that an "intimate relationship . . . exists between code reform and the city's political-civil structure. Building codes often bestow favored economic positions upon different participants by stating construction standards as specifications favoring that participant. For example, standards that specify lumber for residential construction favor the local lumber yard, not the prefabricator of concrete housing modules." Since the proponents of technological change are usually firms outside the local community, they are also outside the local political process. Consequently, the drafters of the local building code may give less weight to their arguments than to those of local political forces, such as labor union locals and local suppliers of traditional building materials. Cost saving methods constitute economic threats to traditional interests, and therefore local officials are likely to be subjected to arguments against the introduction of such methods.

A second reason why local codes tend to be more restrictive than model codes may be because local codes are

---

[10] See The National Commission on Urban Problems (1968); Field and Rivkin (1975); Muth and Wetzler (1976); Field (1980); President's Committee on Urban Housing (1969); General Accounting Office (1982); Noam (1983).

less frequently revised to keep up with new technological developments. The model code organizations issue new editions of their codes every three years. Field and Ventre found in their survey in 1970 that 78 percent of the cities with a model code had made revisions between 1966 and 1969 but only 51 percent of the cities with a locally-drafted code had made revisions in the same time period. A major reason for this is the cost of comprehensive revision. A locality can revise its building code by adopting the latest edition of a model code for only a few hundred dollars. In contrast, the cost is substantially higher for a locality to use its own staff to conduct a comprehensive revision of its code. For example, New York City spent $1.5 million between 1965 and 1968 on a complete revision of its code.

A third reason local codes increase construction costs is that variation in code requirements among local jurisdictions can force builders to use different techniques in different localities. Even if none of the building codes, considered in isolation, requires the use of high cost construction methods, non-uniform codes can raise housing costs by reducing the ability of builders to take advantage of economies of scale. Seidel (1978) found that where local or state building codes were in effect, one-third of the localities reported "significant variations" between their code and those in neighboring communities. He concluded that these differences created extra costs for manufacturers of building products and for builders installing them.

C. Diffusion of Model Codes

The 1960s and 1970s were a time of transition as many cities moved from their local code to a model code. In 1964, only about 47 percent of cities had model codes.[11] Based on

[11] This figure is based on a survey of 140 cities conducted by the International City Management Association. The results are reported in Field and Ventre (1971). This survey found that 45.7 percent of cities used the model codes while 1.4 percent used state codes.

Field and Ventre's survey for the International City Management Association, model codes were used in close to 87 percent of cities by 1970.[12] As discussed below, our survey of 1981 codes found that 97 percent of the cities surveyed used model codes.[13]

The Federal government and private law suits have been important forces behind the increase in the adoption of model codes. The Federal government has promoted the adoption of model codes in three major ways.[14] The most direct method has been by providing funds to localities to modernize their building codes. Another avenue has been through the Urban Renewal Program, especially the provision that localities must adopt a building code based upon a national building code in order to be eligible for urban

---

[12] 73.5 percent of the cities in the sample used one of the model codes, while state or county codes were used by 13.5 percent of cities. Field and Ventre report that their category of state and county codes consists almost entirely of state codes.

A survey conducted by the National Commission on Urban Problems in 1967 found that 54.1 percent of cities with populations over 5,000 used a model code at that time (Manvel, 1968).

[13] See discussion on pp. 51-17. A survey conducted by the Center for Urban Policy Research in 1976, found that only 6 percent of cities had a locally-drafted code. Seventy-seven percent of the cities had a model code, 10 percent had a mandatory state code, and 7 percent had a voluntary state code. (Seidel, 1978).

[14] Interview with Orville G. Lee, director of the Building Technology Research Staff, Department of Housing and Urban Development.

renewal assistance.[15] A third effort was "Operation Breakthrough", a program sponsored by the Department of Housing and Urban Development, to evaluate new building materials and techniques. Demonstration houses were built, and the evaluation of materials and techniques was based on performance standards rather than on the specification standards typical of local codes.

In deciding private law suits, courts have shifted from their traditional doctrine of limited judicial review of building codes and their administration toward a more active stance (Field, 1981). They have moved building code regulation toward a greater responsiveness to new methods and materials. As a result, the courts have encouraged the adoption of model codes as well as more uniform administration of building codes.

In New Jersey, a local building code official denied a permit to build a Gunnison prefabricated house produced by the United States Steel Company, even though the builder submitted evidence of structural adequacy.[16] The evidence included test results from a university testing facility, design approval by the Federal Housing Administration, and evidence of compliance with the state's two building codes governing one and two family houses. The court ordered that a building permit be issued, saying:

> There must be a reasonable relation between the regulations provided therein and the safety, health or other public interests designed to be served; otherwise, there is an unwarranted intrusion on the fundamental

---

[15] Although this program was later replaced by a grant program that meant a reduction in Federal influence over local governments, the jurisdictions that had adopted a model code in order to obtain Federal urban renewal funds did not revert to the use of local codes.

[16] The discussion of cases in this section is based on the description contained in Field (1981).

> prerogative of an owner of property to do with his own as he wishes.[17]

The Supreme Court affirmed this reasoning in 1962 by saying:

> To justify the state in . . . interposing its authority in behalf of the public, it must appear, first that the interests of the public . . . require such interference; and, second, that the means are reasonably necessary for the accomplishment of the purpose, and not unduly oppressive upon individuals.[18]

In 1963, the Seventh Circuit Court of Appeals stated:

> . . . a building code should be reasonably related to the goals of public health, safety and welfare. . . . The exercise of the police power cannot be used as a cloak to prevent the use of new materials and methods of construction merely because they are new and may displace older methods and materials.[19]

In another case, Kingsberry Homes successfully sued Gwinnett County, Georgia, in 1965 when the county government refused to issue building permits for Kingsberry's manufactured houses.[20] Kingsberry built houses in its factories and shipped them in the form of panels for

---

[17] *Cox v. Township of Wall*, 39 N.J. Super. Ct. 243, 120 A.2d 779, 781 (1956).

[18] *Goldblatt v. Town of Hempstead*, 369 U.S. 590 (1962).

[19] *Home Building Contractors, Inc. v. County of Du Page*, 322 F. 2d 635, 637 (7th Cir. 1963).

[20] *Kingsberry Homes Corp. v. Gwinnett County*, 248 F.Supp. 765 (N.D. Ga. 1965); and *Boise Cascade Corp. v. Gwinnett County*, 272 F.Supp. 847 (N.D. Ga. 1976). (During the time between these cases, Boise Cascade acquired Kingsberry Homes.)

assembly on the construction site. Although Kingsberry's houses complied with model building codes, Gwinnett County said they did not meet its own local building code. The reasons were that Kingsberry's houses contained 3/8-inch thick plywood in the roof (instead of 1/2-inch thick plywood) and the corner-bracing consisted of fiberboard sheathing (instead of plywood sheathing or diagonal timbers). Kingsberry regarded the cost of modifying its production methods to meet the Gwinnett County code as prohibitive in view of the small size of the market in Gwinnett County relative to Kingsberry's total market. Extensive tests of both methods were made for the trial. Kingsberry's roof-decking method met the requirements of the Southern model code, the Veterans Administration, and the Federal Housing Administration. The court found that the 3/8 inch plywood used by Kingsberry was equivalent to the 1/2 inch plywood required by the Gwinnett County code. The court also found Kingsberry's fiberboard corner bracing system stronger than the diagonal timber bracing system approved by the county code, even though weaker than the plywood sheathing system also approved by the county code. Therefore, the court held the county's requirements unreasonable, and ruled that the fiberboard requirements of the Southern model code would be acceptable for the county. In a footnote, the judge added that if local requirements exceeded the standard established by competent authorities, the local requirements were unreasonably prohibitive.

In Michigan, a township ordinance prohibiting a roof suspension and interior bearing system was successfully challenged on the basis of testimony by two architects who said that the system provided strength and safety equal to or greater than that required by the local code.[21] In Alabama, the state supreme court allowed the use of 3/4 inch plywood in partition walls as an alternative to the conventional stud wall system specified in the Montgomery building code.[22]

---

[21] *Johnson Construction Co. v. Township of White Lake*, 351 Mich. 374, 88 N.W. 2d 427 (1958).

[22] *Montgomery v. Robbins*, 277 Ala. 29, 166 S. 2d 871 (1964).

These legal challenges had the effect of making some local codes more like the model codes, and they may have prompted some localities to adopt a model code.

D. The Status of Building Codes in 1981

In order to get more recent information about building codes, we purchased copies of the building codes in force in 1981 from a sample of 162 cities throughout the United States. The set of cities was chosen to be as broadly representative of U.S. cities as possible subject to the constraint that data on construction wages, cost of materials, and the adoption of cost-saving building techniques were available. The cities in the sample are listed in Appendix A.

In 1981, 97 percent of the jurisdictions in our sample no longer used a locally-drafted code, but instead had adopted a model code. The distribution of these cities among the model codes were 58 for the BOCA, 31 for the Southern, 61 for the ICBO, and 8 for the New York code. In recent years, two of the four cities that had used their own local code have adopted a model code. Jacksonville, Florida, adopted the Southern model code in 1985, and Washington, D.C., adopted the BOCA model code in 1987. Telephone interviews with the model code organizations in 1987 uncovered no instances of jurisdictions reverting to a local code after adopting a model code.

Although all the jurisdictions using model codes made amendments to them, we found no cases in which the amendments appeared designed to gut the model code by reverting back to an extensive use of specification standards.[23] Amendments to the codes in our sample were made for a variety of purposes. Approximately half of the

---

[23] In particular, none of the model codes in our sample were amended to prohibit any of the cost-saving methods described in section II of this study.

amendments in our sample are purely procedural, setting forth definitions, fees, and inspection schedules. Other amendments made minor changes in specifications or described local conditions (such as snow, wind, seismic, or flood conditions) needed to determine the performance levels required by the model code. Often the amendments made the model code somewhat less restrictive. For example, Wichita, Kansas, broadened the building-permit exemption for above-ground swimming pools; and Houston made an amendment explicitly stating that wind tunnel tests with a miniature scale model are an accepted means of determining whether the structure meets the wind pressure standards in the code.

Some of the amendments did raise the standards, but they still appeared to maintain the code as a performance standard rather than specifying the materials to be used. For example, many jurisdictions have added insulation requirements, but the standards are structured in terms of R-values instead of as requirements to use a particular amount of a specific insulating material. Other examples of added restrictions include requirements to install smoke detectors and limits on the allowable flame-spread ratings of foam plastics used for insulation.

III. The Use of Selected Cost-Saving Construction Methods

To measure the extent of adoption of selected cost-saving construction methods, we used 1981 data from a survey of builders of single-family homes conducted annually by the National Association of Home Builders Research Foundation, an industry trade association. The survey collects information on a variety of builders' practices, on the size of builders, and on the average price of each of the builder's houses. It is mailed to more than 40,000 builders who are members of the National Association of Home Builders (NAHB). About 4,000 usable responses, covering about ten percent of the housing starts in each state, are generally received. The survey was begun in 1974, expanded in 1976, and the data were made available on a county basis for the first time in 1980.[24]

The NAHB Research Foundation survey provided data on builders' adoption of cost-saving methods for constructing the following parts of a house:

1. Roof: The traditional method of supporting a roof is to use roof rafters spaced 16 inches apart. Costs may be reduced by spacing the rafters 24 inches apart or by using

---

[24] See National Association of Home Builders Research Foundation, *Home Builder Surveys*, unpublished memo (undated). The NAHB Research Foundation has conducted two tests that found this survey to be reasonably representative of construction practices in general, despite the relatively poor response rate. The first test was a survey of nonrespondents, conducted in 1976 by the Opinion Research Corporation. Telephone interviews were conducted with 396 randomly selected nonrespondents, and the results were compared with a similarly sized random sample of respondents. The average number of single-family detached housing units built was 21.2 by respondents and 21.8 by nonrespondents.

The second test for reliability was a comparison of the survey results with the 1976 and 1979 new housing characteristics as reported by the Census Bureau in its *C25 Series Construction Reports.* The following ten characteristics were common to both surveys and were used as the basis for comparison: air conditioning, bathrooms, exterior wall covering, fireplaces, foundations, heating fuel, heating system, garages, number of stories, and floor area. The NAHB Research Foundation reported no significant differences between the two surveys for these ten housing characteristics.

preassembled roof trusses instead of rafters. Trusses may be spaced either 16 or 24 inches apart.[25]

2. Load-bearing walls in the top story: Load-bearing walls in the top story of a house may be built with 2x4's using 24 inch spacing in place of the traditional 16 inch spacing. (Even model codes require 16 inch spacing in a wall which bears the weight of both an upper story and the roof of the house.)[26]

3. Partition walls: Partition walls are non-load-bearing walls. The traditional method is to use 2x4's spaced 16 inches apart. Costs may be reduced by using 24 inch spacing of 2x4's, by using 2x3's spaced 16 inches apart, or even by using 2x3's spaced 24 inches apart.[27]

---

[25] While the codes permit the use of roof trusses and of 2x6 and 2x8 rafters spaced 24 inches apart, their use is limited to cases in which the stress and span of the trusses or rafters does not exceed specified values. (See Council of American Building Officials (1979), Appendix B, Tables 7-E through 7-S, pp. 208-235.)

[26] If utility grade, rather than standard grade, 2x4's are used, studs must be spaced 16 inches apart. (See Council of American Building Officials (1986), p. 45 and Uniform Building Code (1982), p. 221.)

[27] While 24 inch spacing of 2x3 studs in partition walls was not permitted in 1981 under the *One and Two Family Dwelling Code*, it was permitted under the BOCA and the Southern codes. (The *One and Two Family Dwelling Code* adopted this practice in its next edition in 1983.) (Council of American Building Officials, 1979 edition, Section R-402.3, p. 29, and 1983 edition, Section R-402.4, p. 47; Southern Building Code Congress International, 1979 edition, Section 1706.6 (a), p. 17-15; and telephone conversation with Richard Lawes, Building Officials and Code Administrators, October 18, 1988).

4. Plumbing: In at least some cases, costs can be reduced by using a preassembled plumbing tree, which is a section of drain and vent pipe for the bathroom.[28] The traditional method is to assemble all the plumbing at the construction site.

5. Bathtub surround: Traditionally tile is used to protect the walls adjacent to the bathtub from water damage. Panels made of fiberglass or other plastics are less expensive to install.

6. Mechanical core: A pre-wired electrical panel board provides cost savings over the traditional on-site wiring of the panel board.

Each of these cost-saving construction methods is generally regarded as progressive and technologically proven, and each of them appears to meet the requirements of the model codes.[29] However, several of them have been repeatedly

---

[28] However, see the discussion on p. 33.

[29] While the individual model codes do not explicitly state that all of these techniques are permissible under the model codes, we believe they are acceptable. The third edition of the *One and Two Family Dwelling Code*, published in 1979 (Council of American Building Officials (1979)), identifies the following practices as acceptable: (i) the use of roof trusses (Figure No. A-7, Note 1, p. 69), (ii) the use of roof rafters of 2x6's or 2x8's spaced 24 inches apart (Tables 7-E through 7-S, pp. 206-235), (iii) the use of 2x4's spaced 24 inches apart in load bearing walls in the upper story of a one or two story home (Figure No. A-4, Note 1, p. 31), (iv) the use of 2x4's spaced 24 inches apart or 2x3's spaced 16 inches apart in partition walls (Section R-402.3, p. 29), and (v) the use of substances other than ceramic tile around bathtubs (Section R-208, p. 13). Since we understand that practices identified as acceptable under the *One and Two Family Dwelling Code* are acceptable under any of the three main model codes, we take this as evidence that these

(continued...)

cited in the past as methods that would be used more frequently if it were not for building code restrictions. In particular, five of them were identified by the Douglas Commission in 1968 and were included in Field and Ventre's survey in 1970.[30] The first three of these methods were

---

[29](...continued)
practices are acceptable in any location with one of the model codes. While neither the *One and Two Family Dwelling Code* nor the individual model codes explicitly identify plumbing trees or pre-wired electrical panel boards as acceptable practices, the language in the codes would not appear to prohibit them; and we have been informed by officials with the model code associations that both of these practices would be considered acceptable under their codes.

It would seem that local building code officials would be unlikely to disallow a method explicitly allowed by the code. Even if a code official attempts to disallow such a practice, he would likely change his mind after the builder points out the language in the code. Our conversations with officials of the model code associations also indicated that local code officials generally allowed methods that met the performance standards of the code. However, if local inspectors do not allow such techniques based on their own interpretation of the performance provisions of the model codes, even these less restrictive codes could inhibit the use of cost saving techniques.

In addition to the fact that 2x3's spaced 24 inches apart were not acceptable everywhere (see footnote 27), there were two other cases in which a technique was not permitted: Canton, Ohio, and Washington, D.C., did not allow the use of 2x3's in partition walls. Both these cities used their own local code in 1981; however, the District of Columbia has since adopted the BOCA model code.

[30] These practices are roof trusses spaced 24 inches apart, 24 inch spacing of 2x4's in partition walls, 2x3 studs in partition walls, a prefabricated plumbing tree, and a prefabricated mechanical core.

selected by Oster and Quigley for their study in 1977.[31] If restrictive building codes had been a primary force in preventing the adoption of these cost-saving methods, we should expect to see them used frequently by the builders in our sample.[32]

Although the 1981 NAHB survey contains data for 3100 builders across the nation, for most of our analysis we included only 901 builders for which we could obtain all of the data needed.[33] The representativeness of these 901 builders in terms of geographic distribution and size of the city in which they are located is indicated in Table 1. For geographic distribution, the sample is compared to the distribution of housing starts in the United States in 1981. Builders in the South account for just over 60 percent of the housing starts in our sample,- slightly more than the Census estimate that nearly 52 percent of housing starts in the U.S. in 1981 took place in the South. Housing starts in the West are also slightly over-sampled, and starts in the Northeast and North Central areas are correspondingly undersampled.

---

[31] Oster and Quigley also included plastic pipe and non-metallic electrical sheathing in their study. However, since the NAHB Research Foundation survey did not collect data on the use of these methods, they could not be included in this study.

[32] We are aware that none of these methods represents a dramatic change in home construction methods. Unfortunately, the NAHB survey did not provide data on any such techniques. Thus, we cannot be certain that the effects we identify would hold as well for more dramatic changes.

[33] Builders were retained in the sample only if they were located in or near a city for which both wage and material cost data were available and for which we were able to obtain a copy of the local building code. In addition, a few jurisdictions were deleted from our sample in order to provide geographic balance.

Table 1

DISTRIBUTION OF BUILDERS IN SAMPLE

Geographic Distribution

Regions	Builders In Sample	Housing Starts In Sample	Housing Starts In U.S., 1981
Northeast	109	1,062	117,000
North Central	161	2,105	165,000
South	455	14,348	562,000
West	176	6,102	240,000
Total	901	23,617	1,084,000
Northeast	12.1%	4.5%	10.8%
North Central	17.9%	8.1%	15.2%
South	50.5%	60.8%	51.9%
West	19.5%	25.8%	22.1%
Total	100.0%	100.0%	100.0%

[Regions are U.S. Census definitions as listed in the Statistical Abstract.]

Size Distribution (For cities over 10,000)

Population	Sample Cities Number	Sample Cities Percent	All Cities Number	All Cities Percent
Over 1,000,000	2	1.3%	6	0.3%
500,000-1,000,000	14	9.2%	16	0.7%
250,000-500,000	28	18.3%	33	1.5%
100,000-250,000	51	33.3%	114	5.2%
50,000-100,000	26	17.0%	250	11.3%
25,000-50,000	15	9.8%	526	23.9%
10,000-25,000	17	11.1%	1260	57.1%

[In addition, two county jurisdictions and 7 cities of less than 10,000 were included in the sample.]

Sources:

Statistical Abstract, for the number of housing starts in the U.S. and the size distribution of all cities.

The survey by the National Association of Home Builders Research Foundation, for the builders and cities in the sample.

In terms of the size of cities, we have quite good coverage among the larger cities. Although the four largest cities are missing from our data, our data does include 60 of the 75 largest cities and over half of all cities with populations over 100,000.[34] However, our coverage is much less complete for smaller cities and towns. We cover less than 30 percent of cities with populations between 50,000 and 100,000, and less than 7 percent of towns with populations between 10,000 and 25,000.

Table 2 shows the percentage of builders using the six cost-saving methods of construction discussed before. To check that our subsequent analysis using a limited sample did not give a distorted picture, we display the results using both the full sample of 3100 builders and the limited sample of 901 builders. Although there were some differences between the results for the two samples, the qualitative pattern was similar. As the table shows, cost-saving methods were typically used by more than half the builders in only one of the six categories examined (namely roof construction). In three of the six construction categories, cost-saving methods were used by less than 10 percent of the builders.

As shown in Table 2, some cost saving techniques are used far more frequently than others. What accounts for their variation in use? The local codes should not have been the explanation. Each of the techniques appears to be acceptable under the model codes; and none of the local codes, which are of course based on the model codes, explicitly stated that

---

[34] Only four builders among the 3100 responding to the NAHB survey reported building single-family houses in the four largest cities (New York, Chicago, Los Angeles, and Philadelphia). Consequently, it was impossible to include any of these cities in the sample. However, suburbs of New York and Los Angeles are included in our sample.

Table 2

FREQUENCY OF ADOPTION OF COST-SAVING METHODS

Cost-Saving Method	Percent of Builders Adopting Method: 3100 Builders	Percent of Builders Adopting Method: 901 Builders
Roof Support System		
Roof trusses spaced 24"	56.6%	49.4%
Roof trusses spaced 16"	3.4	3.0
Roof rafters spaced 24"	15.4	14.5
Load-Bearing Walls		
Wider spacing of 2x4's (24")	4.5	6.1
Partition Walls		
Wider spacing of 2x4's (24")	12.5	16.8
Use of 2x3's spaced 16"	2.2	3.4
Use of 2x3's spaced 24"	0.4	0.3
Panels around Bathtub	41.1	26.5
Plumbing Tree	3.1	5.1
Mechanical Core	0.5	0.4

Source: Compiled from data collected by the National Association of Home Builders Research Foundation, Survey of Home Builders for 1981.

any of the techniques were unacceptable.[35] In an attempt to explain why these techniques, although acceptable under the building codes, were not used more widely, we looked to supply and demand factors to identify variables for a regression analysis of the adoption of the cost-saving methods.

IV. A Supply and Demand Model of Cost-Saving Methods

When purchasing a home, consumers choose between traditional and cost-saving methods of construction.[36] It is more costly to build using traditional techniques and therefore houses using these methods will be more costly. However, home buyers may find that houses built with the traditional techniques are of higher quality.

In four of the five cost-saving methods we examine,[37] it appears that the traditional method may be of higher quality than the innovative, cost-saving method. Roof trusses cause a reduction in usable attic space compared to roof rafters. Traditional spacing of studs in load-bearing walls provides additional rigidity to the house. Traditional spacing of studs in partition walls reduces the likelihood of damage to the walls themselves and makes it easier to find convenient studs

---

[35] While, as noted in footnotes 27 and 29, the use of 2x3's in partition walls, particularly 2x3's spaced 24 inches apart, was not universally permitted, the codes in all jurisdictions did permit the use of 24 inch spacing of 2x4's in partition walls.

[36] While consumers may not actually face the choice between houses that differ only in whether they employ a single cost-saving method, it is expositionally useful to assume that such choices are available.

[37] One of the techniques included in the NAHB survey, the prefabricated mechanical core, was not included in our statistical analysis because only four builders in the sample used it.

for hanging pictures. Tile around the bathtub is generally regarded as more attractive than the most common plastic alternatives.

The number of houses built using a particular traditional method will reflect the number of buyers who value the traditional method enough to pay the added cost of this type of construction. The greater the increase in quality associated with using a particular technique or the smaller the saving associated with the innovative technique, the lower the expected utilization of the technique.

In comparing the rate of use of different techniques, we would expect more widespread use of those techniques that involved the greatest cost saving.[38] To test this hypothesis, we estimated the savings, in 1981 dollars, for materials and labor associated with each of the cost-saving methods.[39] As shown in Table 3, our expectations were confirmed. Specifically, the use of roof trusses or rafters spaced 24 inches apart, which generates the greatest savings, was the method most widely adopted by the builders. The construction methods that involve the least savings were rarely used: prefabricated plumbing trees, 2x3's in partition walls, and prefabricated mechanical cores. For example, 2x3's spaced 16 inches, which save only $27 compared to 2x4's spaced 16 inches and actually costs more than 2x4's

---

[38] This is what would be expected unless consumers viewed those methods that saved the most money as being the most undesirable.

[39] These costs are for the illustrative house described in Appendix B. There are some costs that we have probably not captured, such as increased management costs associated with the use of roof trusses and prefabricated plumbing tree. This issue is discussed in Appendix B.

Our estimate is of only marginal costs; this may be an over-estimate of savings to the extent that there are fixed costs in adopting the cost-saving method.

Table 3

ILLUSTRATIVE COST SAVINGS AND
ADOPTION OF COST-SAVING METHODS

Method	Cost Savings Per House[a] (In 1981 Dollars)	Percent of Builders Using Method
Roof Support System		
Roof trusses spaced 24"	$576	49.4%
Roof trusses spaced 16"	165	3.0
Roof rafters spaced 24"	467	14.5
Panels around Bathtub	99	26.5
Partition Walls		
Wider spacing of 2x4's (24")	50	16.8
Use of 2x3's spaced 16"	27	3.4
Use of 2x3's spaced 24"	68	0.3
Load-Bearing Walls		
Wider spacing of 2x4's (24")	132[b]	6.1
Plumbing Tree	41	5.1
Mechanical Core	38	0.4

[a] The cost savings are illustrative. They are based on a two-story house of 1440 square feet, as described in Appendix B.

[b] Based on 24" spacing of 2x4's in the upper floor. (The model codes do not allow wider spacing on the first floor if there is an upper floor.)

Sources: For adoption, National Association of Home Builders Research Foundation, Survey of Home Builders for 1981. For cost savings, Means, Building Construction Cost Data, 1982, and Engelsman's General Construction Cost Guide.

spaced 24 inches apart, were used by only 3.4 percent of the builders in our sample.[40,41]

In order to further investigate the demand and supply of cost saving techniques, we now turn to an examination of the factors that determine why a particular technique is used by some builders and not by others. We can identify a number of variables that would be likely to affect the demand and supply for any particular cost-saving method. On the demand side, if traditional building methods are considered to reflect higher quality, one would expect wealthier consumers to be

---

[40] Since 24 inch spacing of 2x3's in partition walls was not permitted under the ICBO model code in 1981 (see footnote 27), the extremely small rate of use of 2x3's spaced 24 inches apart -- 0.3 percent of builders -- may not be indicative of the equilibrium demand and supply of this technique.

[41] There were two apparent exceptions to the rule that methods which saved the most money were most frequently adopted. First, roof trusses were widely used, despite the fact that the material and labor savings from using roof trusses as opposed to roof rafters with the same spacing are modest. However, roof trusses have an added advantage, not shown in the table: their use enables the builder to speed up the entire construction process by finishing the roof more quickly to provide shelter for interior construction. This means less delay and uncertainty from bad weather, more efficient scheduling of subcontractors, and lower interest cost on the builder's construction loan. Second, 24 inch spacing is used less often in upper story load-bearing walls than in partition walls (and also less often than substitutes for tile in the bathtub surround) despite the greater total savings; this difference might be attributed to a demand for safety or quality that goes beyond the minimum requirements of the building code. Other possible explanations include the desire on the part of builders to have a uniform spacing of studs in load bearing walls throughout the house (see p. 46) and the ability to use less-expensive utility grade studs if they are spaced 16 inches apart (see footnote 26).

willing to pay more for the traditional method. Although we cannot measure the wealth of house buyers directly, we proxy wealth with the average price of the houses built by each builder in the NAHB survey.[42] Buyers of more expensive houses can be expected to have a lower demand for cost-saving methods not only because they are likely to be wealthier themselves, but also because of their concern that cheaper construction methods might lower the willingness of future wealthy buyers to pay for the house when it is resold.

On the supply side, there is more incentive for builders to adopt cost-saving methods in localities with higher local labor and materials costs. Labor costs might be higher either because prevailing wage rates are higher or because union pressures lead to an inefficient use of labor (for example, union work rules might increase the manhours required to complete a job or might prevent the substitution of unskilled labor for skilled labor). In the opposite direction, however, unions might put pressure on builders

---

[42] Using cross-tab data from the *1980 Census of Housing* we estimated that the Pearson correlation coefficient between the value of owner-occupied houses and family income is 0.5. (See, Bureau of the Census, *1980 Census of Housing*, Vol. 2, Table A-1.) We would expect the correlation between value of housing and wealth to be somewhat higher.

One problem with using average house price as a proxy for purchasers' wealth is that utilization of the cost-saving techniques is expected to reduce the price of a home. Thus, it may appear that we are merely showing that the use of cost-saving techniques results in lower price rather than that lower wealth, as proxied by lower price, creates a greater demand for cost-saving methods. In the context of our cross-tabulation analysis, this may not be a significant problem. The various cost-saving methods save only a few hundred dollars apiece (see Table 3) while the house prices in the sample (which are used to proxy wealth) range from \$12,700 to \$450,000. For a discussion of this problem in the context of our regression analysis, see footnote 60.

directly to retain traditional building methods that require more labor.[43]

We also included the size of the individual builder in our analysis to test whether fixed costs are important in explaining the adoption of cost-saving methods.[44] At least two of the cost-saving methods in our study, roof trusses and prefabricated plumbing trees, may involve significant fixed costs. Adoption of either of these techniques requires the manufacture of parts that fit the particular house. Since any change in the plumbing tree or truss being manufactured is apt to require time to reset the manufacturing process, the costs of these items may be lower when a builder is constructing many houses of the same design. In addition, a crane is generally used to put roof trusses in place in multi-story houses; and the use of a crane is likely to be more economical when a large number of houses are being constructed on the same site.

If fixed costs are important, we would expect builders who are building many homes in the same area and/or who are building many houses with the same design to make more use of the innovative techniques. While we do not have data to identify builders who construct large numbers of houses of the same design or build large numbers of houses at the same site, we use the size of the builder as a proxy. We assume that large builders are more likely to build large numbers of houses with the same floor plan. Similarly, we expect that builders of large numbers of houses are more apt to build a large number on a single site.

---

[43] To the extent that non-union workers have become more common in the construction of single-family houses, less union pressure would be expected, either on builders or on those involved in changing the sections of the model codes pertaining to single-family dwellings.

[44] The NAHB survey provided data on each builder's size.

In our empirical work we used each of the 901 builders as a unit of observation and coded the following variables:[45]

1. Price of house: The average price of all houses (including land) constructed by each builder in 1981.[46]

2. Size of builder: The number of houses constructed by each builder in 1981.[47]

3. Wage rates: The hourly union wage rates in 1981 for carpenters, plumbers, and tilesetters for the market where the builder was located.[48]

4. Material costs: The materials cost saving, based on local materials costs, from utilizing the cost-saving technique in question.[49]

---

[45] Builders were assumed to build all their houses in the locality identified by their mailing address. It is, of course, possible that some builders constructed houses in other locations (either instead of building in the city in which they are headquartered or in addition to such building.) However, we were unable to determine the extent to which this occurred or to determine what, if any, effect such practices had on our results. Nevertheless, since the builders in our sample constructed on average 27 houses in 1981, it would be surprising if many of them operated outside their home market.

[46] This variable was calculated from responses to questions in the NAHB survey

[47] This variable was taken from the NAHB survey.

[48] These data were obtained from *Engelsman's General Construction Cost Guide*

[49] The prices of roof trusses, 2x8 roof rafters, 2x4 wall studs, ceramic tile (4 1/4" square ceramic tile in pregrouted sheets 4 feet square), and copper pipe (4" diameter copper
(continued...)

5. Unionization: The percentage of construction workers belonging to a union.[50]

For each builder we also coded dummy variables indicating the use of the five cost-saving methods in the areas of construction for which we had data:[51]

---

[49](...continued) drain-waste-vent type tubing, 6 feet long) in 1981 were obtained from the 1982 edition of Means *Repair and Remodeling Cost Data* for each market where a builder was located. (Specifically, these prices were calculated by multiplying the national average price for each material reported in Means by an index of local costs for each material given in this source.)

[50] The unionization data were obtained from a survey conducted by Steven G. Allen of North Carolina State University. This survey reports the percentage of construction workers belonging to a union for each of 77 cities. Unfortunately, these data were aggregated across all types of construction -- not just single family housing -- and across all construction trades. We could not find a data source giving union participation rates by city for individual trades or specialized to single family housing construction. Since these data were not available for all of the cities in our sample, the number of builders in the sample was reduced to 512 in the regression analysis where unionization was included in the equation.

[51] As noted above, we did not include the use of a prefabricated mechanical core in our analysis because it was used so infrequently as to make statistical analysis impossible. It might have been preferable to measure the frequency with which the various techniques were used, since a builder might not use the same cost-saving techniques in each house. However, the NAHB survey does not provide such data. (The specific questions from the NAHB survey used to code these variables are shown in Appendix C.)

1. Roof: This variable was coded as 1 if the builder reported that he (a) used roof trusses at least 50 percent of the time, or (b) typically used 2x6 or 2x8 roof rafters spaced 24 inches apart. Otherwise the variable was coded as 0.

2. Load-bearing walls: This variable was coded as 1 if the builder reported spacing 2x4 studs 24 inches apart in the upper-floor walls of a multi-story house or on the first floor of a one-story house. Sixteen-inch spacing of 2x4 studs, the use of 2x6 studs, steel studs, concrete block, load-bearing brick, or other methods were coded as 0.[52]

3. Partition walls: This variable was coded as 1 if the builder reported typically spacing 2x4 studs 24 inches apart or using 2x3 studs. The use of 2x4 studs 16 inches apart, steel studs, or some other method was coded as 0.

4. Plumbing tree: This variable was coded as 1 if the builder reported using a prefabricated plumbing tree. Otherwise the variable was coded as 0.

5. Bathtub surround: This variable was coded as 1 if the builder reported using panels instead of ceramic tile adjacent to the bathtub. (This includes panels made of fiberglass, acrylic plastic, ABS plastic, high pressure laminate, tile board, cultured marble, or other material.) If the builder reported using ceramic tile, the variable was coded as 0.

---

[52] It is possible that our treating of load-bearing brick as a traditional construction method could bias our results. If brick homes generally had brick (rather than wood) load-bearing walls, we might find a spurious correlation between traditional construction methods and higher prices. This could occur if buyers are willing to pay more for brick homes for reasons unrelated to the presence or absence of brick load-bearing walls, *e.g.*, because of a preference for the appearance of a brick home or because brick homes do not need to be painted. However, this does not appear to be a problem since most brick houses are built with a brick facade over a wood load-bearing frame. Only one builder in our sample used brick as the load-bearing material.

To summarize the foregoing discussion, from our supply and demand analysis, we formed the following hypotheses:

1) High-price houses will be less likely to incorporate cost-saving methods, because the high income buyers who buy expensive houses are also willing to pay extra for traditional construction, (2) builders will use labor-saving methods more often in areas where the relevant wage is higher, and (3) builders will use material-saving methods more often in areas where the relevant material costs are higher. In addition, (4) if fixed costs in adopting the use of cost-saving methods are substantial, we expect to see them used more by large builders, and (5) if labor unions are a significant deterrent to the use of cost-saving methods, we would expect to see less use of innovations in areas with a higher rate of unionization.

A. Cross-Tab Analysis

We tested these predictions through both cross-tab and regression analysis. Cross-tab results are easier to interpret, are less sensitive to the influence of a small number of outliers, and can be used to suggest alternative functional forms of the underlying relationships. Regression analysis has the advantage of separating out the effects of correlated variables, as long as the underlying model is specified correctly. Regression analysis also allows us to test our hypotheses formally using tests of statistical significance. In this case, the regression and the cross-tab results displayed similar relationships between the variables.

The cross-tab results are presented in Tables 4, 5, and 6, showing the percentage of builders using each cost-saving method with builders grouped by average price of the house, union wage rate of the relevant trade, and number of houses built.

Table 4 demonstrates, as expected, that cost-saving methods were used much less frequently in high-priced houses, reflecting wealthier buyers' willingness to pay for

Table 4

PRICE OF HOUSE AND ADOPTION OF COST-SAVING METHODS

Price Range	Number of Builders	Roof	Partition Walls	Exterior Wall Spacing	Bathtub Surround	Plumbing Tree
Less than $50,000	80	81.3%	33.8%	16.3%	40.0%	2.5%
$50,000 -74,999	261	75.9	29.9	8.4	34.1	4.6
$75,000 -99,999	214	64.5	18.7	4.7	24.8	4.7
$100,000 -124,999	122	66.4	18.0	6.6	24.6	5.7
$125,000 -149,999	86	57.0	10.5	0.0	14.0	8.1
$150,000 -199,999	78	53.9	9.0	2.6	19.2	5.1
$200,000 and over	60	50.0	3.3	0.0	13.3	6.7

Source: Compiled from data collected by the National Association of Home Builders Research Foundation, Survey of Home Builders for 1981.

Table 5

WAGE RATE AND ADOPTION OF COST-SAVING METHODS

Carpenters' Hourly Wage	Number of Builders	Roof	Partition Walls	Exterior Wall Spacing
Under $13	380	63.9%	20.5%	7.6%
13 - 15.99	413	69.5	23.7	5.8
16 - 18.99	80	62.5	8.8	1.3
19 and over	28	82.1	7.1	3.6

Tilesetters' Hourly Wage	Number of Builders	Bathtub Surround
Under $13	347	23.1%
13 - 15.99	417	26.6
16 - 18.99	98	33.7
19 and over	39	38.5

Plumbers' Hourly Wage	Number of Builders	Plumbing Tree
Under $13	83	3.6%
13 - 15.99	434	2.1
16 - 18.99	264	1.5
19 and over	120	25.0

Sources: Builders' practices were compiled from data collected by the National Association of Home Builders Research Foundation, Survey of Home Builders for 1981 and wage rates are from Engelsman's General Construction Cost Guide.

Table 6

SIZE OF BUILDERS
AND ADOPTION OF COST-SAVING METHODS

Number of Houses Built in 1981	Number of Builders	Roof	Partition Walls	Exterior Wall Spacing	Bathtub Surround	Plumbing Tree
1 - 9	431	61.9%	14.2%	4.4%	29.5%	1.6%
10 - 19	209	63.2	22.5	4.8	27.8	2.4
20 - 29	91	67.0	23.1	8.8	17.6	5.5
30 - 49	77	77.9	16.9	5.2	22.1	19.5
50 - 99	56	85.7	39.3	14.3	25.0	12.5
100 - 1240	37	94.6	56.8	16.2	18.9	18.9

Source: Compiled from data collected by the National Association of Home Builders Research Foundation, Survey of Home Builders for 1981.

traditional methods. This is the result for each of the four methods for which the traditional practice appears to have significant advantages -- roof support systems, stud spacing in load-bearing walls and partition walls, and bathtub surround materials. Only the prefabricated plumbing tree, which has no obvious functional or aesthetic disadvantages, was not used more frequently in low-priced houses.

Table 5 shows that our hypothesis that high wage rates would lead to greater use of cost-saving methods was borne out for plumbers and tilesetters but not for carpenters. The use of prefabricated plumbing trees and substitutes for tile in the bathroom rose in response to higher wages for plumbers and tilesetters, but the effects of carpenters' wages were less clear. While the use of roof trusses, which offers the greatest savings of the three cost-saving methods involving carpenters, appeared if anything to increase with higher carpenters' wages, the use of lower-cost stud systems in walls appeared to be associated with lower rather than higher carpenters' wages.[53]

Our hypothesis that higher materials prices would lead to greater use of cost-saving methods was not supported, and hence the associated cross-tabs were not displayed. Since the bulk of the cost savings are attributable to labor costs as opposed to materials costs, our inability to find a relationship here is not too surprising.

As shown in Table 6, large builders were far more likely than small builders to use prefabricated plumbing trees and to use cost-saving methods of constructing the roof, partition walls, and load-bearing walls. The only cost-saving method not positively related to the size of the builder was the use of alternatives to tile in the bathroom. We interpret these

---

[53] It is possible that higher wage rates are a better proxy for union power than our imperfect measure of unionization in the construction trades. This interpretation of the results would suggest that the carpenters' union successfully resists labor-saving methods in the construction of stud systems in walls.

results as indicating either that fixed costs associated with switching to cost-saving methods are of significant magnitude or that the size of the builder is the result of the decision to adopt cost-saving methods. In particular, the fixed costs of using plumbing trees may explain why plumbing trees are rarely used despite their estimated $50 marginal cost saving and the lack of any obvious quality disadvantages.

Our hypothesis that a high degree of unionization might reduce the use of cost-saving methods was not borne out, and hence no cross-tabs are presented for this variable. Either unions do not significantly affect the use of cost-saving methods, or else the relationship could not be measured because, as mentioned above, the data were not ideally suited to our application.[54]

To identify possible sources of bias in the cross-tabs results, we computed Pearson correlation coefficients for each of the variables introduced to explain variation in the adoption of cost-saving methods. Wages and the degree of unionization were highly correlated, with coefficients near 0.60. In most other cases the correlations were low (about 0.25 or less) but significantly different from zero. Larger builders tended to build more low priced houses, and builders in high wage and highly unionized areas tended to be larger and to build more expensive houses.

B. Regression Analysis

In addition to the cross-tab analysis, we conducted a regression analysis of the data. The advantage of regression analysis is that it can isolate the effects of a change in one variable of interest while holding the values of the other variables constant. Our regression model sought to explain

[54] As discussed in footnote 61, the relationship between higher wages and the use of cost saving methods is consistent with the possibility that higher wages are an indicator of a strong carpenters' union.

whether a builder used a cost-saving method as a function of (1) the number of houses constructed by the builder in 1981 (SIZE),[55] (2) the union wage of the appropriate construction trade (WAGE), (3) the price of the materials associated with each cost-saving method (MATPRICE), (4) the percent of construction trades unionized in the builder's city (UNION), and (5) the average price of the houses constructed by the builder in 1981 (AVPRICE).[56] We used a logit regression model because the dependent variable is binary--*i.e.*, essentially the builder uses either the cost-saving method or the traditional method.[57] The regression model was estimated with a sample of 512 observations for which we had data on unionization.

Table 7, which is based on our logit estimates, provides illustrations of the effect of changing the various independent variables on the probability that builders will use

---

[55] The SIZE variable was entered into the regression equation in a logarithmic form. This was done for three reasons: (1) when SIZE alone was used the coefficients changed markedly in response to the removal of a single large builder, (2) the use of ln(SIZE) increased the goodness of fit, as measured by the log likelihood ratio, and (3) on intuitive grounds, we felt that equal percentage changes in the size of the builder, as opposed to equal absolute changes in size, were more likely to have equal effects on the construction methods used. Using SIZE would have given equal weight to an increase in size from 1 to 51 houses per year and an increase from 1000 to 1050 houses per year. In any case, the pattern of significant coefficients did not change much in response to the specification change.

[56] The AVPRICE variable was also entered in a logarithmic form for reasons similar to those set forth in footnote 55.

[57] Additional information about the logit model is in Appendix D.

Table 7

ESTIMATES OF THE EFFECT OF CHANGES IN THE VARIABLES UPON THE PROBABILITY OF BUILDERS' ADOPTING COST-SAVING METHODS

Independent Variables	Representative Values[a]	Roof	Partition Walls	Exterior Wall Spacing	Bathtub Surround	Plumbing Tree
<u>Supply</u>						
Size	1	.572	.115	.029	.263	.008
	27	.672 **	.181 **	.044 **	.217 **	.022 **
	103	.785	.275	.067	.176	.039
Wage	b	.679	.223	.062	.153	.008
		.672	.181	.044	.217 **	.022 **
		.664	.146	.031	.297	.062
Materials Price	b	.670	.167	.054	.212	.022
		.672	.181	.044	.217	.022
		.673	.197	.036	.221	.021
Unionization	22.6%	.643	.177	.061	.217	.026
	39.9%	.672	.181	.044	.217	.022
	57.2%	.699	.186	.032	.216	.018
<u>Demand</u>						
Average Price	$46,000	.746	.277	.081	.296	.018
	$105,500	.672 **	.181 **	.044 **	.217 **	.022
	$165,000	.587	.114	.024	.154	.027

Asterisks indicate that the independent variable has a significant effect on the probability that builders will use the cost-saving technique. These findings are based on the significance of coefficients in the individual probit equations reported in Appendix D. All significant relationships are at the 1 percent level in a two-tailed test; none of the other relationships are significant at the 5 percent level.

a The representative values are one standard deviation below the mean, the mean, and one standard deviation above the mean. Although the calculations were conducted in terms of logs, the actual values are shown here because they are more readily meaningful.

b No specific wage rates or materials prices are shown because there are three different wage rates (for carpenters, plumbers, and tilesetters) and eight different materials prices (for pipe, tile, plastic panels, and various dimensions of lumber). As with the other variables, the values used in the calculations are one standard deviation below the mean, the mean, and one standard deviation over the mean.

the various techniques.[58] For example, the first group of entries under the heading "Roof" show that there is a 67.2 percent probability that an average size builder, who built 27 houses in 1981, used one of the cost-saving roof support systems. For a builder who constructed only one house in 1981, the probability that he used a cost-saving roof support system is only 57.2 percent. On the other hand, a builder of 103 houses had a 78.5 probability of using an innovative roof system.[59]

Similarly, the entries under the column heading "Bathtub Surround" in the row labeled "Wage" show that there is only a 15.3 percent likelihood that an average builder in a market where the wage of union tilesetters is $11.44 will use plastic panels around the bathtub (rather than ceramic tile). In markets where the wage of union tilesetters is $16.32, the probability that the builder will use plastic panels increases to 29.7 percent.

Table 7 also indicates which variables had a statistically significant affect on the use of the various techniques.[60] These results confirm almost all of the patterns observed in the cross-tab analysis. Increases in average price result in significant decreases in the use of every cost-saving method except plumbing trees.[61] Higher wages for tilesetters and

---

[58] The coefficients and standard errors from the logit analysis are reported in Appendix D.

[59] In all of these comparisons, we assume that the builder has the average values for all of the other independent variables in the analysis.

[60] These results are discussed in more detail in Appendix D.

[61] As we noted above, the average price of a builder's houses will be affected by the extent cost-saving techniques are employed. Thus, there is a simultaneity problem in our regression analysis. Unfortunately, because we use a logit
(continued...)

plumbers significantly increase the use of panels around the bathtub and prefabricated plumbing trees, but higher carpenters' wages do not have a significant effect.[62] Neither the unionization variable nor the materials cost variable is ever significant.[63] Larger builders were significantly more likely to use all of the cost-saving methods except panels around the bathtub.

Overall, the data in Table 7 demonstrate that changes in several of the independent variables have an effect upon the use of cost-saving methods that is both statistically significant and qualitatively important. If one combines changes across variables, the model predicts that large builders of inexpensive houses are far more likely to use

---

[61](...continued)
model to explain the utilization of cost-saving techniques, it is not possible to estimate the simultaneous system that would result by adding a second equation that explains average price. (See Heckman, 1976.)

[62] Carpenters' wages have no significant effect at the 5 percent level. However, at the 10 percent level, higher carpenters' wages significantly *reduce* the use of cost-saving methods in constructing partition walls.

[63] This result, however, may indicate an inadequacy in the measure of union strength used in these equations, rather than a lack of relationship between unionization and the adoption of cost-saving methods. The index of union strength that was used is the percentage of workers in all construction trades who are union members, measured on a city basis. Although this was the best measure of union strength that we could find for our purpose, it is not an ideal measure for this study: it does not distinguish between carpenters, plumbers, and tilesetters, and it does not indicate which builders in the sample used union workers and which used non-union. Such data appear to be unavailable without a special survey.

cost-saving methods than the average builder. Thus, although it is still possible that code enforcement may be somewhat restrictive, much of the reluctance to use cost-saving methods seems to be independent of code restrictions.

To test the robustness of our results we tried using a number of alternative specifications, which yielded almost identical patterns of significance. For example, we tried regressions omitting different combinations of the UNION and MATPRICE variables, partly because the coefficients of these variables were insignificant, and partly to increase the number of observations from 512 to 901.

Since we were concerned that the average price of the houses constructed by each builder might conceivably be an endogenous variable, capturing higher building costs resulting from restrictive building code enforcement, we tried replacing this variable with other proxies for buyers' wealth. Specifically, when we replaced AVPRICE with either the average number of rooms in the houses constructed by the builder or with the average number of square feet in the houses constructed by the builder, none of the results changed qualitatively. The new proxies for buyers' wealth were still highly significant (except in the plumbing tree equation, in which AVPRICE was never significant, even in our original specification), and no other variable gained or lost statistical significance due to the change in specification.

We tried replacing the WAGE variable (which was defined as the union wage) with the non-union wage of the appropriate construction trade. This change made little difference in the results, as might be expected from the fact that the union and non-union wages had correlations near .90 in most cases. We also tried adding a dummy variable for geographic regions of the country, but the only significant geographic relationship was the use of prefabricated plumbing trees in southern California. None of the significant relationships was lost in these regional analyses.

Finally, we tried an additional independent variable that measured the proportion of one-story houses constructed by each builder.[64] The results indicated that builders who constructed a large proportion of one-story houses were more likely to use cost-saving methods in the roof support system, in partition walls, and in exterior wall stud spacing, and were more likely to use prefabricated plumbing trees.[65] (The effects on the use of cost-saving roof support systems, exterior wall stud spacing, and prefabricated plumbing tree were significant at the one percent level; the effect on partition walls was significant at the five percent level.)

These findings are consistent with greater cost savings being achievable from the use of these methods in one-story houses than in multiple-story houses. First, a crane is not needed to install roof trusses in a one-story house. Second, it may be less costly to supervise the framing work if the same stud spacing and the same size studs are used in every wall. The building code requirement that multiple-story houses have 16-inch spacing in load-bearing walls on lower floors may prompt some builders to use 16-inch spacing throughout. Finally, a prefabricated plumbing tree that extends to an upper floor needs to be supported during construction, thereby making its use more complex.

---

[64] The survey conducted by the National Association of Home Builders Research Foundation asked builders to report the number of houses they constructed in 1981 by these styles: one story, two story, split level, and bilevel. A cross-tab analysis that is not reported here indicates some greater use of cost-saving techniques in one-story houses than in other designs.

[65] Adding an independent variable for the proportion of one-story houses constructed by each builder did not change the level of significance of the other variables except for the relationship between builder size and the use of wider stud spacing in exterior walls and the use of panels (instead of tile) around the bathtub. In both these cases the level of significance slipped from one percent to five percent.

IV. Conclusion

Based upon our sample of local building codes, we conclude that in 1981 (and probably today as well) local codes rarely imposed more restrictions than the model codes upon which almost all local codes are now based. However, our study shows that several cost-saving construction methods that are clearly permissible under model codes are still used infrequently, and that there is substantial variation in their use. This variation is associated with such factors as the price of houses built, size of the builder, and local wage rates, but not with construction trade union membership. We conclude that the primary reason builders choose to use more expensive methods in these areas of construction is not because they are forced to do so by antiquated building code regulation, but rather because buyers demand higher quality than is required by the minimum standards set by the codes.

Why are our conclusions so different from those of most other researchers in the field? The most obvious reason is that building codes have changed: Nearly all local codes are now based on model codes and do not generally contain amendments that make the local codes significantly more restrictive than the models. Although we have not made a scientific study of the adoption of model codes, we have pointed to a number of factors that have contributed to their spread, including Federal requirements to adopt a model code in order to qualify for Urban Renewal funds and court decisions preventing the enforcement of restrictive provisions in local codes.

In addition, though, we doubt that the direct costs of building codes were ever as great as some authors have estimated. Without data on the actual use of cost-saving construction methods, previous authors have apparently assumed that these methods would be uniformly adopted when allowed. But our study shows that several of these methods were not widely used in 1981, and probably would not have been widely used in earlier years even if they were permitted. While the estimate of Noam (1983) that the adoption of extreme building code restrictions can increase the price of housing by as much as 4.9% is not subject to methodological criticism, the estimate of the Douglas Commission on Urban Problems that building codes added as much as 15.3% to the price of a house is clearly biased upwards.

Another possible reason why our conclusions differ from other researchers is that we use a different approach to measure the content of building codes. We rely on a reading of the building codes themselves, supplemented by the interpretation of officials in the model code associations, whereas most other researchers have relied upon surveys of local building code officials. Our method has the disadvantage of overlooking useful information on enforcement practices, and it is widely believed that restrictive local enforcement of codes is a significant problem, at least in some localities.[66] To our knowledge, however, no previous studies have provided systematic evidence which clearly distinguishes between restrictive written codes and restrictive enforcement which goes beyond the letter of the code.

Our research methods gave us no direct means of measuring the restrictiveness of local enforcement. However, our regression results did produce indirect evidence supporting the belief that as of 1981 local enforcement did not severely restrict builders' practices. Specifically, the use of cost-saving methods of construction in six aspects of construction by builders in the National Association of Home Builders survey was not significantly lower in areas where construction union membership was high, as would have been expected if construction unions were effective in persuading local officials to adopt restrictive enforcement policies. However, the cost-saving methods we studied have long been regarded as technologically proven, so we have no new evidence regarding whether restrictive enforcement seriously inhibits the use of more recent technological innovations.

---

[66] For example, see Colwell and Kau (1982) and Quigley (1981).

Our finding that nearly all local building codes are based upon model codes points to the importance of ascertaining whether the standards embodied in model codes represent appropriate compromises between safety requirements and costs. In many areas, model codes allow builders considerable discretion to use any materials or methods of construction as long as they meet certain design criteria or pass performance tests. However, the design criteria and performance standards embodied in the codes are taken in large measure from a number of standard-setting organizations. If standard-setting organizations are too conservative in adapting their standards to new methods of construction, perhaps due to pressures from suppliers of materials currently in use, then even the "model" codes may be unduly restrictive. For example, plastic drain-waste-and-vent pipe was not approved by any model code organization until 18 years after its introduction and six years after its approval by the Federal Housing Authority. In addition, the introduction of polyvinylchloride conduit appears to have been delayed.

Furthermore, even model codes have specification sections that endorse particular construction methods as being generally acceptable. Although these endorsements are not exclusive, delays in specifically endorsing new materials and construction methods could significantly retard their acceptance by local building code officials.[67]

While the current state of building code regulation appears to be a considerable improvement over the previous use of more restrictive locally-drafted codes, we cannot conclude that prior inspection and approval of houses through a building code system of regulation is necessarily the best method to assure homeowners of minimum standards of safety and quality in housing. Other public policy options are available, ranging from no governmental regulations at all to

---

[67] For an example of delay in endorsing a particular construction method (the use of smaller-diameter plumbing vents), see Colwell and Kau (1982).

the legislation of a strict liability standard for injuries that occur as a result of substandard construction practices.

In the absence of mandatory building codes, for example, one might expect private institutions to develop to provide homebuyers with the quality assurances currently provided by building codes. Builders, in response to consumer demand, might find it profitable to hire independent private firms to perform prior inspection and certification services comparable to those currently provided by local building inspectors. Alternatively, builders might be disciplined by insurance companies that would insist upon certain standards of construction as a condition for providing liability insurance and would offer lower rates for builders with better quality experience. Finally, less restrictive forms of regulation, such as mandatory disclosure of new or unproven building techniques, may be superior to codes that prevent new techniques. Under disclosure, new home buyers could judge for themselves whether they want to buy a house built with non-traditional methods or materials. In sum, rather than limiting attention to the effects of marginal changes in building codes, future research might explore the costs and benefits of more radical changes in regulatory methods.

Appendix A

BUILDING CODE JURISDICTIONS IN THE SAMPLE

Jurisdiction	Type of Code	Population In 1980 (In thousands)
Akron, OH	BOCA-State	237
Albany, NY	NY State	102
Albuquerque, NM	ICBO-State	332
Amarillo, TX	ICBO	149
Annapolis, MD	BOCA	32
Arlington, VA	BOCA-State	153
Artesia, CA	ICBO-State	14
Atlanta, GA	Southern	425
Auburn, MA	BOCA-State	15
Austin, TX	ICBO	345
Avon, CT	BOCA-State	1
Baltimore, MD	BOCA	787
Baton Rouge, LA	Southern	219
Bellevue, WA	ICBO-State	74
Billerica, MA	BOCA-State	6
Billings, MT	ICBO-State	67
Binghamton, NY	NY-State	56
Birmingham, AL	Southern	284
Boise, ID	ICBO-State	102
Boston, MA	BOCA-State	563
Buffalo, NY	NY-State	358
Burbank, CA	ICBO-State	85
Canton, OH	Locally-drafted	95
Charlotte, NC	Southern-State	314
Chattanooga, TN	Southern	170
Cincinnati, OH	BOCA-State	385
Clarence, NY	NY-State	2
Clearwater, FL	Southern-State	85

Cleveland, OH	BOCA-State	574
Clifton, NJ	BOCA-State	74
Colorado Springs, CO	ICBO	215
Columbia, SC	Southern-State	99
Columbus, GA	Southern-State	169
Columbus, OH	BOCA-State	565
Corpus Christi, TX	Southern	232
Covina, CA	ICBO-State	34
Dallas, TX	ICBO	904
Dayton, OH	BOCA-State	203
Denver, CO	Locally-drafted	492
Depew, NY	NY-State	20
Des Moines, IA	ICBO-State	191
Detroit, MI	BOCA-State	1203
Duluth, MN	ICBO-State	93
Durham, NC	Southern-State	101
El Cajon, CA	ICBO-State	74
El Paso, TX	Southern	425
Elizabeth, NJ	BOCA-State	106
Englewood, NJ	BOCA-State	24
Eugene, OR	ICBO-State	106
Fairfield, CT	BOCA-State	55
Fairport, NY	NY-State	6
Flint, MI	BOCA-State	160
Fort Worth, TX	ICBO	385
Fort Lauderdale, FL	Southern-State	153
Fort Wayne, IN	ICBO-State	172
Fresno, CA	ICBO-State	218
Glastonbury, CT	BOCA-State	10
Glendale, CA	ICBO-State	139
Glendora, CA	ICBO-State	39
Grand Rapids, MI	BOCA-State	182
Greensboro, NC	Southern-State	156
Gresham, OR	ICBO-State	33
Hamburg, NY	NY-State	11
Hartford, CT	BOCA-State	136
Houston, TX	ICBO	1594
Indianapolis, IN	ICBO-State	701
Jackson, MS	Southern-State	203
Jacksonville, FL	Locally-drafted	541
Jersey City, NJ	BOCA-State	224
Kansas City, MO	BOCA	448

Knoxville, TN	Southern	175
La Mesa, CA	ICBO-State	50
La Canada, CA	ICBO-State	20
Lake Oswego, OR	ICBO-State	23
Las Vegas, NV	ICBO-State	165
Little Rock, AR	Southern	158
Lomita, CA	ICBO-State	17
Long Beach, CA	ICBO-State	361
Louisville, KY	BOCA-State	298
Lubbock, TX	ICBO	174
Ludlow, MA	BOCA-State	18
Lynnfield, MA	BOCA-State	11
Madera, CA	ICBO-State	22
Manchester, NH	BOCA	91
Marietta, GA	Southern-State	31
Memphis, TN	BOCA	646
Miami, FL	Southern-State	347
Middlebury, CT	BOCA-State	4
Milwaukee, WI	ICBO-State	636
Minneapolis, MN	ICBO-State	371
Mobile, AL	Southern	200
Modesto, CA	ICBO-State	106
Montgomery, AL	Southern	178
Montgomery County, MD	BOCA	579
Nashville, TN	Southern	456
National City, CA	ICBO-State	49
New Haven, CT	BOCA-State	126
North Attleboro, MA	BOCA-State	19
Ogden, UT	ICBO-State	64
Oklahoma City, OK	BOCA	403
Omaha, NE	BOCA	314
Orange, NJ	BOCA-State	31
Orlando, FL	Southern-State	128
Paramus, NJ	BOCA-State	26
Phoenix, AZ	ICBO	790
Pittsburgh, PA	BOCA	424
Plainfield, NJ	BOCA-State	46
Pleasanton, CA	ICBO-State	35
Pompano Beach, FL	Southern-State	53
Portland, OR	ICBO-State	366
Prince Georges County, MD	BOCA	665
Providence, RI	BOCA-State	157

Rahway, NJ	BOCA-State	27
Raleigh, NC	Southern-State	150
Reading, PA	BOCA	79
Richmond, VA	BOCA-State	219
Rochester, NY	NY-State	242
Sacramento, CA	ICBO-State	276
Salt Lake City, UT	ICBO-State	163
San Antonio, TX	ICBO	785
San Mateo, CA	ICBO-State	78
San Francisco, CA	ICBO	679
San Diego, CA	ICBO-State	876
Santa Ana, CA	ICBO-State	204
Santa Barbara, CA	ICBO-State	75
Santa Monica, CA	ICBO-State	88
Sarasota, FL	Southern-State	49
Savannah, GA	Southern-State	142
Seattle, WA	ICBO-State	494
Shawnee, KS	ICBO-State	30
Shreveport, LA	Southern	206
Simsbury, CT	BOCA-State	5
Sioux Falls, SD	ICBO	81
Solana Beach, CA	ICBO-State	6
South Bend, IN	ICBO-State	110
South Windsor, CT	BOCA-State	10
St. Petersburg, FL	Southern-State	239
St. Louis, MO	BOCA	453
Stockton, CA	ICBO-State	150
Stratford, CT	BOCA-State	51
Tacoma, WA	ICBO-State	159
Tampa, FL	Southern-State	272
Tewskbury, MA	BOCA-State	12
Thousand Oaks, CA	ICBO-State	78
Toledo, OH	BOCA-State	355
Topeka, KS	ICBO-State	115
Torrance, CA	ICBO-State	131
Trenton, NJ	BOCA-State	92
Troy, MI	BOCA-State	67
Tucson, AZ	ICBO	331
Tulsa, OK	BOCA	361
Venice, FL	Southern-State	12
Ventura, CA	ICBO-State	74
Washington, D.C.	Locally-drafted	638

Waterbury, CT	BOCA-State	103
Westfield, NJ	BOCA-State	30
Wichita, KS	ICBO-State	279
Wilmington, DE	BOCA	70
Windsor, CT	BOCA-State	16
Winston-Salem, NC	Southern-State	132
Worcester, MA	BOCA-State	162
York, PA	BOCA	45

Appendix B

DESCRIPTION OF THE HOUSE USED FOR ESTIMATES OF COST SAVINGS

The estimates of cost savings in Table 3 are based on a hypothetical house. These cost savings are only illustrative, since they necessarily vary with the size and plan of the house.

The hypothetical house used for this illustration is a two-story house of simple rectangular shape, 24 feet by 30 feet. The roof is a straight-line design, without dormers or valleys. The first floor consists of a living room, dining room, kitchen, and entrance hall; the second floor consists of three bedrooms and a bath.

The details of the floor plan are, of course, arbitrary. This design requires 277 feet of load-bearing walls and 52 feet of non-load-bearing walls. For load-bearing walls, this translates into 208 studs if spaced 16 inches apart and 174 studs if spaced 16 inches apart on the first floor and 24 inches apart on the second floor. For non-load-bearing walls, the requirements are 39 studs if spaced 16 inches apart and 26 studs if spaced 24 inches apart. The roof support system involves 24 roof trusses or rafters if spaced 16 inches apart and 16 roof trusses or rafters if spaced 24 inches apart.

The costs of materials and of installation were obtained from Means, *Building Construction Cost Data, 1982*, and Engelsman's *1982 General Construction Cost Guide*.

Each savings estimate is the difference between the cost of the traditional method and the cost of the newer method for this hypothetical house. These costs consist of materials and labor. For the following cost-saving methods, savings are made in both materials and labor: wider spacing of studs and of roof rafters or trusses, the use of 2x3 studs instead of 2x4's, and the use of panels instead of ceramic tiles around the bathtub. For prefabricated items, the cost of the newer material slightly exceeds that of the traditional material, and the source of the saving is the reduction in labor required for installation. This is the case for the roof truss, the prefabricated plumbing tree, and the prefabricated mechanical core.

For some methods, the cost estimates are affected by the specific material used and its dimensions. For wall studs, the dimensions are 2x4 inches and 2x3 inches in eight foot lengths. For roof rafters, 2x8 inch beams are used, and the cost of ceiling joists are included in order to put roof rafters on the same basis as roof trusses. For wall covering around the bathtub, the cost comparison is made between acrylonitrile-butadiene-styrene plastic paneling and pregrouted sheets of ceramic tile 4 1/4 inches square, for 60 square feet of wall surface. For the prefabricated plumbing tree, the cost estimate for the traditional material is based on six feet of copper drain-waste-vent type tubing, 4 inches in diameter.

No estimates have been attempted for some of the differences in costs associated with the use of these cost-saving methods. For example, the use of roof trusses or a prefabricated plumbing tree requires advance planning and scheduling that are not required when the lumber or pipe is assembled on the construction site. The cost of supervising the framing crew is probably somewhat higher if wider stud spacing or 2x3 inch studs are used in some walls but not in others. A prefabricated plumbing tree costs somewhat less to install on a first floor than on an upper floor (because it does not need to be propped in place), but this cost differential was not estimated. Installation of roof trusses typically involves the use of a light crane for multi-story houses and the per-house cost of the crane varies with the number of multi-story houses at the construction site. The rental cost of a crane was included in the cost estimate and prorated over the normal productivity of a framing crew, but no adjustment was made for the probability that many of the one-story houses were constructed without a crane. No doubt some other cost differences were also not captured.

Appendix C

SELECTED QUESTIONS FROM THE NAHB SURVEY

This appendix reproduces the questions selected from the survey conducted by the National Association of Home Builders Research Foundation for use in this study. The responses to these questions are also reported.

The cover of the questionnaire contained this preface:
Dear Home Builder,

Subject: Did you build any houses in 1981?

If you did, would you please tell us about them. As our industry continues to go through a variety of changes and challenges, your experiences in 1981 are an important addition to our data base.

At first glance, the form may appear long and somewhat technical. However, YOU ARE NOT EXPECTED TO MAKE AN EXTENSIVE DETAILED RESEARCH OF YOUR RECORDS IN COMPLETING THIS SURVEY. You will notice that it is organized so you can fill it out with only numbers or checks. Please answer the questions to the best of your knowledge.

As you know, this annual study is the key element in the Research Foundation's continuing study of detailed housing trends. Therefore your reply is very important. The resulting data is used by the foundation to help keep your trade association, the editors of Builder magazine, and various manufacturers of building products informed. The data may also be used to aid in NAHB's legislative efforts.

We are most appreciative of the time you will take in completing the form. Individual replies will be held in confidence. You may be sure you will receive a copy of the results similar to the report included with this questionnaire.

Please return the questionnaire in the envelope provided as soon as possible.

This message was printed across the top of each page: "Use spaces below to check the one most typical practice or material used, unless otherwise noted".

The questions reproduced below are the ones that were used in this study. They are supplemented by the responses from the 901 builders used for the cross tabs and regression analysis:

How many single-family detached houses did you complete in the twelve (12) months beginning January 1981 through December 1981?

Show the number of houses here ____________________

Show county area here ____________________

BUILDING COMPONENTS

Did you use any of the following building components?

			Responses	
Use	Do Not Use	Item	Use	Do Not Use
[ ]	[ ]	Plumbing tree	46	855
[ ]	[ ]	Pre-fab mechanical core	4	897

EXTERIOR WALL STRUCTURE
(check one per story)

First Story	Upper Stories (If Any)		Responses First Story	Responses Upper Stories
[ ]	[ ]	2x4's 16" o.c. wood stud	739	557
[ ]	[ ]	2x4's 24" o.c. wood stud	45	29
[ ]	[ ]	2x6's 16" o.c. wood stud	33	22
[ ]	[ ]	2x6's 24" o.c. wood stud	27	20
[ ]	[ ]	Steel stud	2	1
[ ]	[ ]	Concrete block	39	2
[ ]	[ ]	Load bearing brick	1	0
[ ]	[ ]	Other ________ (Specify)	6	2
		[No response	9	268]

[The abbreviation "o.c." means on center; i.e., the space between studs is measured at the center of each stud.]

ROOF FRAMING
What percent of the total square feet of your roofs used the following framing materials?

Trusses (see "A" which follows)	______%
Rafters (see "B" which follows)	______%
Wood ceiling joists (see "C" which follows)	______%
Steel bar joists	______%
Wood flat trusses	______%
Other ________________ (Specify)	______%
	100%

[ ] Did not use roof framing

[For the 901 builders, 472 responses ranged from 50% to 100%, and 70 were below 50%; 359 responses indicated no use of trusses.]

A. Roof Trusses

If you indicated that you used roof trusses, please check typical type below. (check one)

		Responses
[ ]	Trusses 16" o.c.	35
[ ]	Trusses 24" o.c.	505

B. Rafters

If you indicated above that you used rafters, please check typical type below. (check one)

		Responses
[ ]	2x4 rafters 16" o.c.	13
[ ]	2x6 rafters 16" o.c.	204
[ ]	2x8 rafters 16" o.c.	133
[ ]	2x6 rafters 24" o.c.	134
[ ]	2x8 rafters 24" o.c.	44
[ ]	2x10 rafters 24" o.c.	50

BATHTUB SURROUND MATERIALS (check one)

		Responses
[ ]	Ceramic tile	643
[ ]	Fiberglass	191
[ ]	Acrylic plastic	4
[ ]	ABS plastic	1
[ ]	High pressure laminate	8
[ ]	Tile board	3
[ ]	Cultured marble	23
[ ]	Other ________________ (Specify)	9
[No response		19]

INTERIOR PARTITION FRAMING

Please indicate your most typical method of interior framing. (check one)

		Responses
[ ]	2x3 studs 16" o.c.	31
[ ]	2x3 studs 24" o.c.	3
[ ]	2x4 studs 16" o.c.	691
[ ]	2x4 studs 24" o.c.	151
[ ]	Steel studs	10
[ ]	Other ________________ (Specify)	2
[No response		13]

Appendix D

METHODOLOGY OF THE LOGIT ANALYSIS

Because the data from the National Association of Home Builders' Research Foundation survey only indicated whether or not a builder used a particular technique, the dependent variables in our statistical analyses were not continuous. Rather, they assumed only one of the two values zero or one.[1] Because of this characteristic of the data, it was necessary to use a technique designed to handle a dichotomous dependent variable.[2] We chose to use a logit analysis.

Specifically, for each of the five cost-saving methods studied, the following model was estimated:

---

[1] There is one exception to this. For roof trusses, the NAHB survey asked builders the percentage of the roof area they supported with roof trusses. Thus, the survey did provide essentially continuous data for this cost-saving method. However, this was the only cost-saving method for which data were not requested on a 0,1 basis. In order to use the same methodology for all the cost-saving methods, we converted these responses to a 0,1 basis by counting builders that reported using roof trusses on 50 percent or more of their roof areas as adopters of roof trusses.

[2] Standard ordinary least squares (OLS) regression techniques are not appropriate when the dependent variable is dichotomous both because the OLS model can give estimates greater than one and less than zero and because the error term implied by the dichotomous dependent variable is not appropriate for OLS estimation. (See Judge, Griffiths, Hill, Lutkopohl, and Lee, 1985, p. 757.)

$$\ln(P/(1-P)) = c_0 + c_1 \ln(AVPRICE) + c_2 \ln(SIZE) + c_3 \, WAGE + c_4 \, MATPRICE + c_5 \, UNION,$$

where

P = the probability that a builder uses the cost saving method,

AVPRICE = the average price of the houses constructed by the builder, measured in dollars,

SIZE = number of houses constructed by the builder in 1981,

WAGE = the union wage of the appropriate trade (carpenters' wage for roof and walls, plumbers' wage for plumbing tree, and tilesetters' wage for bathtub surround), measured in dollars per hour,

MATPRICE = the price of the materials appropriate in each case, measured in dollars,

UNION = the percent of the construction trade unionized in the builder's city, expressed in decimal form.

The results of the logit regression analyses are shown in Table 8. This table shows which variables are significantly related to the probability of a builder using each cost-saving method examined in the study.[3] The most frequently significant independent variables are: the average price of the house, the size of the builder, and the wage rate for the unionized construction trade involved. The extent of

---

[3] There is no simple way to interpret the individual coefficients in a logit analysis. However, some indication of the effects of changes in the various variables can be obtained from an examination of Table 7 in the text. (See Judge, Griffiths, Hill, Lutkopohl, and Lee, 1985, pp. 766-767, for a discussion of the interpretation of coefficients in a logit model.)

Table 8

INDEPENDENT LOGISTIC ESTIMATES OF THE PROBABILITY OF BUILDERS' ADOPTING COST-SAVING METHODS

Independent Variable	Expected Sign	Roof	Exterior Partition Walls	Wall Spacing	Bathtub Surround	Plumbing Tree
<u>Supply</u>						
Log of Size	+	.33 (4.68)**	.42 (5.06)**	.35 (2.78)**	-.20 (-2.62)**	.82 (5.62)**
Wage	+	-.02 (-0.31)	-.11 (-1.87)	-.16 (-1.45)	.17 (3.54)**	.41 (4.51)**
Materials Price	+	.004 (0.01)	.61 (0.97)	-1.28 (-1.18)	.15 (0.23)	-.02 (-0.10)
Unionization	-	.73 (1.15)	.18 (0.23)	-2.02 (-1.50)	-.01 (-0.01)	-1.10 (-0.69)
<u>Demand</u>						
Log of Average Price	-	-.71 (-4.09)**	-1.07 (-4.90)**	-1.30 (-3.51)**	-.82 (-4.21)**	.44 (1.01)
Likelihood ratio test		49.86**	66.56**	38.86**	37.85**	89.08**

Asymptotic t-ratios are in parentheses. Asterisks indicate the independent variable has a significant effect on the probability that builders will use the cost-saving technique. All the significant relationships are at the 1 percent level in a two-tailed test; none of the other relationships are significant at the 5 percent level.

unionization of the construction trades is not a significant variable in any of the equations.

BIBLIOGRAPHY

Colwell, Peter F., and James B. Kau, "The Economics of Building Codes and Standards," in *Resolving the Housing Crisis*, M. Bruce Johnson, ed., (San Francisco: Pacific Institute for Policy Research, 1982).

Council of American Building Officials, *One and Two Family Dwelling Code* (Alexandria, Virginia: Council of American Building Officials, Second Edition, 1979; Third Edition, 1983; Fourth Edition, 1986).

Field, Charles G., *Building Regulatory Practices and the Courts* (Washington, D.C.: Federal Trade Commission, September 1980).

__________, "Judicial Solutions to the Tension Between Construction Codes and Innovations," *Urban Law and Public Policy*, 1981 (Vol. 4).

__________, and Steven R. Rivkin, *The Building Code Burden* (Lexington, Massachusetts: D.C. Heath, 1975).

__________, and Francis T. Ventre, "Local Regulation of Building: Agencies, Codes and Politics," *The Municipal Yearbook* (Washington, D.C.: International City Management Association, 1971).

__________, *Operation Breakthrough--Lessons Learned About Demonstrating New Technology* (Washington, D.C.: General Accounting Office, 1976).

General Accounting Office, *Why Are New House Prices So High, How Are They Influenced by Government Regulations, and Can Prices be Reduced?* (Washington, D.C.: General Accounting Office, 1978).

__________, *Greater Use of Innovative Building Materials and Construction Techniques Could Reduce Housing Costs* (Washington, D.C.: General Accounting Office, 1982).

Heckman, James J. "Simultaneous Equation Models with Continuous and Discrete Endogenous Variables and Structural Shifts," in S.M. Goldfeld and R.E. Quandt (eds.), *Studies in Non-Linear Estimation*, Ballinger, 1976.

International Conference of Building Officials, *Uniform Building Code* (Whittier, California: 1982 Edition).

Judge, George G., W. E. Griffiths, R. Carter Hill, Helmut Lutkopohl, and Tsoung-Chao Lee, *The Theory and Practice of Econometrics*, Second Edition (New York: John Wiley and Sons, 1985).

Keating, Barry P., "Standards: Implicit, Explicit and Mandatory," *Economic Inquiry*, July 1981 (vol. 19).

Manvel, Allen D., *Local Land and Building Regulation*, Report No. 6 to the National Commission on Urban Problems (Washington, D.C.: Government Printing Office, 1968).

Muth, Richard F., and Elliot Wetzler, "The Effect of Constraints on Housing Costs", *Journal of Urban Economics*, January 1976 (vol. 3, no. 1).

National Association of Home Builders Research Foundation, *Home Builder Surveys*, unpublished memo (undated).

National Commission on Urban Problems (The Douglas Commission), *Building the American City*, (Washington, D.C.: Government Printing Office, 1968).

Noam, Eli M., "The Interaction of Building Codes and Housing Prices," *Journal of the American Real Estate and Urban Economic Association*, Winter 1983 (vol. 10, no. 4).

__________, "Market Power and Regulation: A Simultaneous Approach," *Journal of Industrial Economics*, March 1984 (vol. 32, no. 3).

Nutt-Powell, Thomas E., *Manufactured Homes* (Boston: Auburn House, 1982).

Oster, Sharon M. and John M. Quigley, "Regulatory Barriers to the Diffusion of Innovation: Some Evidence from Building Codes," *The Bell Journal*, Autumn 1977 (vol. 8, no. 2).

President's Commission on Housing, *Report* (Washington, D.C.: Government Printing Office, 1982).

President's Committee on Urban Housing (The Kaiser Committee), *A Decent Home* (Washington, D.C.: Government Printing Office, 1969).

Quigley, John M., *Residential Construction and Public Policy* (Mimeo, University of California at Berkeley, December, 1981).

Seidel, Stephen R., *Housing Costs and Government Regulations: Confronting the Regulatory Maze* (New Brunswick, New Jersey: The Center for Urban Policy Research, 1978).

Southern Building Code Congress International, *Standard Building Code* (Birmingham, Alabama: 1979 Edition).

U.S. Congress, Housing Subcommittee on Housing and Community Development, *Hearings: National Manufactured Home Construction and Safety Standards, Parts 1 and 2* (Washington, D.C.: Government Printing Office, 1981).

Ventre, Francis T., "Maintaining Technological Currency in the Local Building Code: Patterns of Communication and Influence," *Urban Data Service Report* (Washington, D.C.: International City Management Association, 1971).

__________, "Innovation in Residential Construction", *Technology Review*, November 1979 (vol. 82, no. 2).

Cases and Law

Boise Cascade Corp. v. Gwinnett County, 272 F.Supp. 847 (N.D. Ga. 1967). *Kingsberry Homes Corp. v. Gwinnett County*, 248 F.Supp. 765 (N.D. Ga. 1965).

Cox v. Township of Wall, 39 N.J. Super. ct. 243, 120 A. 2d 779, 781 (1956).

Goldblatt v. Town of Hempstead, 369 U.S. 590 (1962).

Home Building Contractors, Inc., v. County of Du Page, 322 F. 2d 635, 637 (7th Cir. 1963).

Johnson Construction Co. v. Township of White Lake, 351 Michigan 374, 88 N.W. 2d 426 (1958).

The Housing Act of 1954, Section 701.

The Mobile Home Construction and Safety Standards Act, 1974.

Montgomery v. Robbins, 277 Ala. 29, 166 So. 2d. 871 (1964).

Data Sources

Allen, Steven G., *Survey of Unionization in Construction* (North Carolina State University, Raleigh, 1980) (unpublished).

Bureau of the Census, *1980 Census of Housing* (Washington, D.C.: Government Printing Office, 1983).

Engelsman, Coert, *1982 Engelsman's General Construction Cost Guide* (New York: Van Nostrand Reinhold, 1982).

Means, Robert Snow, *Building Construction Cost Data, 1982* (Kingston, Massachusetts: Robert Snow Means Co., 1982).

__________, *1981 Labor Rates for the Construction Industry* (Kingston, Massachusetts: Robert Snow Means Co., 1981).

__________, *Repair and Remodeling Cost Data, 1982* (Kingston, Massachusetts: Robert Snow Means Co., 1982).

National Association of Home Builders Research Foundation, *Survey of Home Builders, 1982* (Rockville, Maryland: 1982).

National Conference of States on Building Codes and Standards, *Directory of State Building Codes and Regulations* (Herndon, Virginia: 1982).