The homebuilding process provides a useful structure to introduce the housing industry, but it does not fully explain the industry or its relationship with the innovation process. This chapter supplements Chapter Three by describing several of the industry’s overarching characteristics, by providing insight into the motives of its participants, and by highlighting examples of innovations that are in various stages of realization.

**INDUSTRY CHARACTERISTICS AND THEIR EFFECT ON INNOVATION**

The U.S. housing industry is often described as competitive, cyclical, and fragmented, but what do these terms mean? What is the justification or evidence for these claims? What are the implications for innovation? This section answers these questions for the housing industry in general although, in many cases, discussion focuses on homebuilders in particular, because of their central role in making the decision to adopt an innovation. Nonetheless, this focus does not suggest that other participants are unimportant.

**Low Barriers to Entry Make the Housing Industry Highly Competitive**

The housing industry, and homebuilding in particular, are often described as highly competitive, because the industry's high fragmentation and low capital requirements make it relatively easy for firms
to enter and exit.\(^1\) For example, those seeking to start a homebuilding firm can borrow money to purchase land and materials and pay subcontractors. Since subcontractors provide their own tools and equipment, homebuilders increasingly focus on process management. Also, most builders, especially small builders, use similar methods to manage this process, and, therefore homebuilders often earn only a small to modest profit on each home. As a result, they have few earnings to invest in innovation-related investments.\(^2\)

Although innovation researchers argue that competition leads firms to embrace innovation to differentiate their products, homebuilders often feel that learning about and installing innovations cost more than buyers are willing to pay. That said, some builders have been quite successful at using innovations to create a niche market for their services (e.g., energy-efficient builders). However, others argue that because of the ease of entering and exiting the market, builders avoid innovations that pose unnecessary risk, since a bad outcome might lead to an unhappy customer or future costs to remove the innovation and replace it with traditional materials. As a result, builders often describe themselves as risk-averse with respect to innovations to protect their reputation and reduce the chance of losing money or going bankrupt.\(^3\)

**Cyclical Business Cycles Lead to Low Investment in Employees and Training**

As with the economy in general, the housing industry experiences cyclical changes in demand. However, its ups and downs have historically been steeper than those of the economy at large. In fact, by one measure, national investment in residential construction has

\(^1\)NAHB Research Center et al. (1989, p. 19).
\(^2\)Builders and other participants in the housing industry may finance innovation efforts through loans, equity, or debt. Depending on the type of business (i.e., proprietorship versus corporation) and its anticipated cash flows, the cost and risk of obtaining such financing may be undesirable.
\(^3\)We would prefer to explain builder behavior by citing quantitative data but, as previously stated, there are few or no such data. For this reason, our insights are drawn from builders’ self-assessments of their attitudes and decisions toward innovation even if they are potentially less accurate.
been 50 percent more variable than in the overall economy during the last half century.4

This variability has led many parts of the industry to reduce unneeded equipment and staff that could push them into bankruptcy should the economy slow. For example, at many homebuilding firms, payroll has been reduced to the minimum needed for administrative and project management purposes with the bulk of construction work subcontracted project by project or even day by day.5 As a result, homebuilders increasingly manage the construction process rather than build homes themselves.

However, in seeking to minimize costs, the industry has reduced its ability to use innovations that require equipment or training, especially if either is expensive. This is because by shifting employees to trade contractors, all but the largest homebuilders lost the ability to influence the market for skilled and unskilled labor. Thus, builders no longer have the option to train their own workers to use innovations. Rather, they now need to find trade contractors with workers who have such training (or invest in it themselves). However, trade contractors also have reservations because of their own need to remain competitive and survive industry cycles. In addition, employee turnover is high in the construction trades, so there is little incentive for an employer to invest in training. Both homebuilders and trade contractors have therefore become risk-averse to training, which can lock them into using standard materials and procedures because the labor system is generally unable to provide anything more.

The Majority of Single-Family Homes Are Built by Small and Medium-Size Homebuilders

In 1997, there were about 470,000 single-family homebuilding firms in the United States.6 These firms ranged from sole proprietorships

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4Data from the U.S. Department of Commerce (2002) show that the three-year annual rolling “coefficient of variability” of fixed residential investment was 53 percent larger than the same measure of gross domestic product for the period 1946 to 1999.
5NAHB Research Center et al. (1989, p. 20).
6Data for firms with employees come from the U.S. Census Bureau (Table 5, 1999a; Table 5, 1999b; and Table 1, 2001a).
(i.e., a self-employed individual with no employees) to small, medium, and large firms. Of firms with employees, about one-third specialized in remodeling with the balance focused on building new homes. However, because many sole proprietorships are believed to focus on remodeling, it is generally believed that remodelers represent more than one-third of all builders (see Figure 4.1).

The most common type of homebuilding firm is the sole proprietorship, representing 70 percent. These firms typically coordinate the work of others or provide relatively narrow remodeling services. In 1997, these firms were responsible for 15 percent of the nation’s annual residential construction work by dollar value.

Figure 4.1—Single-Family Homebuilding Firms by Number of Employees and by Annual Value of Residential Construction Put in Place, 1997

7U.S. Census Bureau (Table 10, 1999b).
8The regulatory reporting requirements for sole proprietorships vary by state. As a result, the business focus on sole proprietorships is not available for the country as a whole.
9Although sole proprietorships represent nearly 75 percent of the number of businesses in the United States, they typically represent only 3 percent of national receipts. The fact that sole proprietors represent 15 percent of receipts in the homebuilding industry demonstrates that they have a much larger effect than the national average. See www.census.gov/prod/www/abs/nonemp.html.
Small homebuilders having one to four employees were the second-largest category of homebuilder. These firms represented 23 percent of homebuilders and they completed 25 percent of 1997 residential construction work by dollar value.

Medium-sized homebuilders having between five and 19 employees represented 6 percent of firms and completed 28 percent of the value of residential construction. Finally, large homebuilders, sometimes also referred to as production builders, having 20 or more employees accounted for less than 1 percent of firms, but they put in place 32 percent of the value of the nation’s residential construction activity.

These statistics show that although 32 percent of the nation’s residential construction work is conducted by a few large firms, 68 percent is performed by firms with fewer than 20 employees. This means that the overwhelming majority of the nation’s homes are built and remodeled by firms of modest size. However, even more important, almost 40 percent of the residential construction value is completed by firms with four or fewer employees. Finally, an astonishing 93 percent of homebuilding firms—or 435,000 firms—have four or fewer employees.

These characteristics reveal that small homebuilding firms have a very large effect on the nation’s new and existing housing stock. For this reason, they play a large role in determining the rate of innovation in housing. Although the general literature on innovation argues that small companies are often more innovative than large ones, the competitive and cyclical nature of the industry usually means that these homebuilders have insufficient resources to learn about new innovations much less to invent or develop new ones of their own. In addition, because small homebuilders lack the economies of scale of larger builders, they are unlikely to adopt innovations unless they provide significant productivity gains.\(^\text{10}\)

Others argue that the logistical difficulties inherent in communicating with small and medium-sized builders place large builders in a better position to promote innovation, since they arguably have more employees and capital, better access to information, and more influence with trade contractors. However, large builders counter

\(^{10}\text{NAHB Research Center et al. (1989, p. 19).}\)
that they build homes so quickly that if they were to adopt an innovation shortly after its introduction, the innovation would already be widely deployed before any defects were identified. To support this argument, they cite past innovations such as fire-retardant treated plywood, “barrier-type” Exterior Insulation Finishing Systems (EIFSs), and polybutylene plumbing, which were widely deployed before problems appeared requiring replacement, sometimes at significant cost to homebuilders.11

Furthermore, since many of the largest builders are publicly held companies, these firms argue that adopting innovations before they are proven to be safe, reliable, and profitable violates their responsibility to shareholders and diminishes their standing with investment analysts who are wary of exposing themselves to unnecessary risks. As a result, large builders argue that it is better for small homebuilders with less at risk to experiment with and validate innovations first.

In short, despite the diversity inherent in homebuilding firms, builders of all sizes find reasons to be wary of innovations, often leading them to stay with the status quo.

**Fragmentation Slows Information Sharing and Innovation Acceptance**

Another defining characteristic of the housing industry is that it is fragmented along geographic, vertical, and horizontal dimensions. Geographic fragmentation results from municipal regulation, industry competitiveness, and the predominance of smaller builders. This type of fragmentation makes it more difficult for innovations to spread. Accordingly, an innovation may be accepted in one area of the country but not in another. In addition, because codes vary from place to place and firms tend to be small, many homebuilders work in only one or a few jurisdictions, thereby slowing the passage of information through informal networks.

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11For a representative discussion of these problems, see NAHB Research Center (2001c).
The sheer number and small size of firms also result in horizontal fragmentation. Even within a geographic area, homebuilders may not directly communicate with most of their competitors, and trade contractors typically do not interact with other skilled trades to look for innovations that would improve their collective product or productivity. An important countervailing force, however, is the high turnover rates in the homebuilding industry, which means that there is a relatively large flow of information among firms through the workers themselves. In addition, industry and association magazines, newsletters, advertisements, and web sites continue to improve the flow of innovation information, but educating all aspects of the industry still requires significant time and effort. Unfortunately, the high turnover of staff is likely to deter investment in training, and free flowing information over the Internet is not the same as training and experience.

Finally, the industry is also vertically fragmented, because most firms focus on a single stage of the homebuilding process rather than on several stages. As a result, firms operate independently and have few incentives to innovate in ways that might help others unless they were to capture benefits sufficiently large to justify the innovation on its own. The even larger challenge posed by vertical fragmentation, however, is that it complicates the sharing and disseminating of information, which, as Chapter Two showed, is a key factor in whether a decision agent decides to adopt an innovation. For example, a homebuyer may request that the builder use a new building material that he or she read about on the Internet. However, the builder may resist if the innovation’s costs, benefits, or risks are unfamiliar; if trade contractors do not know how to install it; and if suppliers do not stock it. Finally, builders may also resist if they fear that code inspectors will not allow it. A final manifestation of the negative effect of vertical fragmentation is that it makes it difficult for manufac-

\[\text{\textsuperscript{12}NAHB Research Center (1991, p. 23); and Slaughter (1993).}\]

\[\text{\textsuperscript{13}Evaluation reports, as described in Chapter Three, are intended to address all of these concerns by stating under what conditions an innovation satisfies each of the model codes.}\]
turers to obtain feedback from customers or builders about new product ideas.\textsuperscript{14}

The net effect of fragmentation is that it increases the number of people who need to learn about an innovation and it decreases the efficiency with which they can learn about it. As a result, it lengthens the duration of the innovation process by requiring that more participants play the role of enabling, influence, and decision agents.\textsuperscript{15}

\textbf{Benefits of Innovations Are Often Hard to Protect}

The housing industry, and the homebuilding process especially, are largely process-based. In almost all cases, the process is open and transparent to a large number of outside contractors. As a result, unlike high-tech industries such as electronics and biotechnology where innovators can protect their innovations through secrecy and patents, it is more difficult for homebuilders and others in the housing industry to protect their innovations.

In the case of product innovations, the scarce funds used to develop the innovation must also be used to register and protect the innovation’s intellectual property. This is more than many firms can afford. In the case of process innovations (i.e., innovations that alter how a home is built), protecting them is difficult—especially for small and medium-size builders—because of their dependence on outside contractors who may take their ideas to other job sites.\textsuperscript{16} Innovators may also resist seeking code approval or code modifications, since many of these processes occur in open, public forums potentially giving competitors the opportunity to introduce an imitation.\textsuperscript{17}

\textsuperscript{14}Construction industry studies have shown that many intermediate building product innovations are developed by builders and then communicated to the product manufacturers for commercialization and further development. Vertical fragmentation can undermine this process, as can innovations that span multiple firms. See Slaughter (1993).

\textsuperscript{15}This conclusion is shared by innovation researchers. For example, von Hippel (1988) found that fragmentation in an industry deters innovation, because of the complex interactions among participants that may be required to introduce new products and methods.

\textsuperscript{16}NAHB Research Center (1998, 2001b); and NAHB Research Center et al. (1989, p. ii).

\textsuperscript{17}Dave Conover, National Evaluation Service, personal communication, July 12, 2002.
Each of these characteristics reduces the incentive for individuals and firms to promote innovation. Although the difficulty of protecting innovation means that low-cost, easily implemented innovations have few barriers to dissemination, it is far more important to realize that without incentives, innovations will not be created and there will be nothing to be diffused.

**PARTICIPANTS MOTIVES TOWARD INNOVATION**

Chapter Three showed how the industry’s participants work together to put a homebuyer in a new home. That presentation may suggest that homebuilding is a relatively straightforward process, but in reality it is quite complex. Many complexities stem from the fact that building a single home requires that many thousands of decisions be made by hundreds of individuals.

Sometimes these decisions are made using the agent-based model described in Chapter Two. In other cases, decisions are made after negotiating with others or considering how others will respond to decisions with which they disagree. It is the aggregation of the many millions of decisions made throughout the industry each year that defines the status quo and creates opportunities for change and innovation.

In this section, we step through the homebuilding process and review the primary motives of participants and how those motives are likely to influence their inclination toward innovation. This is important because, as Chapters Two and Three showed, throughout the homebuilding process, participants are routinely thrust into and rotate through the roles of decision agent, enabling agent, and influence agent. For this reason, it is important to understand participants’ motives and how they decide to support or not support an innovation.

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18 As explained in Chapter Three, this discussion will focus on the most directly involved participants, and each will be discussed only in the stage where they are most involved.

19 Although it is tempting to think of the land developer as the decision agent in the land development stage, or the homebuilder in the construction stage, in reality many decisions must be negotiated with other parties such as designers, building departments, trade contractors, and lenders.
Before beginning this discussion, recall that the motives presented are the result of insights gathered during conversations with individuals from industry, government, and academia over the course of three years of research on housing innovation. By sharing these insights, we seek to illuminate why groups are more or less likely to support an innovation by putting innovation in the context of their primary responsibilities and functions. We would have preferred to use quantitative behavioral data describing what participants do rather than what they say, but such data are not available and collecting them would have been beyond the scope of this study. Accordingly, the reader should recognize that the motives presented will not necessarily represent all participants. (This would also be true of quantitative data had they been available.) In short, the reader should use this discussion to gain general insight into each group and how they may view innovation in general.

Last, to provide greater insight into housing innovations themselves, each section of this chapter also presents several examples of innovations that are in various stages of development and deployment. These examples help to illustrate both the benefits and the challenges to innovation.

**Land Development**

Innovations in the land development stage are mostly, but not entirely, land-use innovations. Although land-use innovations may seem unrelated to the homes ultimately built on that land, the decisions made in this stage often have much larger effects on homes than those that occur later in the homebuilding process. This is because lot size, orientation, and proximity to open space, neighbors, and transportation corridors can all affect the type and characteristics of the final home. In addition, land-use innovations may have significantly larger effects on residents’ quality of life, the environment, and society than almost any other innovation. Once made, these decisions are largely irreversible.

Several examples of land development innovations include the following:

- **Designing Lots for Solar Access.** Orienting individual lots with their long axis running east to west maximizes access to solar en-
energy (i.e., it maximizes the southern exposure). This allows the architect to harness the sun’s energy to heat the home in the winter while using roof overhangs to shade the home in the summer. This simple step can save significant energy and money over the life of the home.20

- **Planning for Smart Growth.** Meeting housing demand by planning for higher density, mixed use, open space, transit, and walking access can increase the quality of life for residents and help protect the environment.

- **Information Technology for Land Development.** An innovation unrelated to land use is for local governments to use information technology and the Internet to provide faster, more accurate, and more complete access to information about publicly available land and property records such as land-use plans, zoning status, tax records, maps, covenants, and proffers among much else.21

**Developers.** The principal business of land developers is to buy undeveloped land, to prepare it for resale, and then to sell it. Since all money, whether borrowed or not, has a time value, developers have a strong motivation to complete the land development process as quickly as possible.

This emphasis on speed challenges the innovation process in five ways. First, developers need time to learn about an innovation. Second, if they want to adopt it, they need to find land development designers and contractors who are qualified and willing to do such work. Third, if an innovation requires rezoning the land (i.e., changing zoning from single family to mixed use), the developer must make the case before the local planning and zoning department. Similarly, if an innovation requires a change in an existing restrictive covenant, it may be too time consuming or expensive to obtain a waiver. Finally, depending on the nature of the innovation, the developer may need to convince investors that the innovation is likely to benefit them as well.

20 For more information, see North Carolina Solar Center (2002). Another useful reference is the U.S. Department of Energy (2002d).

21 One example is the Land Development System (LDSnet) of Fairfax County, Virginia, Department of Planning and Zoning. See Virginia Department of Planning and Zoning (n.d.).
This last concern is particularly important, because some land-use innovations may be perceived as reducing the value of the land, because changes may increase design and development costs, reduce the number of lots for sale, and potentially reduce the sales price of individual lots. For these reasons, developers (as well as their investors) may consider land-use innovations too risky—at least until others have demonstrated that they can be applied profitably.

Planning and Zoning Departments and Elected Officials. A developer may need to obtain approvals from planning and zoning departments or elected officials or both to start a development consistent with existing zoning, depending on local laws. However, if a developer also seeks to change the current zoning, a more extensive process including public hearings may be required.

Since these bodies operate in public view, including through public hearings, land-use decisions often attract significant community interest and public comment. These efforts may add cost and delay to the development process. Therefore, developers may avoid or minimize such requests if they believe the change or proposed innovation would not be broadly supported by the community or would not lead to a net reduction in cost or time. This can potentially reduce the use of such innovations.

Community Interest Groups. Community interest groups often seek to influence major projects and land-use decisions. They do this by lobbying local officials, speaking at public hearings, advertising in the print or television media, or directly engaging the public. Depending on their specific cause and whether an innovation helps or hurts that cause, they may take a strong position either for or against an innovation. These groups may seek to preserve the status quo as a way to protect the property values of their own existing homes among other social causes. In many cases, in preserving the status quo these groups oppose innovations that are conspicuous or might otherwise change the character of the community.

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Some innovations may reduce the construction time or cost on their own, but related public input may reduce these benefits. As a result, developers generally consider the net benefits when deciding whether to adopt an innovation.
Design

Design stage innovations grow the knowledge base used to improve the products and processes that shape a home. Since knowledge is used by all participants, design innovations are exceptionally broad. Examples of design innovations include the following:

- **Computer-Based Design Tools.** Energy-10 and DOE-2 help designers increase a home’s energy efficiency by using systems analysis to optimize window size and placement, roof overhangs, and air-conditioning sizing among other things.23

- **Information Dissemination via the Internet.** The Internet is also transforming how information reaches designers because manufacturers can now share information directly and efficiently via the web. This is providing architects, engineers, and especially homebuyers with more information to shape the design of the home.24

- **Advances in Building Materials and Products.** Design innovations can also improve building materials, products, and processes. For example, I-joists, pre-cast foundations, and insulating concrete forms (ICFs) show how new designs can lead to innovative building materials and products.25

**Architects and Engineers.** Although architects and engineers often see themselves as the primary sources of innovation, their professional obligations also require that they understand the cost and performance implications of innovations. This presents a challenge for innovations with which they are unfamiliar and for which little independent and objective information is available. In addition, residential architects and engineers generally have limited resources available to acquire information about innovations or to explain the merits of innovations to clients.

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23 For more information on these and other computer-based design tools, see www.eren.doe.gov/buildings/energy_tools/doe_tools.html. A recently completed assessment of the effect of the DOE-2 program can be found in National Research Council (2001, pp. 100–104).


25 These innovations are discussed in NAHB Research Center (2001c); and Phillips (2001, pp. 72–74).
The huge volume and relative simplicity of residential construction, as compared to commercial and industrial construction, lead to fewer, shorter, and generally more routine interactions. As a result, residential architects and engineers may avoid using innovations—especially innovations without evaluation reports—that they worry will be difficult to explain to those in the regulatory system.

**Homebuyers.** When looking to buy or build a home, homebuyers look for many things, but innovation is typically less important than are location, aesthetics, value, the chance for appreciation, and the quality of the neighborhood and surrounding schools. For this reason, although homeowners are often interested in innovations that could improve energy efficiency, increase durability, or lower maintenance costs, this interest is typically mitigated if the innovation is perceived as potentially reducing other important traits such as the present or future value of the home.

**Testing, Certification, and Evaluation Groups.** Taken together, testing, certification, and evaluation groups play a critical role in enabling innovation. By providing a mechanism to independently, objectively, and professionally test, certify, and evaluate performance with respect to codes and standards, these groups and the reports they produce quickly and credibly provide the information needed by designers, builders, and code officials. Also, by freely distributing evaluation reports on the Internet, the housing industry will increasingly have instantaneous access (including through wireless access) to these important documents.

**Pre-Construction**

Innovations relevant to the pre-construction phase include those that change how plans are reviewed, permits issued, and building materials produced among others. Examples of these types of innovations include the following:

- **Internet Tools for Regulation, Management, and Information Sharing.** Information technology (IT) can be used to streamline the pre-construction phase. Although still in the early phases of

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26Sweaney et al. (2001).
adoption, moving portions of the plan review permitting processes onto the web can increase speed and convenience while lowering costs. IT can also be used to share code changes and product evaluations more quickly, potentially even in the field using wireless technology. Management tools can help builders schedule subcontractors and material procurement while helping material producers and product manufacturers better manage their supply chains.27

- Manufacturing Advances. New processes for manufacturing materials, products, and components can also improve the pre-construction phase. For example, improving the efficiency and automating the production of pre-fabricated components (e.g., roof trusses and wall sections) or even building housing in development-specific assembly lines are important innovations.28

Model Code Organizations. The membership of model code groups generally consists of public code officials and the private sector. During the course of any given year, technical committees hold hearings and prepare proposals for consideration at the code group’s annual meeting. The technical committees consist of industry personnel and public safety officials, but most model codes are changed only if a majority of public safety officials nominated by their state and local governments vote in favor of a committee proposal. Although many feel that a system of “democratic voting by public officials” is the best decision process for ensuring that the public interest is served, others argue that it slows the rate at which the codes change and innovations can be introduced.29

Regulatory Agencies. In seeking to enforce existing building codes, regulatory officials sometimes prefer conventional designs, materials, and products to innovations since they are already familiar with

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27 More detailed discussions of these innovations can be found in NAHB Research Center (2001b); and Hassell et al. (2000). In addition, the National Conference of States on Building Codes and Standards has significant information on these issues on its web site at www.ncsbscs.org/.

28 These innovations are discussed in NAHB Research Center (2001a); and Phillips (2001, pp. 72–74).

29 The voting and larger decision processes used by model code groups is a heated topic. Interested readers should visit the web sites of the International Code Council and the National Fire Protection Association to learn more about this debate.
them. However, when agency personnel consider innovations, they typically need more time to determine if they meet local requirements (possibly by reviewing the evaluation reports and other documentation). Depending on how long it takes for agency personnel to make this decision, the time or cost benefits of using the innovation may be diminished.\(^{30}\)

**Material Producers, Product Manufacturers, and Pre-Fabricators.** The producers of building materials, products, and components seek to make a profit by selling quality products to broad and niche markets. To do this, they may consider a number of factors beyond the product itself.

**Suppliers.** Similarly, suppliers want to earn a profit by stocking the products and materials their customers want. Although suppliers do not oppose innovation, they may be less inclined to stock an innovation of which their customers are unaware.

**Construction**

Innovations in the construction stage change how homebuilders and trade contractors physically construct the home. In many cases, construction innovations are influenced by material, product, and component innovations that occur in the design and pre-construction stages. However, in other cases, innovations relate to information technology and construction-related process innovations. Sample construction innovations include the following:

- **Using IT to Streamline Field Inspections.** IT can be used to streamline the scheduling of field inspections as well as to aid with the inspections themselves and needed record-keeping and follow-up\(^{31}\)

- **Pre-Fabricated Components and Alternative Materials.** Building homes from pre-fabricated components (e.g., pre-cast footers, wall panels, roof trusses) or alternative materials such as insulat-

\(^{30}\)Field and Rivkin (1975).

\(^{31}\)See NAHB Research Center (2001b); Hassell et al. (2000); and the web site of the National Conference of States on Building Codes and Standards at www.ncsbscs.org/.\)
using concrete forms or steel framing can potentially speed construction while improving quality.

- **Improved Construction Techniques.** Better sealing around windows, improving fresh air ventilation, and placing heating, ventilating, and air-conditioning (HVAC) ducts in conditioned spaces can improve energy efficiency and reduce energy bills.

**Homebuilders.** Homebuilders stay in business by building quality homes at a profit. Therefore, builders are motivated to improve the coordination and productivity of trade contractors, reduce the cost of materials, and ensure that regulatory requirements are met. Acting on these motives requires evaluating changes in the price and quality of labor and materials, the potential for call-back repairs or liability, the long-term importance of goodwill and cooperation with trade contractors and suppliers, and weighing the regulatory and “market” risk of innovations that may not be familiar to field inspectors or desired by homeowners.

An additional dimension to builder motives and how builders weigh innovation-related decisions relates to the size of the building firms themselves. Small and medium-sized builders might intentionally use visible innovations such as high-performance windows and placing ducts in air-conditioning spaces to differentiate their homes. Large builders, however, may prefer “hidden” innovations such as pre-fabricated components that can improve productivity while still producing homes that look traditional. This is particularly true with larger housing developments where large builders can establish such techniques as the communitywide standard for how homes are built.

**Trade Contractors.** Trade contractors typically provide a narrow set of services defined by skills learned on the job or through special training. Since these services are largely defined by past experiences and often by the codes themselves, contractors may have few motivations to adopt an innovation. This is especially true if the innovation could reduce the demand for their services.

Finally, the skills and experiences amassed by skilled laborers can either help or hurt innovation. This is because their knowledge can either be combined with creativity to develop a new way of doing something, or their knowledge can constrain their creativity and cause them to simply accept traditional approaches without ques-
tion. Several innovation researchers argue that creativity often leads to process innovations on the job site, but they often go unnoticed, since there are no mechanisms for recognizing or communicating these innovations to others.\footnote{Slaughter (1993).}

**Post-Construction**

After a home is built, there are many opportunities for innovation. But the true importance of innovation in the post-construction phase is that many decisions about innovation occurring earlier in the process are influenced by how designers and homebuilders anticipate that the parties in the post-construction stage will react to their decisions. Since successfully selling a home requires finding a buyer, arranging financing, and obtaining insurance, designers and builders consider how these parties will react to an innovation before they make a decision to use it. As a result, the post-construction phase is recognized as exerting significant indirect pressure on whether innovations are adopted in the earlier stages.\footnote{Personal communication during an industry roundtable discussion on “Housing Innovation and the Appraisal Process,” organized by NAHB Research Center, Bowie, Md., December 18, 2001.}

Examples of innovations that directly and indirectly affect the post-construction stage include the following:

- **Database on the Effect of Innovations on Real Estate Prices.** Databases that store and share information on the market value of innovations can help appraisers, Realtors, homeowners, and homebuilders learn about how innovations are valued by the real estate market.\footnote{One example is the Appraisal Institute Residential Database that seeks to provide a nationwide source of appraisal data, including innovative homes. However, its potential will be realized only if the database is populated, easily accessible, and broadly used. For more information on this effort, see www.airdport.com/. Also see Harney (2000, p. G01).}

- **Mortgage Underwriting Software.** In the mid-1990s, Freddie Mac and Fannie Mae each introduced mortgage underwriting software to standardize and accelerate loan evaluation, issuance, and transferring the mortgage to the secondary market. This...
software has helped the nation’s 25,000 mortgage brokers increase the percentage of mortgages they originate from 20 percent in the early 1990s to more than 50 percent by 2000.\textsuperscript{35}

- **Innovation-Promoting Mortgages.** Several secondary lenders offer mortgages that reward housing innovations such as energy efficiency, renewable energy, sustainable or “green” materials, or access to public transit.\textsuperscript{36} These mortgages use the estimated cost savings from reduced energy and transportation costs to either increase the size of the loan or improve its terms.\textsuperscript{37}

- **Analysis and Dissemination of the Benefits of Innovations to Insurers.** Once quantitative information on the performance of innovations is available, analysis and dissemination of results help insurers, lenders, Realtors, and homeowners better understand the potential risk-reducing benefits of some innovations.\textsuperscript{38}

- **Computer-Based Remodeling Tools.** Homeowners can also benefit from computer-based tools that help them learn how to remodel their homes in ways that can save them money and increase its value. Although many product manufacturers and their associations offer tools to better quantify the benefits of their products (e.g., washing machines, windows), state and federal agencies do so as well.\textsuperscript{39}

\textsuperscript{35}In exchange for a small fee, mortgage brokers can evaluate loans and sell them directly to the secondary market without partnering with a bank and other traditional lenders. For more information see Freddie Mac (1996); and Barta (2001).

\textsuperscript{36}See Fannie Mae (2002).


\textsuperscript{38}The “Fortified Home” program of the insurance industry’s Institute for Business and Home Safety (IBHS) provides participating insurers with guidelines on safety features relevant to hazards in a given geographic area. These guidelines can then be used to offer discounted premiums or deductible waivers to homebuyers who buy homes that have these features. See PATH Working Group on Barriers/Insurance (1999).

\textsuperscript{39}One user-friendly tool focused on energy savings is the Home Energy Saver developed and maintained by the Department of Energy’s Lawrence Berkeley National Laboratory; see homeenergysaver.lbl.gov (accessed June 8, 2002). Another tool focused on durability is the National Economic Service-Life Tool (NEST). This tool will inform homeowners and homebuilders about how building material selection can improve durability and lower long-term maintenance costs.
Real Estate Agents and Salespersons. Real estate agents and salespersons seek to match buyers, sellers, and homes. When it comes to homes with innovations, their ability to fulfill this role depends on whether they are aware of those innovations, their costs and benefits, and how they affect the perceived value of the home to those who do and do not value the innovation. Thus, agents or salespersons need to be fairly knowledgeable about an innovation and its positive or negative aspects. This possibly difficult level of awareness must be accomplished before innovations can become common.

Mortgage Brokers. To match homebuyers and lenders, mortgage brokers estimate the borrower’s ability to pay, work with an appraiser to estimate the home’s value, and seek financing from a lender. In general, their motives are to complete the entire process quickly and easily while not overestimating the value of a home, since the lender may review this closely. A broker may therefore prefer to use a standard appraisal, rather than a custom appraisal, which may cause a home with innovations to be more conservatively valued. The desire to complete the process quickly and easily may also lead the broker to prefer using standard mortgages rather than innovative mortgages such as those focused on energy efficiency, which may require or be perceived as requiring specialized training, processing time, and costs.

Appraisers. In estimating the market value of a home, appraisers may moderate their valuation so as to neither overestimate nor underestimate its value. This helps ensure that banks do not make a larger loan than could be recovered if the borrower defaults. However, in seeking to moderate the appraisal, they may tend toward local averages alone rather than taking into account the effect that an innovation may have on that average. This is because appraisers, especially those conducting a standard appraisal, may not have the necessary information to accurately value it. Unless they are being paid for a custom appraisal, appraisers are unlikely to have the time or resources to investigate how and if an innovation should affect the value of the home. As a result, although appraisers play a critical role in recognizing and certifying the value of an innovation, they do not have strong incentives to learn about them.\footnote{For a detailed discussion of these issues, see NAHB Research Center (2002).}
Primary and Secondary Lenders. Fundamentally, primary and secondary lenders want to make sure that a borrower has sufficient credit and income so as to not default on a loan. In addition, they want to make sure that the home is not overvalued so that, regardless of who holds the mortgage, the value of the loan can be recovered if the borrower defaults.

From this point on, the motivations of lenders begin to differ, especially as related to innovations, because, although innovations can affect a home’s market value, they can also make homes more affordable. Since some primary and secondary lenders are public corporations or quasi-government institutions, they typically have a special obligation to making homes more affordable. This means that innovations that reduce energy costs, maintenance costs, insurance risks, or transportation costs all provide a way to help fulfill this public charge. For this reason, lenders with public ties, and in the long run all lenders, have an incentive to recognize and adjust loan terms because of the presence of a beneficial innovation. However, because few innovations have sufficient data available on either their performance and ability to reduce costs or their effect on default rates, these innovative mortgage products are still rarely used.

Insurers. In measuring risk and setting insurance rates, insurers seek to quantitatively determine how an individual home is likely to compare to others. Since most homes use similar materials, products, and methods, insurers have a wealth of data on how they perform under extreme conditions such as wind, flood, fire, and snow. However, innovations suffer from a lack of data about how they perform (e.g., how does a new structural systems endure high wind, how does a new roofing system resist fire).

Many of the methods insurers use to analyze and manage risk cannot easily be applied to innovations. When insurers are unsure how to measure and manage risks posed by an innovation, they do not know whether to award a discount based on a lower risk, charge a higher premium for a higher risk (or increased uncertainty), or simply reject the applicant.41 As a result, insurers and those anticipating their re-

action to innovations may choose not to adopt innovations, thereby contributing to slowing the rate of innovation in housing.

IMPLICATIONS FOR INNOVATION

This chapter has shown that although innovations continue to occur, industry characteristics and participant motives often present additional challenges to innovations. For example, low barriers to entry, cyclical business cycles, and the predominance of small firms tend to reduce the willingness of builders to try innovations. Fragmentation and the difficulty of protecting innovations also increase the cost and risk of completing the innovation process. Furthermore, since the primary responsibilities of many industry participants are defined by issues other than innovation, increasing their awareness of innovations is quite challenging.

As stated in this chapter’s opening, many of the insights described have been informed by the authors’ discussions with industry participants over several years. As also stated in the opening, the reader should recognize that what people say is often different from what they do. Since quantitative behavioral data were not readily available and since gathering such data was beyond the scope of this study, the strongest conclusion this chapter can draw is that the structural aspects of the industry and the primary motives of its participants are likely to slow the rate of innovation. As a result, the benefits that innovation can provide are realized more slowly than they otherwise might be.

This conclusion leads to the following question: If the housing industry innovates more slowly than we would like, what can be done to increase the rate of innovation? As a first step to answering this question, the next chapter reviews past efforts by the federal government to do just that.