Building Codes: What Are They Good For?

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The views expressed in this article are those of the author and do not represent the official positions or policies of the Office of Policy Development and Research, the U.S. Department of Housing and Urban Development, or the U.S. Government.

Abstract

This article presents an economic framework for evaluating the net benefits or costs of building code regulations through their effect on housing markets, accounting for distributional impacts. The role of building codes can primarily be classified into three scenarios: (1) An industry standard that reduces transaction costs; (2) An isolated quality standard; or (3) A quality standard with spillover effects. To holistically evaluate the impact of a particular building regulation, we propose three major guidelines: (1) Correct market failures; (2) Estimate market impacts; and (3) Account for distributional considerations. This framework is applied to energy efficiency regulations and solar panels in particular. Energy efficiency codes reduce negative environmental externalities and information asymmetry and promote high-quality long-term affordable housing stock; however, the willingness to pay for energy efficiency varies with income. Policymakers must consider how policies intended to promote the welfare of low-income housing residents might create exclusionary impacts due to increasing the cost of supplying housing.

Building Regulations and Regulatory Barriers

Building code regulations are intended to ensure a certain level of housing safety and quality, but there can be a tension between mandating high-quality housing and ensuring affordability. To find the right balance, it is important to consider the costs of exclusionary market effects and weigh this against the benefits of raising the welfare of the lowest-income housing users. This article offers guidelines to assist the planner with the difficult task of ensuring public health and safety without creating an additional burden on low-income residents of a community.

There are a large number of regulations that can potentially impact housing affordability. Researchers and practitioners often point to land use regulations as a major source of regulatory barriers. In addition to land use and zoning regulations, industry stakeholders have identified building regulations as potential barriers to affordable housing.[1] Many developers have expressed that building codes have become more aspirational rather than strictly safety-oriented and have pointed specifically to energy efficiency standards as an example of overreach. Some posit that building codes generate industry inefficiencies by promoting wasteful construction practices whereby previously utilized materials are rendered obsolete prematurely, creating waste down the supply chain (Kelly, 1996). It can often take longer than 3 years—the time between International Code Council updates of internationally adopted building code standards—to develop new building materials or products, over which time building and energy efficiency codes may have changed in ways that render the goods no longer usable. This may slow innovation in the building industry and overall development timelines (Kelly, 1996). Building codes may also be less flexible in allowing for the use of recycled construction materials (Volokh, 1996). Finally, building codes may hinder the rehabilitation of existing buildings if they have to be retrofitted to current-day standards (Schill, 2005). An earlier study (Oster and Quigley, 1977) found that wealthier communities tended to shy away from adopting newer codes that included cost-saving features. It is important to understand some of these unintended and potentially exclusionary consequences of building regulations.

The exclusionary effects of overregulation can be intentional or unintentional. Although the Supreme Court banned racial housing covenants in 1917 and the 1968 Fair Housing Act banned housing discrimination based on race and other protected classes, many communities enacted regulations that were not racial in language but had the same effect of excluding Black residents from living in the area. These regulations included zoning only for single-family owner-occupied housing, which de facto excluded the majority of Black Americans, who, through generations of discrimination, had not accumulated the capital needed to access this type of housing (Rothstein, 2017). Evaluating the disparate impacts of housing policies on protected classes and other vulnerable groups is one way to determine whether housing and its associated opportunities are equally accessible across differently regulated areas.

Building codes should not be rejected outright because there may be associated costs. On average, building codes might not have added to construction costs. Annual data from 1890 to 2018 show that construction costs, unlike home prices, have not changed significantly since the early 2000s as the international I-codes were introduced (exhibit C-1). Still, home prices have increased substantially. Gyourko and Molloy (2015) determined these price increases are influenced much more by land costs than building costs, which are relatively uniform no matter where construction is happening.[2]

Effective building codes can promote industry efficiency and improve both housing and neighborhood quality. Ideally, building codes correct market failures. However, overregulation can

[1] From roundtables held by the White House Council on Eliminating Regulatory Barriers to Affordable Housing in 2019 and 2020.

[2] Land costs are in turn highly affected by land use and zoning regulations, which have a much larger effect on restricting the supply and affordability of housing.

stifle competition, innovation, and general market efficiency. In the U.S. housing market, more tightly constrained markets, where the housing stock is not keeping up with population growth, are criticized by many as being overregulated. Artificial impediments to housing production or operation can reduce housing affordability, disproportionately limiting economic opportunities for the poor (Glaeser, Gyourko, and Saks, 2005). The affordability of housing should be an overriding policy goal. Flexible and low-cost housing markets allow job seekers to move to high-productivity cities (Duranton and Puga, 2019; Ganong and Shoag, 2017; Glaser and Gyourko, 2018; Herkenhoff, Ohanian, and Prescott, 2018; Hsieh and Moretti, 2019). Other costs to consider arise from limiting families' access to high-opportunity areas (see Chetty, Hendren, and Katz, 2016).

Purpose of Building Codes

Building codes regulate the characteristics of a structure by specifying the requirements needed to adequately protect the safety, health, and welfare of occupants. The original purpose of codes was to establish standards to protect buildings and their inhabitants from natural disasters and fires. Codes are also intended to ensure a building's structural integrity and the reliability of electrical, plumbing, and mechanical systems, as well as improve accessibility and energy efficiency.

Building code regulations were first developed at the local and state level to protect safety and public health, particularly regarding fires and crowded tenement living. At the turn of the 20th century, it became clear that the existing state of U.S. housing development had led to unsafe living conditions and that construction needed to be more tightly regulated. The insurance industry was instrumental in establishing the first National Electrical Code in 1897. In 1900, the National Housing Association was established to advocate for housing reforms regarding health and sanitation in response to widespread unhealthy living conditions in tenement housing (Veiller, 1910). The National Board of Fire Underwriters published the first U.S. model building code in 1905 (Listokin and Hattis, 2005).

Energy efficiency regulations have been pursued historically during energy shocks. In 1950, before the existence of the U.S. Department of Housing and Urban Development (HUD), the Housing and Home Finance Agency developed residential energy efficiency requirements in response to defaults on federally backed mortgages arising from excessive energy bills. In 1977, the U.S. Department of Energy (DOE) was created in response to the price shocks of the Arab Oil Embargo. Energy conservation was a key component of the DOE's original mission. Federal energy efficiency programs exist across agencies, including the DOE's Low Income Weatherization Assistance Program; the Department of Health and Human Services' Low Income Home Energy Assistance Program; energy-efficient mortgages under Fannie Mae, Freddie Mac, and the Federal Housing Administration; and the Environmental Protection Agency's ENERGY STAR Certified Homes; among others. These programs demonstrate the public interest in energy efficiency due to the resilience and social welfare generated by energy savings.

Optimal Building Codes and Potential Housing Impacts

To evaluate the impact of a building code on the housing market, we review three potential roles of a building code: (1) a mutually beneficial guideline for industry and consumers that, by establishing agreed-upon rules, lowers transaction costs; (2) a minimum quality standard without neighborhood effects; and (3) a minimum quality standard with spillover effects to neighboring structures. Understanding the potential market impacts of implementing a building code helps estimate and later evaluate the building code's overall desirability and whether the net benefits will differ by income group.

Building Codes as an Industry Guideline

A model building code serves as a guideline for builders as to what is a safe and durable structure. There are returns to scale for uniform industry standards. Builders and local governments can avoid the costs of research and learning through trial and error. Lenders can be more certain of the underlying value of the collateral if it is built to a code with which they are familiar.[3] Insurance companies, landlords, and homebuyers will spend less on building inspectors if the task is to verify that the structure meets a well-known code, rather than gauging the risk inherent in a less familiar construction style. With such advantages, building standards would be adopted by industry without being compelled.

A voluntarily adopted building code could favor affordability. Costs should fall in the middle of the housing market. The cost savings will be passed on to renters and owner-occupants. Lower-cost housing in the middle of the market would eventually filter down to low-income households. One author offers the possibility that minimum quality standards could enhance price competition among producers if quality becomes less variable (Ronnen, 1991). For housing at the upper end of the market, prescriptive building codes could slow innovation (Maxwell, 1998). While limiting the spectrum of housing available to the top of the income distribution, this potential effect could expand affordability by leading to more homes produced in the middle of the market.

Alternatively, an independently chosen building code could also reduce affordability. Leland (1979) explains that an industry may have an incentive to set quality standards higher than the level desired by consumers. Restricting production through higher standards allows producers to raise industry profits as long as the associated price increase is sufficient to offset the cost of the standard. This would lead to negative consequences for lower-quality housing producers and low-income consumers.

Whether a building code is voluntary or mandated, a housing market could function better in the presence of minimum quality standards. Building codes could, under certain circumstances, deter an undersupply of decent and affordable housing. If any producer is willing to supply inferior construction, and buyers cannot accurately ascertain the quality level, quality is driven out of the market (Akerlof, 1970). A building code instills trust in the housing market. In the absence of building codes, buyers lower their willingness to pay for a given home due to the uncertainty concerning the quality of construction. Lower sales prices would lead to fewer homes built, creating an under-supply of housing and quality, even for low-income homebuyers. The existence of minimum quality building standards diminishes information asymmetry and fosters a market where buyers can more easily assess a given home's true value. It is difficult to know how

[3] The Federal Housing Administration introduced its earliest version of Minimum Property Standards in 1935 to mitigate the risk of insuring debt collateralized by housing assets of uncertain quality.

pervasive this type of market failure is and whether it requires a regulatory response. However, that information asymmetry exists is proven by the existence of building inspections and 10-year construction warranties. Even if the quality standard leads to an overall expansion of consumer and producer surplus, however, households unable to afford more expensive housing could be harmed by an optimal quality standard (Shapiro, 1983).

One study concluded that asymmetric information does not inhibit optimal building patterns by finding that mandated participation in the National Flood Insurance Program and establishing a building code for coastal areas reduced the vacant land value on Florida's barrier islands (Dehring, 2006). While it is possible that the code was stricter than optimal, it is also possible that the decline in land values stems from owners being required to internalize the costs of risk. Federal, state, and local governments provide an implicit subsidy to low-quality housing through resources spent on rescue and reconstruction after a natural disaster. Instead of viewing the empirical result as showing that building codes necessarily inhibit profitability, it can be viewed as evidence that the lack of standards provides an inefficient subsidy to low-quality housing. Considering only private costs would lead to an incorrect evaluation of a policy that raises the long-run cost-effectiveness of providing a built environment. For example, the National Institute of Building Sciences' (2019) multi-year study on natural hazard mitigation has found that designing buildings to meet the latest International Residential Code and International Building Code can generate as much as $11 in national benefits for every $1 of investment.

The arguments for the stabilizing influence of building codes is undermined if there is a confusing diversity across jurisdictions. The unevenness of state and local building codes may be a greater source of compliance costs than their existence in general (IBHS, 2018; Koebel et al., 2004; Vaughan and Turner, 2013). As compared to other developed countries, the United States is unique in its mix of voluntary and mandatory requirements, which makes standardization for builders and developers across geographic jurisdictions challenging, creating inefficiencies that would be passed on to consumers in the form of higher housing costs (Young, 2014).

Minimum Quality Standard as Consumer Protection

A standard argument for building codes is that a minimum quality standard is required to protect consumers from their own ignorance of the risks from living in an unsafe structure. Such an approach can seem overbearing but may be justified for certain characteristics of housing. Examples include safety features, such as self-tripping Ground Fault Circuit Interrupter (GFCI) outlets, which reduce electrical shocks, and railings along stairs, which prevent occupants from falling. A carbon monoxide detector is required in homes in most states because tenants are not fully informed of the dangers of carbon monoxide poisoning. These features provide greater benefit to risk-averse households.

If there is sufficient evidence that markets are self-regulating, then imposing a minimum quality standard would harm consumers who knowingly and willingly choose to consume less of the required safety attributes. The loss would be equal to the difference between the price of a home with the minimum supply of the regulated attributes and what the household is willing to spend (Rosen, 1974). Because lower-income households consume less of most goods, those who might suffer from a minimum quality standard may also be low-income. One study proposes that building codes intended to promote health and safety may also contribute to health risks by adding to the cost of supplying housing (Hammitt et al., 1999). Hedonic wage research reveals similar insights: risky occupations are often low-wage ones, not because there is no hazard premium, but because safety, like any other good, is a normal one—demand increases with income (Viscusi, 2018). The willingness to pay for a better situation is restricted by income and wealth, whereas the willingness to accept detrimental situations is not.

Relying on the market to solve public health and safety concerns is questionable when the product involved is complex, difficult to evaluate, and the consequences of consumer or producer error are grave and irreversible. Mandating that households pay for healthier housing may be merited when some occupants do not have freedom of choice (Breyer, 1993). Children suffer most from exposure to lead but are not the ones deciding whether to inhabit a dwelling with lead-based paint. Insisting on safety features at construction may be more efficient for features that are prohibitively expensive to add after a home has been built. The government's challenge is to balance the perceived gains from better housing with direct and indirect costs. In general, the most effective policy may be to deter the production of extremely hazardous features rather than attempt to eliminate risk completely (Oi, 1973).

The effect of safety provisions on housing production is ambiguous. Consumers who are less risk-averse may not value these safety features and may be less willing to pay for them. However, if most home buyers see these provisions as adding value, demand for homes with these features, which would primarily be newer construction, would increase. Households that would have consumed housing of an equal or greater quality than the minimum would not be adversely affected.

Minimum Quality Standard to Promote Positive Externalities

Building codes can serve to reduce negative externalities that otherwise exist in the housing market. For example, homeowners and landlords have an incentive to prevent fires from starting on their own property but less of an incentive to prevent a fire from spreading to neighboring properties, as the costs are borne by the neighbors. The development of building codes in the United States was a direct response to catastrophic fires that spread quickly and destroyed neighborhoods and large sections of cities. The prohibition of wooden chimneys and fire walls in Boston is an early example. Anchoring standards in HUD's Manufactured Home Construction and Safety Code exist to prevent manufactured homes from being lifted from their foundations and causing damage to other properties during storms with high winds. Most of the benefits from these provisions accrue to neighboring property owners rather than to the owner and occupants. The reduction of the negative externalities justifies the costs of these provisions, which are borne solely by the owner. This type of building code also increases the value of all homes as the risks from neighbor inattention are reduced.

Raising the quality of a building through minimum quality standards has positive effects on neighboring homes. A positive neighborhood effect would be one that lowers the cost of operation of nearby homes or creates amenities in the area. Such external effects would increase the demand for the location by landlords pursuing profits and tenants seeking quality of life. Market pressure for those units will impact the affordability of shelter in the affected area, with potential spillovers to other submarkets. Building codes would directly and immediately affect only the neighborhoods where there is a clustering of new construction and rehabilitation. Newly built units are generally in proximity of one another because most of the homes in an area follow a similar lifecycle (Mieszkowski and Mills, 1993). This geographic separation creates areas where the positive externality exists and where there is a premium. Even as the minimum level of quality spreads throughout the entire stock, variation will remain if different types and vintages of housing impart and receive the externality at different intensities. Initially, the neighborhood effects would be limited to high-income areas where there is a more substantial level of new construction.

Consider the effect on affordability of a building code that creates an amenity enjoyed by neighbors. Safety may be the most obvious example. Because fires spread, lowering the chance of a fire in one home reduces the risk of damage to its neighbors. A fire code would increase the supply of safety in the affected neighborhoods, and raising the supply of public safety makes it less expensive. A greater supply of amenities would reduce the price differential between locations with different amounts of safety (Bartik, 1988).[4] Making safety more affordable could attract low-income households to the affected area. Dense areas where there is less housing separation would benefit the most from positive neighborhood effects.

HUD's experience in building regulations is in the realm of manufactured housing.[5] Additions to the safety standards included more stringent wind standards in 1994 as a response to the disproportionate damage to manufactured homes during Hurricane Andrew. An analysis of the increased cost of production and resulting deadweight loss compared to the averted public and private damages from a hurricane predicted significant net benefits of the rule (benefit-cost ratio of 8 to 5).[6] Ten years later, during another difficult hurricane season for Florida, homes built to the 1994 standard performed significantly better than pre-1994 homes (IBTS, 2005). Despite the success of the engineering standard, the economic benefits may not be directly realized by all residents of manufactured housing built to the new standard. Much of the benefit of the rule was to reduce disaster assistance for displaced residents and limit damage to neighboring properties. The rule removed an implicit social subsidy of manufactured housing in vulnerable areas. The long-term benefits are to promote a lower depreciation of the housing stock. However, there is no immediate way of transferring this gain in efficiency to low-income residents.

Whether low-income households benefit depends partly on the response of high-income households. If enhanced safety makes dense areas more desirable, then high-income households may outbid low-income households for those locations that improved more than average. Affordability of housing will decline in this case. The net welfare effect on low-income households will depend on whether the safety benefits are great enough for them to sustain the increase in rents. There are locational characteristics for which low-income households possess a willingness

[4] Many insights discussed in this section regarding neighborhood amenities were derived from Bartik (1988).

[5] In 1974, Congress passed the National Manufactured Housing Construction and Safety Standards Act, which authorized HUD to establish and enforce construction and safety standards for factory-built manufactured housing.

[6] For a brief description, see Housing Impact Analysis, prepared for U.S. Department of Housing and Urban Development (Dacquisto and Rodda, 2006).

to pay.[7] If the price of housing were to rise more than the willingness to pay, then in the long run, households would be displaced.[8]

Framework for Evaluating Building Regulations

With an understanding of the different market roles a building code plays, we develop a framework to evaluate building regulations more holistically. The framework includes the following guidelines: (1) Rely on a strong market failure argument; (2) Account for the impact of the code on the housing market; and (3) Account for distributional impacts. Following this framework will allow a practitioner to develop a nuanced perspective of whether a regulation or code is a regulatory barrier to affordable housing. Finally, enforcing compliance is essential to realizing the desired outcome of the planner. Rather than responding to complaints, proactive enforcement will be costly and must be accounted for in any benefit-cost analysis.

Rely on a Strong Market Failure Argument

We have considered several helpful economic roles of a building code: (1) a mutually beneficial guideline for industry and consumers that, by establishing agreed-upon rules, lowers transaction costs; (2) a minimum quality standard isolated with no neighborhood spillover effects; and (3) a minimum quality standard with spillover effects to neighboring structures affecting either the cost of operation (supply-side) for a given type of housing or neighborhood amenities that improve the desirability of any structure. The first role reduces uncertainty concerning construction quality and fosters a well-functioning housing market. The second role provides safety benefits to the occupants of the home. The third role reduces negative externalities, which benefits neighboring property owners and occupants. Whether any of these justifications are valid for a specific regulation will depend upon how a building code is designed and the nature of the local housing market.

To justify a regulation, there should be strong evidence that the housing market fails to provide an essential amenity for which there is a willingness to pay. A lower level of quality is not necessarily a sufficient justification: the characteristics of the housing stock may be such that all inhabitants cannot be made better off. Policy intervention is recommended only when there appear to be genuine threats to public health and safety or a level of quality uncertainty that restricts the availability of credit. Before proceeding with a market failure argument, ask whether the private market has already provided solutions, even imperfect ones, to resolve undesirable outcomes. Negative externalities could be remedied through bargaining between neighbors (Coase, 1960), residents self-selecting into small communities (Tiebout, 1956), or large developers building an entire neighborhood with the profit-maximizing level of public amenities. Potential harm to residents of unsafe buildings could be curbed through information campaigns or liability. The information required for direct regulation may be greater than the knowledge needed for these more decentralized strategies (Spence, 1977). Transaction costs may be a barrier to the success of options that have the allure of requiring less intervention by government, and as a result, are exclusionary.

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[7] For example, low-income households place more value on locations which enjoy low costs of transportation (Daniere, 1994).

[8] The discussion of demand-side amenities and the impact on housing submarkets is described in more detail in appendix B.

Suppose that a planner has determined that mandatory standards are the best way of supporting an inclusive community. Remaining skeptical of the benefits of their own policy is an effective approach for ensuring that the code does not impose an excessive cost. For example, if a research study finds a high benefit-cost ratio, planners should investigate the barriers to achieving such a favorable outcome. Perhaps addressing the root cause of the failure, if possible, would be more effective than a stricter building code. Planners are still more likely to find themselves in a world where the options available to them are second-best (Lipsey and Lancaster, 1956). Markets will respond to regulatory intervention as its participants adjust to minimize costs.

Make use of policy studies judiciously. Be suspicious of hedonic studies that find very high premiums for any feature of a building or its location. Hedonic analysis is difficult to do correctly; the theory, data requirements, and empirical methods are challenging.[9] It is helpful to double-check results by determining if they make economic sense. For example, if an energy efficiency certification has been determined to raise the value of the building, ask whether the expected reduction of utility bills is within a similar realm. Use estimates of benefits and costs calculated by architects and engineers, but consider how human behavior could alter the predicted outcome. A study of federal product safety regulations (Viscusi, 1985) found that "technological solutions to safety problems may induce a lulling effect on consumer behavior."

Account for the Impact of the Code on the Housing Market

Housing markets have unique characteristics that influence how a minimum quality standard will affect affordability. These include price and income elasticity of demand for housing, the responsiveness of supply, heterogeneity of the housing stock, topographical constraints, and the localization of regulations. The impact of a building regulation on all income groups will ultimately be determined by its impact on the profitability of offering housing. Affordability and availability of housing will be improved only if the cost of producing declines as a result of the building code. Typically, economists measure any adverse impact by the net decline of economic impact (Harberger, 1964). Analysis of the housing market is made more difficult by some of its unique aspects.[10]

First, shelter is a necessary good. Low-income households have little flexibility in adjusting to the cost of housing because there is no substitute for shelter. If building codes raise the cost of shelter, then low-income households will either have to sacrifice other goods or leave the community to seek affordable shelter elsewhere. Being forced to move excludes low-income households from access to essential economic opportunities. The gravity of artificially raising the cost of housing should encourage the planner to carefully consider the most cost-effective building codes.

Second, housing structures and locations vary by characteristics and quality. When a household consumes housing, it buys multiple attributes in addition to shelter. Households bid more for high-quality housing, providing an incentive for landlords and builders to meet the demand for valued attributes. Demand for particular features will vary with a household's preferences and income, just as for any other good. In a well-functioning market, a household will be able to choose the level of quality and type of housing that matches its own willingness to pay with a producer's profitability.

[9] See Palmquist (2005) for a review of empirical property value models.

[10] For an in-depth review of housing impact analysis, see Dacquisto and Rodda (2006).

Third, housing is durable. Most of the housing stock has already been produced. After construction, housing depreciates, a process that can be decelerated through regular maintenance. Eventually, housing is redeveloped. Altering the building code will affect only new construction and rehabilitation. The immediate effect is inconsequential. The economic impact on the housing market will not be realized until the new quality standards have diffused throughout a significant portion of the housing stock. The longevity of housing structures poses a unique challenge to the planner wishing to implement a building code: making the correct policy decision will yield returns for a generation, but an error is relatively irreversible.

The durability of housing makes real estate an asset. The treatment of real estate as an asset can make benefit-cost analysis more complex. A large share of the financial flows that result from changes in asset values may represent transfers between buyers and sellers (a zero-sum gain) rather than benefits that expand economic welfare or costs that reduce it. Double-counting benefits or costs can also be difficult to avoid. Changes in costs of operation, the lifetime of the building, and rental revenue are embodied in the change in real estate value and should not be counted as a separate impact.

Fourth, housing is spatially fixed. For producers, spatial fixity makes it impossible to escape the costs of inefficient regulation. For consumers, choosing a home is equivalent to choosing a location and its associated advantages and disadvantages. The value of the location will be reflected in the price of housing and the land upon which it is built.[11] The willingness to pay to avoid the adverse health and quality of life consequences, if known and significant, will be embedded in the price of housing.[12] Studying home prices is one way to uncover the value of nontraded goods such as environmental quality.[13] The capitalization of spatial externalities into property values provides a compelling motivation for regulation.

Understanding the market effects of goods that are not explicitly priced, like the implicit market for housing, requires the estimating of revealed preference using methods like hedonic analysis, which average the price differential between comparable housing units that differ on the variable of interest, holding other structural and neighborhood characteristics constant. The challenge is that hedonic price estimations differ by market segment. Examples of housing market characteristics by which hedonic pricing varies are detailed in exhibit 1.

Exhibit 1

Selected Examples of Housing Variables by which Hedonic Price and Willingness-to-Pay Vary

Variable	Supporting Studies
Tenure (owner-occupied vs. renter-occupied)	Hyland et al. (2013)
Building type (single-family vs. multi-family)	Im et al. (2017)
Population density (rural vs. urban neighborhood)	Hyland et al. (2013)
Average neighborhood housing prices	Hyland et al. (2013)
Use (commercial vs. residential building)	Popescu et al. (2012)
Energy efficiency rating	de Ayala et al. (2016)

[11] The impact on vacant land values would be immediate.

[12] Knowledge affects the evaluation of risk fundamentally. See Gayer, Hamilton, and Viscusi (2000).

[13] For a review, see Chay and Greenstone (2005).

Some studies estimate that building codes, through technological and administrative barriers, increase the cost of housing by 1 to 5 percent (Listokin and Hattis, 2005). A study of 1,100 localities in 1970 found that building codes raised housing values by $1,000 on average (Noam, 1982). In addition to the effect of codes on housing values, housing values simultaneously influence the strictness of building codes. A study investigating the effect of the 1994 South Florida Building Code for homes sold between 2000 and 2007 in Miami-Dade County found that, all else equal, homes built under the newer code were 10.4 percent higher in price, with higher premiums in coastal areas with greater storm risk (Dumm, Sirmans, and Smersh, 2011). These safety premiums were also greatest following a damaging hurricane. Bartram (2019) finds that resolving building code violations increases rents. While this empirical literature shows that the value of building codes are capitalized into housing prices, this is not enough to conclude that building codes have net benefits across all housing segments. To do so, we must consider the distributional impacts of building regulations.

Account for Distributional Impacts

Standard cost-benefit analyses ignore distributional impacts. The implicit assumption is that aggregate net benefits can be redistributed from winners of a policy change to compensate any losers. Because this redistribution does not occur in practice and low-income groups will bear a disproportionate burden, we urge policymakers to consider as detailed a distribution as possible. An evaluation of the effects of a public policy change on different income groups should account for the indirect effects on a household's budget of a change in housing costs. Lower-income households face a tighter budget constraint and cannot outbid higher income households in the implicit market for quality, so will be excluded from the most desirable areas. The hedonic premium for a desirable feature of a community reduces the affordability of shelter and will have the indirect impact of excluding lower-income households.[14] This creates tension between resolving market failures and ensuring affordability. Recognizing housing market impacts and considering how demand for a policy varies by income contributes toward progressive public policy.

Any external neighborhood effects should reduce costs by more than the direct cost of building to code. One suggestion for limiting the direct cost to builders of affordable housing is to apply a less strict standard for the rehabilitation of existing buildings than for the construction of new ones (Galvan, 2005). An increase in demand in a particular neighborhood will reduce affordability but act as an incentive to expand the supply of housing and even alter the type of housing being built. Reducing the external costs of proximity stimulates density of construction. Walden (1987) finds that housing codes, which set operating standards for housing, lead to higher density but have no impact on housing expenditures. Other regulations that restrict builders, such as minimum lot size zoning, can inhibit realizing the gains from building codes.

It is hard to know whether the impact on affordability will outweigh the public benefits of a building code. We can only say for certain that affordability will not be harmed when the building code results in lower costs of building and maintaining homes across all submarkets. A more or less equal distribution between different types of housing ensures that lower income households

[14] Builders and landlords resolve this challenge by offering the type of housing that is easily marketable and best matches consumers' tastes.

will not be outbid and displaced from their neighborhoods. The spatial scale of markets regulated by the same building code also affects the costs borne by producers that are passed on to housing consumers. The unevenness of building codes across jurisdictions can create comparative disadvantages for housing markets subject to more stringent or disparate standards, artificially inflating housing costs. Because regions do not compete in perfectly competitive markets for their residents, many residents have limited choice in responding to additional housing costs, with disproportionate impacts on the least mobile and poorest households.

Application: Energy Efficiency Regulations

Motivated by industry concerns that energy efficiency codes may represent a regulatory overreach, we investigate their impact on housing affordability using our proposed evaluation framework. While building regulations are more uniform than land use regulations, building codes do differ by state and locality. Nelson attempts to understand energy code adoption in the contiguous United States as related to factors like climate, political ideology, gas prices, population growth, educational attainment, and professionalism in legislatures. He concludes that cost-benefit analysis is not a factor behind adoption. One or more of these other underlying factors may be the real driver for variation in local code usage (Nelson, 2012).

Energy Efficiency and Market Failures

In the case of energy efficiency codes, market failures indicating a potential need for public intervention include negative environmental externalities and information asymmetry in housing markets. The broadest public benefit of limiting residential energy consumption is potentially slowing climate change by reducing greenhouse gas emissions. Housing is a major consumer of energy, which has global implications, as the United States is the second largest energy consumer in the world. In the United States, 39 percent of energy use and 72 percent of electricity use originates from buildings, more than one-half of which is attributed to residential buildings (Im et al., 2017). Residential buildings contribute to between 20 and 25 percent of total greenhouse gas emissions (Im et al., 2017). About half of the energy used in homes is from space conditioning (heating and cooling). While different types of energy may be "cleaner" or "dirtier" to produce, all energy production creates externalities either in the manufacturing of the equipment needed to capture energy or in the capturing of energy itself. These externalities come in the form of damage caused by greenhouse gas emissions and other air pollutants, including reduction of agricultural productivity, sea level rise and the accompanying infrastructure cost of mitigation, adverse health effects, storms and extreme weather events, increased residential energy expenditures to maintain comfort, and the loss of ecosystems (Auffhammer, 2018).

The social cost of carbon is widely dispersed. Energy inefficiency in housing contributes to negative externalities through excessive energy production that has uneven and disproportionate health and safety impacts on poorer, more vulnerable populations with less capital to move away from energy production sites and power plants. The American Lung Association has found that 150 million Americans are exposed to unhealthy levels of air pollution, much of which is from power plants (American Lung Association, 2020). According to the U.S. National Climate Assessment, losses will not be distributed equally because the most vulnerable populations have a lower capacity to prepare for and adapt to the challenges introduced by climate change (Reidmiller et al., 2017). If lower-income communities are less resilient, then pursuing a cost-effective climate change policy will confer benefits that are pro-poor. Preventative measures that protect the safety, health, and the land itself can be considered necessary for sustaining the economy. The hedonic value of reducing risk will make housing less affordable, but the net impact could be inclusive.

A market characterized by information asymmetry is a classic justification for public intervention. In the case of housing markets, do homebuyers and renters care about energy efficiency, and would they be able to acquire housing suited to their preferences without the widespread adoption and use of energy efficiency codes? While some energy-efficient features, like energy-efficient appliances with EnergyStar labels, may be noticeable to a home seeker, others would need hired expertise, like an independent assessor, to assess accurately (Palmer et al., 2013). This is true for structures like walls and insulation. There is the possibility for “lemons” in the rental market if landlords are not incentivized to rent out energy-inefficient units at any lower rate than more energy-efficient units. If market asymmetries exist, they could result in the prevalence of fewer energy-efficient buildings than socially optimally desired.

Attention may be better focused on standardizing codes and mass production methods for energy retrofits, which represent the bulk of the housing stock and are arguably more sustainable than building new housing (Frey et al., 2011). Retrofitting sees a greater need for prices to be lowered to increase take-up and may face greater challenges concerning regulatory barriers (Gerarden, 2008). Similarly, another option on top of energy efficiency codes for new construction relates to the density of housing constructed. Glaeser and Kahn (2010) argue that the bulk of environmental savings come from building in places with a lower carbon footprint and fewer per capita carbon emissions. These are places with higher-density housing requiring shorter and less energy-intensive commutes and more efficient, cost-effective supplying of utilities (Kurvinen and Saari, 2020).

Energy Efficiency and Housing Market Impacts

Enhanced energy efficiency would be worth a hedonic premium at least as high as the accompanying reduction of utility bills. Less expensive energy could also spur greater energy consumption and so would yield a comfort dividend. Households that consume energy relatively intensively would be willing to pay more for energy-efficient units. Given the incentive to producers, the housing market should provide the level and variety of energy efficiency to satisfy the private demand for energy-efficient housing. Any energy-efficiency policy motivated by the creation of private savings should be based on evidence that there are market failures or barriers to the provision of energy-efficient housing.

Looking specifically at the International Energy Efficiency Code (IECC), Koirala, Bohara, and Berrens (2014) find that housing rents increased 23.3 percent due to capitalization of the value of the IECC. A hedonic study of the American Housing Survey used differences in fuel bills to estimate that homeowners capitalize energy efficiency into home prices at a rate of 4 to 10 percent (Nevin and Watson, 1998). Another empirical study found that income sorting did not occur in response to a local environmental change (Greenstone and Gallagher, 2008). The income sensitivity of the willingness to pay for environmental quality will have implications for whether improvements that raise the cost of housing will have an exclusionary impact. Empirical measurements of the income elasticity of demand are positive but less than one, indicating that environmental quality is a necessary good (Barbier, Czajkowski, and Hanley, 2017; Pearce, 2006).

An issue that could prevent the alignment of housing producers' and users' incentives is timing. If energy savings only net out over the lifespan of the housing, then housing developers' and users' economic incentives to invest in energy efficiency can be lessened if neither plan to retain ownership or tenure long enough to realize these savings. This scenario would result in deadweight loss, or net societal costs due to less energy-efficient housing being produced than is optimal. Through case studies of green affordable housing projects, New Ecology and the Green Community Development Corporations Initiative have found that the length of a developer's ownership interest affects whether they realize net benefits or net costs (Bradshaw et al., 2005). On average, they found that green affordable housing developments generate a 2.4 percent "green premium" in total development costs. However, using a lifecycle approach and accounting for lower utilities, operating expenses, and maintenance, along with unquantified effects, allows green housing to be more cost-effective.

The income elasticity of demand for energy in the residential sector has been estimated to be below one, indicating that energy is a necessary good and that enhancing its availability could be favorable to low-income households (Fouquet, 2014). Energy costs represent 26 percent of total housing costs for very low-income households (Lee, Chin, and Marden, 1993). Sixty-seven percent of low-income households at or below 200 percent of the federal poverty level are energy-burdened, meaning they spend six percent or more of their total household income on energy costs. According to the Residential Energy Consumption Survey administered by the U.S. Energy Information Administration (last administered in 2015), 31 percent of U.S. households report facing a challenge in paying their energy bills or in sustaining adequate heating and cooling, 14 percent say they have received a disconnection notice, 20 percent report having to forgo necessities like food or medicine to pay an energy bill, and 11 percent say they have had to keep their home at an unhealthy temperature (U.S. Energy Information Administration, 2018). Energy insecurity can cause stress, mental health degradation, and shame in one's home, whereas having energy security results in positive consequences, including increased productivity and better child development outcomes (Hernández, 2016).

The fact that energy insecurity negatively affects a significant number of housing users means that households are making tradeoffs to live in homes that are bad for them. Their budget constraints may hinder them from being able to make true choices when it comes to energy-efficient homes. If this is the case, then regulation can ensure that private markets meet this otherwise unmet need. Requiring homes to be energy-efficient protects the large number of energy-insecure households in the United States from adverse health and social consequences that they may be unable to avoid based on their limited market power.

In long-run housing markets, of utmost importance is the turning of newly built housing today into the housing of lower-income residents in the future, also known as filtering (Rosenthal, 2014; Zuk and Chapple, 2016). Data from the American Community Survey shows that the loss rates of older housing stock are low and are continuing to decrease to unsustainable levels (less than 0.1 percent in the Northeast and West regions) as new production has waned (Emrath, 2019). While energy expenses play a major role in low-income households' housing decisions, lower-income households pay on average 11 percent more per square foot for energy and live in housing that is 10 years older on average than other households (Lee, Chin, and Marden, 1993). Older housing is more energy-inefficient, has poorer quality, and wears down sooner. Without the capital to make upgrades, poorer and more vulnerable households may resort to risky behavior to improve habitability, like using stoves or ovens to heat their homes, which could kill them through carbon monoxide poisoning. Replacing old energy-inefficient infill housing with higher-density energy-efficient new housing would expand the long-run supply of high-quality housing. Ensuring that buildings constructed today are of as high quality as can be reasonably achieved by manufacturers, builders, and developers helps to add better affordable housing stock for the future.

Energy Efficiency and Distributional Considerations

Measuring willingness to pay is important for understanding the potential for market premiums that would generate incentives for developers to invest in energy efficiency. While there is generally a positive willingness-to-pay (WTP) for energy efficiency, it varies across different user and market segments. Research on Building Energy Ratings (BER) in Europe using discrete choice experiments has shown that marginal WTP is positive for improved energy efficiency, although the marginal WTP diminishes for each higher BER (Carroll, Aravena, and Denny, 2016). Said another way, the disutility at the lower end is larger than the utility gain at the higher end. Literature valuing Energy Performance Certificates across different European Union countries has found that the premiums and discounts for energy efficiency ratings are much more pronounced for owner-occupied housing than rental housing (Marmolejo-Duarte and Chen, 2019). Segmented hedonic models of Energy Performance Certificates in Barcelona found a "brown discount" for energy inefficiency in cheaper housing segments and a smaller valuation of energy efficiency in the newest dwellings (Marmolejo-Duarte and Chen, 2019). The most energy-efficient "A" rating was found to have a 12.2 percent impact on price in the central expensive housing segment but an impact of 33.2 percent on price in working-class neighborhoods with older housing. This shows that residents may expect a certain level of energy efficiency in new housing, but they more highly value information about energy efficiency in older stock. It also means that the same regulations may have different consequences, even for neighborhoods within the same jurisdiction.

Surveys have also found variation in how much residents value energy efficiency. The Consumers Union and Buildings Codes Assistance Project (which produces Consumer Reports) surveyed 5,000 adults and found that 82 percent of homeowners felt that they had a right to housing with minimum energy efficiency standards, and 79 percent would pay more to have more affordable and predictable energy bills and overall operational costs (Vaughan, 2012). A 2019 survey by the National Association of Homebuilders found that 16 percent of millennials would pay more for an environmentally friendly home, while 33 percent want an environmentally friendly home but would not pay more; the others do not take into account environmental considerations in buying a home (NAHB, 2019). For an energy-efficient home that would save a resident $1000 per year in utility costs, 34 percent of millennials would be willing to pay an extra $10,000 or more upfront, while 35 percent would pay between $1,000 and $10,000 extra. On average, buyers are willing to pay an extra $8,728 upfront to save $1,000 per year in utilities, or $5,000 for the median buyer.

This shows a large range in WTP that is not driven by energy savings alone. This literature supports the justification for public incentives if building more energy-efficient homes is societally optimal but the private market would not produce these on its own.

Application: Solar Panels

For the next application of our evaluation framework, we examine the justification behind regulations around residential solar panels. This is motivated by California's residential solar mandate, which was passed in 2018 and took effect at the beginning of 2020. Solar panels are a visible, high-tech symbol of energy efficiency and environmentalism. Because their installation costs are expensive and they are an external add-on structure instead of an upgrade of an existing structure, they may be perceived as more of a luxury product and less of a necessity than other types of weatherization-focused energy efficiency improvements. We are interested in analyzing whether this is the case.

Solar Panels and Market Failures

There are multiple market failures at play in the world of energy utilities that might warrant a need for a solar mandate. These include the failure of prices for fossil fuel-derived energy to reflect negative externalities and the monopolistic nature of energy distribution markets, which can alternatively prevent solar seekers from being financially incentivized to install solar or can shift utility cost burdens onto lower-income non-solar users.

First, energy derived from non-renewable sources is currently not priced at a level that captures the negative externalities caused by the production of this energy. Thus, using price alone to make choices about residential energy use does not lead to societally optimal outcomes.

Second, energy distribution is largely a natural monopoly or oligopoly because, by the nature of the industry, with its high fixed costs, distributors need very high coverage in order to operate with economies of scale, which creates high barriers to entry (Body of Knowledge on Infrastructure Regulation, 2012; O'Neill, Whitmore, and Veloso, 1996). Grid infrastructure is largely centralized, and states must borrow large amounts of money to invest in grid upgrades. While grid modernization is a widespread strategy, not all local or regional grid systems have shifted to accommodate distributed energy resources, which would lower the need to build systems for peak capacity. All of this is to say that customers making one-off decisions to invest in solar panels or other nontraditional energy sources may not save as much money as would be expected because of rates that they as residents would still need to pay for the state's continued investments in grid infrastructure (Silverstein, 2014). An example of perverse outcomes can be seen in California, where the overgeneration of energy through solar homes and other renewables has sometimes led California to have to pay neighboring states to take California's excess energy (Penn, 2017). The negative pricing is used to compensate a state like Arizona for restricting its own energy supplies during times of oversupply.

Depending on how rates are set, incentives to promote individual solar panel installation can burden poorer non-solar users with increased bills, generating issues of equity (Cardwell, 2016; Johnson, et al., 2017). In total, these phenomena show that, in a monopolized market like residential energy utilities, there may be a need for state intervention to align the incentives of consumers and producers with what is socially optimal.

Solar Panels and Housing Market Impacts

To understand the potential impact of residential solar mandates on housing prices, we use the American Housing Survey to create a hedonic model of single-family owner-occupied homes with and without solar panels. We use a pooled metro sample from the 2017 AHS Metropolitan Public Use File, which includes one metropolitan area in California (San Jose-Sunnyvale-Santa Clara). This is useful because California has enacted a wide range of policies around solar panel use, allowing for a comparison of areas with and without residential solar regulations.

Descriptive statistics for the sample are reported in Appendix 1. The pooled sample includes 10 metropolitan areas[15] comprising 10,354 single-family owner-occupied detached homes without solar panels and 403 with solar panels. On average, the estimated market values of homes with solar panels were almost twice as high as those without (approximately $675,000, compared to $339,000). A preliminary analysis by the authors finds a premium as high as 10 percent of the reported value for some homes. Our estimates are on the high end compared to results found by other literature estimating the capitalized value of solar panels.[16] Other researchers' estimates include average premiums of $15,000 across eight states (Hoen et al.; 2017), $35,000 in Hawaii (Wee; 2016), $45,000 (or a 15 percent premium) in Arizona (Qiu, Wang, and Wang, 2017); and a 3.5 percent premium in San Diego (Dastrup et al., 2012).

There may be behavioral factors influencing the overvaluation of solar panels. Conspicuous consumption, a form of virtue signaling through the types of consumption in which one participates, has been applied to the field of environmentalism through what is known as conspicuous conservation. Social experiments have found that individuals are willing to pay more for green products in order to signal altruistic qualities (Griskevicius, Tybur, and Van den Bergh, 2010). It may be the case that environmentally motivated households, or households in environmentally signaling neighborhoods, are willing to pay more for solar panels than they would receive in energy savings and other benefits for motivations around personal status (Fuerst, Oikarinen, and Harjunen, 2016; Kahn and Kok, 2014). This may be an issue if these other factors raise the demand curve for solar panels above the price that lower-income households would be willing to pay.

[15] The metropolitan areas surveyed in the 2017 American Housing Survey include: Baltimore-Columbia-Towson, MD; Birmingham-Hoover, AL; Las Vegas-Henderson-Paradise, NV; Minneapolis-St. Paul-Bloomington, MN-WI; Oklahoma City, OK; Richmond, VA; Rochester, NY; San Antonio-New Braunfels, TX; San Jose-Sunnyvale-Santa Clara, CA; and Tampa-St. Petersburg-Clearwater, FL.

[16] The major difference is that this study uses respondent estimates of home market values rather than more objective sales price data. Research has found that homeowners may overestimate the value of their homes as compared to appraised values by up to 8 percent (Harney, 2015).

Solar Panels and Distributional Considerations

Using the same hedonic model, we investigate whether the WTP for solar panels differs for lower-income and higher-income households. Splitting the sample by the median income of solar households ($110,080) finds no statistically significant correlation between solar panels and home prices for either segment. There may not be enough households with solar panels in the sample to produce sufficient power for this estimator when broken into these segments. If the model had found different estimators for higher-income and lower-income households, it would shed light on whether solar panels could be interpreted to be a luxury good. Although low-income households may appreciate having a solar panel, it is not necessary for the production of shelter. If this were the case, requiring solar panels on all housing might have no perceived benefits for a significant portion of homeowners, and requirements to install solar panels on all housing without subsidies may not be justified and could potentially place an undue burden on the lowest-income households.

Conclusion

The role of housing policy should be to create vibrant and inclusive communities. Building codes can promote decent and affordable housing by providing mutually beneficial industry guidelines, consumer safety, and regulating externalities. We have also found that the implementation of building codes could, under certain conditions, reduce the affordability and availability of housing. Adding homes of high quality to the housing stock is essential for creating long-run affordable housing that is safe, habitable, and affordable to maintain. Building codes and energy efficiency programs have arisen naturally as a resilience strategy in response to environmental and economic shocks and the need for energy conservation, but what is their effect on housing markets? We advise that the ultimate goal of the planner not be limited to raising quality but to expanding choice, opportunity, and diversity of the housing stock. The explicit consideration of the distributional impact of a proposed building code is key to understanding whether the policy constitutes a regulatory barrier. Building regulations that correct market failures but create exclusionary impacts through their effect on housing markets may warrant public subsidy or other public policies to confer benefits that do not disproportionately exclude poor residents.

We considered energy-efficiency and solar panel requirements and concluded that prioritizing retrofitting of existing homes that were built under less rigorous energy codes and building more densely are effective ways of increasing the affordability and energy efficiency of the housing stock. We found that solar panels are associated with an economically significant increase in the reported price of detached homes but do not have sufficient power to determine how this varies by household income. Initial analysis indicates that solar panels are a luxury good that a lower-income household would not value as highly as it would other energy efficiency upgrades. If the net benefits of solar panels are positive due to the mitigation of environmental externalities, they may deserve subsidization to increase production and ensure that lower-income households can afford to live in areas endangered by climate change.

Appendixes

Appendix A. Solar Panels in the American Housing Survey

We use the 2017 AHS Metropolitan Public Use File, which includes one metropolitan area in California (San Jose-Sunnyvale-Santa Clara). This is useful because California has enacted a wide range of policies around solar panel use, allowing for a comparison of areas with and without residential solar regulations.

The metro with the most homes with solar panels in the sample is San Jose-Sunnyvale-Santa Clara, with 150 such homes, representing 6.4 percent of its stock (exhibit A-1). This is followed by Las Vegas-Henderson-Paradise, NV, with 101 homes (4.3 percent of homes); Baltimore-Columbia-Towson, MD, with 77 homes (3.6 percent of homes); San Antonio-New Braunfels, TX, with 66 homes (2.7 percent of homes); and Tampa-St. Petersburg-Clearwater, FL, with 57 homes (2.6 percent of homes). Most of these metropolitan areas, except Baltimore, are located in the southern part of the United States—areas with higher solar insolation.

Exhibit A-1

Solar Panels by Metro, American Housing Survey 2017 Metropolitan Sample

Metro	N, homes with solar panels	N, total homes	Percent of homes with solar panels
Baltimore-Columbia-Towson, MD	77	2,124	3.6%
Birmingham-Hoover, AL	21	2,159	1.0%
Las Vegas-Henderson-Paradise, NV	101	2,367	4.3%
Minneapolis-St. Paul-Bloomington, MN-WI	21	2,314	0.9%
Oklahoma City, OK	18	2,483	0.7%
Richmond, VA	13	2,213	0.6%
Rochester, NY	22	2,181	1.0%
San Antonio-New Braunfels, TX	66	2,488	2.7%
San Jose-Sunnyvale-Santa Clara, CA	150	2,332	6.4%
Tampa-St. Petersburg-Clearwater, FL	57	2,187	2.6%
TOTAL	546	22,848	2.4%

Sources: U.S. Department of Housing and Urban Development. (2019). American Housing Survey (AHS) 2017 Metropolitan Public Use File (PUF)

In the 2017 metro sample, 448 of 546 homes with solar panels (or 82 percent) are single-family detached homes. Additionally, 429 of 518 homes with solar panels that are owned or rented (83 percent) are owner-occupied as opposed to rented. Thus, we focus our sample on owner-occupied single-family detached homes (N = 403). There are implications for focusing on specific housing tenure and building types; incentives for saving energy and investing in energy efficiency are aligned for owners because they must pay for their own utilities, unlike some renters. Additionally, households in detached single-family homes typically use more energy than those in attached homes and multifamily housing because of the urban heat island effect and the greater proportion of energy used for heating than cooling (Obrinsky and Walter, 2016).

Examining homes with and without solar panels across the pooled metro sample shows some differences (exhibit A-2). Estimated market valuations of homes with solar panels were almost twice as high as those without (approximately $675,000, compared to $339,000). The household income reported by households with solar panels was also higher than that reported by those without—about $149,000, compared to $106,000. Homes with solar panels were on average 6 years newer. Homes with solar panels reported higher quality amenities and neighborhood characteristics on average compared to those without, except in terms of the number of floors, the lot size, and the neighborhood quality based on nearby schools and petty and serious crime; this may indicate that homes with solar panels are located in more urban areas with higher density and more expensive land.

Exhibit A-2

Descriptive Statistics of Owner-Occupied Detached Homes by Reported Presence of Solar Panels from American Housing Survey 2017 Metropolitan Sample (1 of 2)

Variable	No solar panels (N = 10,354)		Solar panels (N = 403)	
Market value (reported $)	339,217	(504,196)	675,135	(951,917)
Household income (annual $)	106,184	(105,258)	148,833	(161,779)
Number of occupants	2.58	(1.37)	2.87	(1.48)
Age of home (years)	47.81	(24.42)	41.89	(20.89)
Total number of rooms	6.80	(1.56)	7.32	(1.54)
Lot size				
Less than 1/8 acre	9.0%		8.7%	
1/8 up to 1/4 acre	40.2%		54.2%	
1/4 up to 1/2 acre	25.1%		16.2%	
1/2 up to 1 acre	8.9%		5.2%	
1 up to 5 acres	11.5%		11.9%	
5 up to 10 acres	2.5%		2.0%	
10 acres or more	2.7%		1.7%	
Unit size				
Less than 500 sq ft	0.2%		0.3%	
500 to 749 sq ft	0.5%		0.0%	
750 to 999 sq ft	3.0%		1.1%	
1000 to 1499 sq ft	19.9%		13.4%	
1500 to 1999 sq ft	27.3%		26.0%	
2000 to 2499 sq ft	20.9%		22.0%	
2500 to 2999 sq ft	11.5%		14.5%	
3000 to 3999 sq ft	11.2%		14.7%	
4000 sq ft or more	5.4%		8.0%	

Exhibit A-2

Descriptive Statistics of Owner-Occupied Detached Homes by Reported Presence of Solar Panels from American Housing Survey 2017 Metropolitan Sample (2 of 2)

Variable	No solar panels (N = 10,354)		Solar panels (N = 403)	
Central AC (reported central air conditioning system)	85.5%	(35.3%)	90.3%	(29.6%)
Adequacy (reported adequate)	97.0%	(17.1%)	99.3%	(8.6%)
Neighborhood rating (1 to 10)	8.52	(1.53)	8.68	(1.40)
Utility cost (monthly $)	267.25	(111.27)	294.84	(134.16)
Electricity cost (monthly $)	145.10	(76.20)	154.84	(82.50)

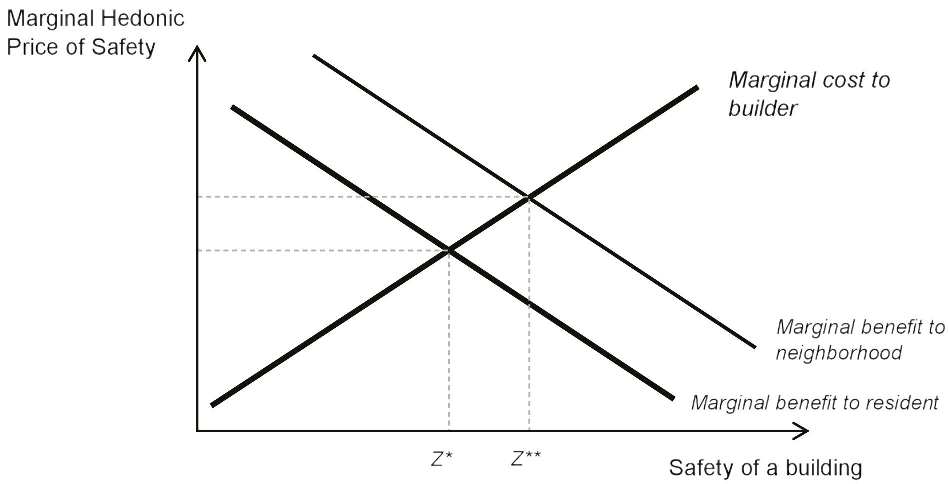
Sources: U.S. Department of Housing and Urban Development. (2019). American Housing Survey (AHS) 2017 Metropolitan Public Use File (PUF)

Appendix B. Illustration of Optimal Regulation

Market prices match consumers who want different levels of a housing attribute to producers willing to supply those features. In this example, the attribute is safety. The household and the builder agree to an exchange when the level of safety provided maximizes the builder's profits and the household's utility given the price for that particular type of building. In exhibit B-1, the level of safety determined by the market is z^*. Every home can be at a different level of safety; a market-wide hedonic price function would connect these individual outcomes. For the builder, the incremental cost of producing one more unit of safety is represented by the upward sloping line *Marginal cost to builder*. Reducing risk is achievable, but producing a building in which no risk is present is infeasible. For the consumer, the additional satisfaction derived from reducing risk is represented by a downward sloping curve, the *Marginal benefit to the resident*. Every additional unit of safety increases well-being, but by less than the previous unit. The diminishing marginal utility of a good is explained by the tradeoffs a consumer makes when facing a limited budget. Spending more on one good necessitates giving up another good. The marginal benefit of the safety curve would be shaped differently for households with different preferences, incomes, and knowledge or experience. Lower-income households are likely to consume less safety. Risk-averse households would choose more.

Exhibit B-1

Supply and Demand Diagram for a Building Safety Code: Optimal Safety of an Individual Building



Z = level of safety determined by the market. Z** = optimal level of safety.*
Source: Diagram is derived from Marshall, A. (1890). Principles of Economics

Government policy is justified when there is strong evidence that the market outcome is suboptimal for society. If there are positive spillovers from safety, then a household would gain from their neighbors consuming housing with safety features, such as fireproofing. If the positive externalities are significant, then free riding is a possibility: one neighbor can reduce their own safety expenditures to the other's detriment. This externality can be represented by adding the marginal benefits to the community of a safe building to the marginal benefits to the individual resident to derive the *Marginal benefit to the neighborhood*. The socially optimal level of safety would be indicated by z^{**}. The role of the building code would be to require this higher level of safety.

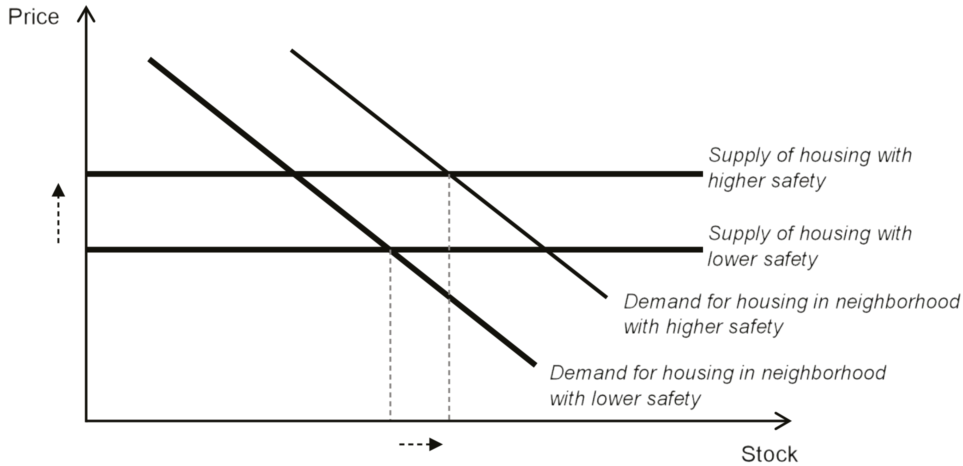
The challenge is knowing the optimal level of safety, z^{**}. How much greater the socially optimal level is than the market outcome will depend upon the types of buildings (dense or not), the incomes and preferences of residents, building technologies, and legal liability. Instead, imagine that positive spillovers were lower than estimated. The cost imposed upon the resident of the building, forced to buy more safety than desired, would be measured by the area between the private marginal benefit and marginal cost above the optimal outcome. This concept of the cost of excessive regulation can be similarly applied to evaluating multiple regulations providing a similar benefit.

Consider the impact on a housing submarket. Raising the required level of safety increases the cost of supplying a home by the amount of the increased level of safety. This is shown as an upward shift of the supply curve, shown in this diagram as perfectly elastic for ease of exposition. The supply of housing is more likely to be upward sloping because the easiest land to develop will be used first, and height becomes increasingly more expensive with every floor.[17] Regulations can also reduce the flexibility of builders. With a more inelastic supply, some of the costs will be shared by builders.

[17] The supply of a housing can be likened to a jagged "S": a vertical middle represents the fixed stock of housing; the upward sloping portion for higher prices represents the increasing cost of adding to the stock, and for lower prices the abandonment and demolition of housing.

Exhibit B-2

Supply and Demand Diagram for a Building Safety Code: Neighborhood Benefits of Safety in the Long-Run Equilibrium



Source: Diagram is derived from Marshall, A. (1890). Principles of Economics

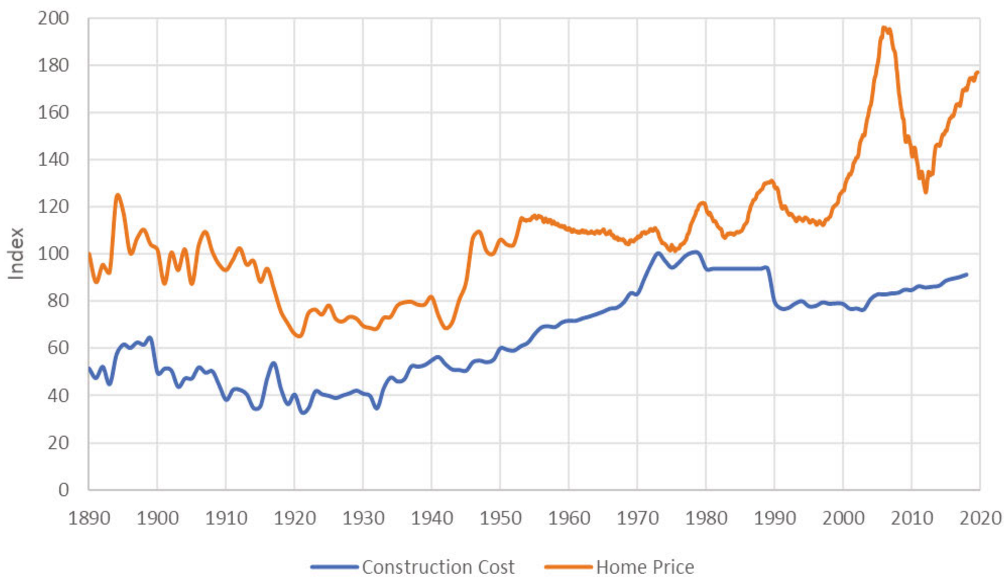
On its own, the increase in cost reduces affordability and the long-run supply of housing. The extent of the cost increase depends on the difference between the cost of providing the regulated and unregulated level of safety. An increased level of safety throughout the building stock increases the demand for housing. Inhabitants will be willing to pay more to live in a neighborhood in which externalities are efficiently regulated.[18] The demand shift determines the response by builders. Exhibit B-2 shows the situation for which the public benefits of the building code to consumers is a significant improvement from the unregulated outcome. In this ideal case, although prices increase, people will be better off because the benefits of public safety offset the cost increase. As a result, the housing stock expands. However, there is no guarantee that the availability of housing would increase. If the regulator overshoots the optimal level of safety and imposes an excessive standard, then the demand curve for housing would shift out by less than the supply: the long-run stock of housing would decline, and net affordability would be adversely affected. Another factor to consider is that, in the long run, households will move. The expansion of demand could stem from new occupants attracted by enhanced safety. Even if the regulation were determined to be optimal for the average households, many residents could be displaced to areas without the same post-regulation level of amenities.

[18] There will also be a slight outward shift of demand because individual units will be of higher quality. This shift is not shown to avoid clutter and because it is not the motivation for the regulation.

Appendix C. Real Home Prices and Real Construction Costs (United States 1890-2018)

Exhibit C-1

U.S. Real Home Prices and Construction Costs, 1890 to 2019



Source: Robert Shiller, http://www.econ.yale.edu/~shiller/data.htm

Exhibit C-1 shows trends in U.S. construction costs and real home prices over the last century. Some researchers attribute the gap between the price and cost of a new addition to the housing stock to land use regulations. However, the gap between housing and construction costs cannot be attributed to regulations alone. The divergence between prices and construction costs could arise from a speculative demand for housing or demographic trends. Higher interest rates could reduce the difference. A well-functioning land market could result in a wedge between the price of newly developed residential land and construction costs from opportunity costs of development such as rents from agricultural land, the value of other potential land uses, uncertainty concerning future prices, and even anticipated economic growth. A higher cost of land acquisition could also be attributed to prior building activity that already developed the most cost-effective sites. The importance of the unique features of the natural and built environment in determining the impact of regulations makes metro-level studies more revealing than estimates derived from national data. An analysis at such an aggregate level will not reflect disproportionate burdens on specific areas, income groups, or demographic groups.

Regardless, the housing industry is restricted in productivity growth relative to other sectors that rely less on immobile production factors such as land, making inefficient regulation of that factor more difficult to overcome.

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References

Akerlof, George A. 1970. "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism," *Quarterly Journal of Economics* 84 (3): 488–500. https://doi.org/10.2307/1879431.

American Lung Association. 2020. *State of the Air 2020*. Chicago: American Lung Association. https://www.stateoftheair.org/assets/SOTA-2020.pdf.

Auffhammer, Maximilian. 2018. "Quantifying Economic Damages from Climate Change," *Journal of Economic Perspectives* 32 (4): 33–52.

Barbier, Edward B., Mikołaj Czajkowski, and Nicholas Hanley. 2017. "Is the Income Elasticity of the Willingness to Pay for Pollution Control Constant?" *Environmental and Resource Economics* 68: 663–682.

Bartik, Timothy J. 1988. "Measuring the Benefits of Amenity Improvements in Hedonic Price Models," *Land Economics* 64 (2): 172–183.

Bartram, Robin. 2019. "The Cost of Code Violations: How Building Codes Shape Residential Sales Prices and Rents," *Housing Policy Debate* 29 (6): 931–946.

Body of Knowledge on Infrastructure Regulation. 2012. Competition in Utility Markets. http://regulationbodyofknowledge.org/market-structure-and-competition/competition-utility-markets/.

Bradshaw, William, Edward F. Connelly, Madeline Fraser Cook, James Goldstein, and Justin Pauly. 2005. *The Costs and Benefits of Green Affordable Housing*. Cambridge, MA: New Ecology.

Breyer, Stephen. 1993. *Breaking the Vicious Circle: Toward Effective Risk Regulation*. Cambridge, MA: Harvard University Press.

Cardwell, Diane. 2016. "Why Home Solar Panels No Longer Pay in Some States," *New York Times*, Jul 26. https://www.nytimes.com/2016/07/27/business/energy-environment/why-home-solar-panels-no-longer-pay-in-some-states.html.

Carroll, James, Claudia Aravena, and Eleanor Denny. 2016. "Low Energy Efficiency in Rental Properties: Asymmetric Information or Low Willingness-to-Pay?" *Energy Policy* 96: 617–629.

Chay, Kenneth Y., and Michael Greenstone. 2005. "Does Air Quality Matter? Evidence from the Housing Market," *Journal of Political Economy* 113 (2): 376–424.

Chetty, Raj, Nathaniel Hendren, and Lawrence F. Katz. 2016. "The Effects of Exposure to Better Neighborhoods on Children: New Evidence from the Moving to Opportunity Experiment," *American Economic Review* 106 (4): 855–902.

Coase, Ronald H. 1960. "The Problem of Social Cost." In *Classic Papers in Natural Resource Economics*, edited by Chennat Gopalakrishnan. London, UK: Palgrave Macmillan: 87–137.

Dacquisto, David J., and David T. Rodda. 2006. *Housing Impact Analysis*. Washington, DC: U.S. Department of Housing and Urban Development, Office of Policy Development and Research.

Daniere, Amrita G. 1994. "Estimating Willingness-to-Pay for Housing Attributes: An Application to Cairo and Manila," *Regional Science and Urban Economics* 24 (5): 577–599.

Dastrup, Samuel R., Joshua G. Zivin, Dora L. Costa, and Matthew E. Kahn. 2012. "Understanding the Solar Home Price Premium: Electricity Generation and 'Green' Social Status," *European Economic Review* 56 (5): 961–973.

de Ayala, Amaia, Ibon Galarraga, and Joseph V. Spadaro. 2016. "The Price Of Energy Efficiency in the Spanish Housing Market," *Energy Policy* 94: 16–24.

Dehring, Carolyn A. 2006. "Building Codes and Land Values in High Hazard Areas," *Land Economics* 82 (4): 513–528.

Dumm, Randy E., G. Stacy Sirmans, and Greg Smersh. 2011. "The Capitalization of Building Codes in House Prices," *The Journal of Real Estate Finance and Economics* 42 (1): 30–50.

Duranton, Gilles, and Diego Puga. 2019. Urban Growth and its Aggregate Implications. NBER Working paper w26591. Cambridge, MA: National Bureau of Economic Research.

Emrath, Paul. 2019. More Homes Needed to Replace Older Stock. National Association of Home Builders: Eye on Housing, Jan 24. https://eyeonhousing.org/2019/01/more-homes-needed-to-replace-older-stock/.

Fouquet, Roger. 2014. "Long-Run Demand for Energy Services: Income and Price Elasticities over Two Hundred Years," *Review of Environmental Economics and Policy* 8 (2): 186–207.

Frey, Patrice, Liz Dunn, Ric Cochran, Katie Spataro, Jason F. McLennan, Ralph DiNola, and Beth Heider. 2011. *The Greenest Building: Quantifying the Environmental Value of Building Reuse*. Seattle, WA: Preservation Green Lab, National Trust for Historic Preservation. https://living-future.org/wp-content/uploads/2016/11/The_Greenest_Building.pdf.

Fuerst, Franz, Elias Oikarinen, and Oskari Harjunen. 2016. "Green Signalling Effects in the Market for Energy-Efficient Residential Buildings," *Applied Energy* 180: 560–571.

Galvan, Sara C. 2005. "Rehabilitating Rehab Through State Building Codes," *Yale Law Journal* 115: 1744.

Ganong, Peter, and Daniel Shoag. 2017. "Why has Regional Income Convergence in the U.S. Declined?" *Journal of Urban Economics* 102: 76–90.

Gayer, Ted, James T. Hamilton, and W. Kip Viscusi. 2000. "Private Values of Risk Tradeoffs at Superfund Sites: Housing Market Evidence on Learning About Risk," *Review of Economics and Statistics* 82 (3): 439–451.

Gerarden, Todd. 2008. *Residential Energy Retrofits: An Untapped Resource Right at Home*. Washington, DC: Federation of American Scientists. https://fas.org/programs/energy/btech/policy/Residential%20Energy%20Retrofits.pdf.

Glaeser, Edward, and Joseph Gyourko. 2018. "The Economic Implications of Housing Supply," *Journal of Economic Perspectives* 32 (1): 3-30.

Glaeser, Edward L., Joseph Gyourko, and Raven Saks. 2005. "Why is Manhattan so Expensive? Regulation and the Rise in Housing Prices," *The Journal of Law and Economics* 48 (2): 331–369.

Glaeser, Edward L., and Matthew E. Kahn. 2010. "The Greenness of Cities: Carbon Dioxide Emissions and Urban Development," *Journal of Urban Economics*, 67 (3): 404–418.

Greenstone, Michael, and Justin Gallagher. 2008. "Does Hazardous Waste Matter? Evidence from the Housing Market and the Superfund Program," *The Quarterly Journal of Economics* 123 (3): 951–1003.

Griskevicius, Vladas, Joshua M. Tybur, and Bram Van den Bergh. 2010. "Going Green to be Seen: Status, Reputation, and Conspicuous Conservation," *Journal of Personality and Social Psychology* 98 (3): 392.

Gyourko, Joseph, and Raven Molloy. 2015. "Regulation and Housing Supply." In *Handbook of Regional and Urban Economics*. Vol. 5. Amsterdam, Netherlands: Elsevier: 1289–1337.

Hammitt, James K., Eric S. Belsky, Jonathan I. Levy, and John D. Graham. 1999. "Residential Building Codes, Affordability, and Health Protection: A Risk-Tradeoff Approach," *Risk Analysis* 19 (6): 1037–1058.

Harberger, Arnold C. 1964. "The Measurement of Waste," *The American Economic Review* 54 (3): 58–76.

Harney, Kenneth R. 2015. "Why Owners Often Overestimate Their Home Market's Value," *Los Angeles Times*, Jun 3. https://www.latimes.com/business/la-fi-harney-20150604-story.html.

Herkenhoff, Kyle F., Lee E. Ohanian, and Edward C. Prescott. 2018. Tarnishing the Golden and Empire States: Land-use Restrictions and the U.S. Economic Slowdown," *Journal of Monetary Economics* 93: 89–109.

Hernández, Diana. 2016. "Understanding 'Energy Insecurity' and Why it Matters to Health," *Social Science & Medicine* 167: 1–10. https://doi.org/10.1016/j.socscimed.2016.08.029.

Hoen, Ben, Sandra Adomatis, Thomas Jackson, Joshua Graff-Zivin, Mark Thayer, Geoffrey T. Klise, and Ryan Wiser. 2017. "Multi-State Residential Transaction Estimates of Solar Photovoltaic System Premiums," *Renewable Energy Focus* 19–20: 90–103.

Hsieh, Chang-Tai, and Enrico Moretti. 2019. "Housing Constraints and Spatial Misallocation," *American Economic Journal: Macroeconomics* 11 (2): 1–39.

Hyland, Marie, Ronan C. Lyons, and Seán Lyons. 2013. "The Value of Domestic Building Energy Efficiency—Evidence from Ireland," *Energy Economics* 40: 943–952.

Im, Jongho, Youngme Seo, Kristen S. Cetin, and Jasmeet Singh. 2017. "Energy Efficiency in U.S. Residential Rental Housing: Adoption Rates and Impact on Rent," *Applied Energy* 205: 1021–1033.

The Institute for Building Technology and Safety (IBTS). 2005. *Assessment of Damage to Manufactured Homes Caused by Hurricane Charley.* Report prepared for U.S. Department of Housing and Urban Development, Office of Regulatory Affairs and Manufactured Housing. Washington, DC: U.S. Department of Housing and Urban Development. https://www.huduser.gov/Publications/pdf/HurricaneCharley04.pdf.

Insurance Institute for Business & Home Safety (IBHS). 2018. *Rating the States 2018: An Assessment of Residential Building Code and Enforcement Systems for Life Safety and Property Protection in Hurricane-Prone Regions, Atlantic and Gulf Coast States*. Richburg, SC: Insurance Institute for Business & Home Safety. https://ibhs.org/wp-content/uploads/wpmembers/files/Rating-the-States-2018_IBHS.pdf.

Johnson, Erik, Ross Beppler, Chris Blackburn, Benjamin Staver, Marilyn Brown, and Daniel Matisoff. 2017. "Peak Shifting and Cross-Class Subsidization: The Impacts of Solar PV on Changes in Electricity Costs," *Energy Policy* 106: 436–444.

Kahn, Matthew E., and Nils Kok. 2014. "The Capitalization of Green Labels in the California Housing Market," *Regional Science and Urban Economics* 47: 25–34.

Kelly, Eric D. 1996. "Fair Housing, Good Housing or Expensive Housing: Are Building Codes Part of the Problem or Part of the Solution?" *The John Marshall Law Review* 29 (2): 349–368.

Koebel, C. Theodore, Maria Papadakis, Ed Hudson, and Marilyn Cavell. 2004. *The Diffusion of Innovation in the Residential Building Industry*. Report prepared for the U.S. Department of Housing and Urban Development, Office of Policy Development and Research. Blacksburg, VA: Virginia Center for Housing Research.

Koirala, Bishwa S., Alok K. Bohara, and Robert P. Berrens. 2014. "Estimating the Net Implicit Price of Energy Efficient Building Codes on U.S. Households," *Energy Policy* 73: 667–675.

Kurvinen, Antti, and Arto Saari. 2020. "Urban Housing Density and Infrastructure Costs," *Sustainability* 12 (2): 497.

Lee, A.D., R.I. Chin, and C.L. Marden. 1993. *Affordable Housing: Reducing the Energy Cost Burden*. Report prepared for the U.S. Department of Energy. Richland, WA: Pacific Northwest Laboratory.

Listokin, David, and David B. Hattis. 2005. "Building Codes and Housing," *Cityscape* 8 (1): 21–67. https://www.huduser.gov/periodicals/cityscpe/vol8num1/ch2.pdf.

Leland, Hayne E. 1979. "Quacks, Lemons, and Licensing: A Theory of Minimum Quality Standards," *Journal of Political Economy* 87 (6): 1328–1346.

Lipsey, R.G., and Kelvin Lancaster. 1956. "The General Theory of Second Best," Review of *Economic Studies* 24 (1): 11–32.

Marmolejo-Duarte, Carlos, and Ai Chen. 2019. "The Uneven Price Impact of Energy Efficiency Ratings on Housing Segments. Implications for Public Policy and Private Markets," *Sustainability* 11 (2): 372.

Maxwell, John W. 1998. "Minimum Quality Standards as a Barrier to Innovation," *Economics Letters* 58 (3): 355–360.

Mieszkowski, Peter, and Edwin S. Mills. 1993. "The Causes of Metropolitan Suburbanization," *Journal of Economic Perspectives* 7 (3): 135–147.

National Association of Home Builders (NAHB). 2019. *What Home Buyers Really Want, 2019 Edition*. NAHB Economics Group.

National Institute of Building Sciences. 2019. *Natural Hazard Mitigation Saves: 2018 Interim Report*. Washington, DC: Multihazard Mitigation Council.

Nelson, Hal T. 2012. "Government Performance and U.S. Residential Building Energy Codes." In *The Performance of Nations*. Lanham, MD and Plymouth, UK: Rowman & Littlefield: 267–292.

Nevin, Rick, and Gregory Watson. 1998. "Evidence of Rational Market Valuations for Home Energy Efficiency," *The Appraisal Journal* 4 (66): 401–409. https://mpra.ub.uni-muenchen.de/35343/.

Noam, Eli M. 1982. "The Interaction of Building Codes and Housing Prices," *Real Estate Economics* 10 (4): 394–404.

Obrinsky, Mark, and Caitlin Walter. "Energy Efficiency in Multifamily Rental Homes: An Analysis of Residential Energy Consumption Data." *Journal of Sustainable Real Estate* 8.1 (2016): 2-19.

Oi, Walter Y. 1973. "The Economics of Product Safety," *The Bell Journal of Economics and Management Science* 4 (1): 3–28.

O'Neill, Richard P., Charles S. Whitmore, and Michelle Veloso. 1996. *The Governance of Energy Displacement Network Oligopolies*. Washington, DC: Office of Economic Policy, Federal Energy Regulatory Commission.

Oster, Sharon M., and John M. Quigley. "Regulatory Barriers to the Diffusion of innovation: Some Evidence from Building Codes," *The Bell Journal of Economics* (1977): 361–377.

Palmer, K., M. Walls, H. Gordon, and T. Gerarden. 2013. "Assessing the Energy-Efficiency Information Gap: Results from a Survey of Home Energy Auditors," *Energy Efficiency* 6 (2): 271–292.

Palmquist, Raymond B. 2005. "Property Value Models." In *Handbook of Environmental Economics*, edited by Karl Mäler and J.R. Vincent. Amsterdam, Netherlands: Elsevier: 763-819.

Pearce, David W. 2006. "Framework for Assessing the Distribution of Environmental Quality." In *The Distributional Effects of Environmental Policy,* edited by Y. Serret and N. Johnstone. Cheltenham, UK, Northampton, MA, and Paris: Edward Elgar Publishing and OECD: 23–78.

Penn, Ivan. 2017. "California Invested Heavily in Solar Power. Now There's So Much That Other States are Sometimes Paid to Take It," *Los Angeles Times*, Jun 22. https://www.latimes.com/projects/la-fi-electricity-solar/.

Popescu, Daniela, Sven Bienert, Christian Schützenhofer, and Rodica Boazu. 2012. "Impact of Energy Efficiency Measures on the Economic Value of Buildings," *Applied Energy* 89 (1): 454–463.

Qiu, Yueming, Yi David Wang, and Jianfeng Wang. 2017. "Soak Up the Sun: Impact of Solar Energy Systems on Residential Home Values in Arizona," *Energy Economics* 66: 328–336.

Reidmiller, David, Christopher W. Avery, David R. Easterling, Kenneth E. Kunkel, K.L.M. Lewis, Thomas K. Maycock, and Brooke C. Stewart. 2017. *Fourth National Climate Assessment. Volume II: Impacts, Risks, and Adaptation in the United States, Report-in-Brief*. Washington, DC: U.S. Global Change Research Program.

Ronnen, Uri. 1991. "Minimum Quality Standards, Fixed Costs, and Competition," *The RAND Journal of Economics* 22 (4): 490–504.

Rosen, Sherwin. 1974. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition," *Journal of Political Economy* 82 (1): 34–55.

Rosenthal, S. S. 2014. "Are Private Markets and Filtering a Viable Source of Low-Income Housing? Estimates from a 'Repeat Income' Model," *American Economic Review* 104 (2): 687–706.

Rothstein, Richard. 2017. The Color of Law: *A Forgotten History of How Our Government Segregated America*. New York, NY: Liveright Publishing.

Schill, Michael H. 2005. "Regulations and Housing Development: What We Know," *Cityscape* 8 (1): 5–19.

Shapiro, Carl. 1983. "Premiums for High Quality Products as Returns to Reputations," *The Quarterly Journal of Economics* 98 (4): 659–679.

Silverstein, Ken. 2014. "Who Pays for Grid Expansions When Homeowners Generate Their Own Electricity?" *IEEE Spectrum*, Jan 23. https://spectrum.ieee.org/energywise/energy/the-smarter-grid/who-pays-for-grid-expansions-when-homeowners-generate-their-electricity.

Spence, Michael. 1977. "Consumer Misperceptions, Product Failure and Producer Liability," *The Review of Economic Studies* 44 (3): 561–572.

Tiebout, Charles M. 1956. "A Pure Theory of Local Expenditures," *Journal of Political Economy* 64 (5): 416–424.

U.S. Energy Information Administration. 2018. "One in Three U.S. Households Faces a Challenge in Meeting Energy Needs," Sep 19. https://www.eia.gov/todayinenergy/detail.php?id=37072.

Vaughan, Ellen. 2012. "How Do Consumers Feel About Energy Codes? Environmental and Energy Study Institute," Mar 20. https://www.eesi.org/briefings/view/how-do-consumers-feel-about-energy-codes?/how-do-consumers-feel-about-energy-codes-20-mar-2012.

Vaughan, Ellen, and Jim Turner. 2013. The Value and Impact of Building Codes. Environmental and Energy Study Institute, Sep 30. Washington, DC: Environmental and Energy Study Institute. https://www.eesi.org/files/Value-and-Impact-of-Building-Codes.pdf.

Veiller, L. (1910). The National Housing Association. New York.

Viscusi, W. Kip. 2018. *Pricing Lives: Guideposts for a Safer Society*. Princeton, NJ: Princeton University Press.

———. 1985 "Consumer Behavior and the Safety Effects of Product Safety Regulation," *The Journal of Law and Economics* 28 (3): 527–553.

Volokh, Alexander. 1996. *How Government Building Codes and Construction Standards Discourage Recycling*. Reason Foundation Policy Report. Los Angeles, CA: Reason Foundation. https://reason.org/wp-content/uploads/files/e2c2e38a8ee0c9082487023b7bf69a40.pdf.

Walden, Michael L. 1987. "Effects of Housing Codes on Local Housing Markets," *Real Estate Economics* 15 (2): 13–31.

Wee, Sherilyn. 2016. "The Effect of Residential Solar Photovoltaic Systems on Home Value: A Case Study of Hawai'i," *Renewable Energy* 91: 282–292.

Young, Rachel. 2014. *Global Approaches: A Comparison of Building Energy Codes in 15 Countries. American Council for an Energy-Efficient Economy*. ACEEE Summer Study on Energy Efficiency in Buildings. https://www.aceee.org/files/proceedings/2014/data/papers/3-606.pdf.

Zuk, Miriam, and Karen Chapple. 2016. *Housing Production, Filtering and Displacement: Untangling the Relationships*. UC Berkeley Research Brief. https://escholarship.org/content/qt7bx938fx/qt7bx938fx.pdf.