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The value of basic building code insulation

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ABSTRACT

We take advantage of unusually wide variation in thermal insulation in a sample of house sales to estimate the market value of basic code-level insulation. Insulation levels vary across the houses in our sample because standard practice in New Zealand was to build houses with no thermal insulation prior to implementation of insulation standards in 1978, and the extent of insulation retrofits varies across the sample. The estimated premium on an otherwise similar house insulated to code levels exceeds the cost of installation at construction: insulating to basic code levels at construction passes the market test. The premium instead reflects the higher cost of retro-fit installation. We suspect that price, cost, and performance risk have discouraged widespread code-level retro-fits in this market.

1. Introduction

Governments in developed countries routinely set minimum required levels of thermal insulation in new residential construction. At least two types of market failure justify these requirements. The first is limited consumer information: potential home buyers have difficulty observing the quality of thermal insulation installed behind wall linings, so well-enforced insulation requirements provide assurance of minimum levels of insulation. The second arises from externalities: in addition to its benefit to the household, efficient space heating provides social benefits by reducing demand for energy produced from environmentally damaging sources and for treatment of health problems associated with living in cool or damp environments.

Of interest is whether insulation requirements pass a cost–benefit test. If home buyers value better thermal insulation, competition for a better insulated home bids up its sale price. A sale price premium at least as large as the cost of installation provides evidence that private benefit exceeds cost. Any external benefit adds to net social benefit.

Laquatra et al. (2002) review papers that report estimates of sale price premia associated with variation across houses in a variety of measures of thermal efficiency. Most provide evidence of positive market capitalization, though Laquatra et al. express concerns about measurement and methodological issues. The estimates most applicable to a cost–benefit test of insulation requirements appear to be those in Longstreth et al. (1984) as they include estimates of the market values of variation in the thickness of installed ceiling and wall insulation (as reported by home owners in a survey). In their sample of sales in the 1970s in Columbus, Ohio, each additional inch in thickness of wall or ceiling insulation adds, on average, about $500 (about 1%) to sale price. There is no discussion of the cost of installing insulation, but given the time period, these premia may recover most of the installation costs incurred at construction.

More recent work focuses on the market value of energy efficiency improvements beyond typical code requirements. Pfleger et al. (2011) compare sales in 2009/10 of houses built under Energy Star requirements (which are at least 15% more energy efficient than houses built to 2004 International Residential Building code standards) in Raleigh/Durham, North Carolina with sales of similar houses built under local code requirements. They find that Energy Star houses sold for an average premium of 1.6%, which is higher than the 0.5% to 1.5% increase in construction cost typical of Energy Star requirements; Energy Star improvements beyond those of local code requirements appear to pass a cost–benefit test in that sample. Bloom et al. (2011) also report significant sales price premia on Energy Star houses in Fort Collins, Colorado.

Turning to Europe, Brounen and Kok (2011) report the results of analysis of sales in The Netherlands in 2008/09 of houses with and

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without Energy Performance Certificates, which rate general energy performance on a 7-point scale. Houses rated as "green" sell for a statistically and economically significant 3.6% (~€8500), but the costs incurred in obtaining this level of energy efficiency are not discussed. Mandell and Wilhelmsson (2011) supplement standard information about house sales with a postal survey to obtain home owner measures of house characteristics. Houses with better solar exposure and "extra" insulation command significant sale price premia, but again there is no comparison of the premia to installation cost.

This paper reports estimates of the market value of insulation over an unusually large range. Modest requirements for minimum levels of thermal insulation were imposed in New Zealand only in 1978 and not fully implemented until at least 1980, despite cool mid-latitude winter temperatures. Standard practice prior to implementation of code requirements was to build with no wall, ceiling, or floor insulation. Clark et al. (2005) report the results from a large-scale survey conducted in 2004/05. It reveals widespread retro-fits of ceiling insulation, some retro-fits of floor insulation, and few retro-fits of wall insulation, presumably due to its relatively high cost. As a result, the current insulating efficiency of houses built before insulation requirements varies widely due to variation in construction materials and the extent of insulation retrofits. This large variation in insulating efficiency provides an unusual opportunity to estimate the market value of basic building code levels of thermal insulation.

The data analyzed in this study consist of observations on detached single-family houses in Dunedin, New Zealand that sold in 2002–05. Dunedin is a regional service center with a port, a university, and a population at that time of about 120,000. Dunedin experiences a cool maritime climate; the city is located on the east (i.e., Pacific) coast of New Zealand's South Island at about 46° south latitude. The average daily winter low and high temperatures over the last 30 years are 3.7 °C and 11.1 °C, respectively.[1] Importantly, only about one sixth of Dunedin's approximately 40,000 houses were built after 1980, and the proportion is smaller in the central areas from which the sample comes. Thus over five sixths of the central Dunedin housing stock, including well-constructed and maintained houses occupied by middle and upper-middle income households, lack basic building code levels of insulation installed at construction.

We start with a before-versus-after study. The data consist of observations on sales in 2005 of houses built from the 1920s through the 1990s. The results of a standard hedonic sale price regression indicate surprisingly little variation in sale prices with age across the sample of houses built prior to insulation requirements. Newer houses built under insulation requirements command an average 8½% price premium over observationally similar houses in the older sample. This jump in sale prices, which amounts to approximately $20,000 for a median-priced house, seems plausible as a lower bound on the market value of basic building code insulation, a lower bound because the typical older house has been retro-fitted with some insulation.[2]

A concern, however, is that this premium includes the value of any unobserved characteristics of newer houses in addition to insulation. We treat this problem by collecting via site visits more detailed data on construction characteristics and current condition of a sample of 98 homes recruited from a random draw from middle-income neighborhoods in the set of 2005 sales. The sample is relatively small due to the cost of site visits.

We create a new and more direct measure of insulating efficiency from the data collected during site visits. Using specialized software we measure the energy required to maintain each 1 °C difference in indoor relative to outdoor temperature. We measure the insulating efficiency of the house as the ratio of this energy requirement if the house had insulation meeting code requirements in 2002 (somewhat higher than those implemented in 1978) to that required with construction characteristics as measured. Insulating efficiency varies from 0.4 to 0.9 over most of the sample. Including a measure of house condition obtained during site visits as a control variable, standard hedonic estimates indicate an insulation premium somewhat lower than the corresponding estimate from the large sample: about 8% of sale price for 2002 code-level insulation. This premium clearly exceeds the cost of installing insulation at construction, and appears roughly consistent with the higher (and more variable) cost of retro-fitting insulation in houses built prior to code requirements; retro-fit insulation appears to pass the market test, on average. The standard error on the estimated market value is, however, large, reflecting variation in the highest bids made for houses with varying levels of insulation retro-fits.

The remainder of the paper is organized as follows. Section 2 provides background and conceptual foundations. Section 3 describes the sample of house sales analyzed. Section 4 reports the results of the large-scale before-versus-after study. Section 5 reports the results of the analysis of the smaller, but more detailed subsample. Section 6 discusses the results in the context of implications for policy.

2. Background and conceptual framework

The combination of at least four key aspects of housing distinguishes it from other goods: heterogeneity (i.e., variation in structural, neighborhood, and accessibility characteristics), durability, high alteration cost, and immobility. The durability of housing implies that construction technologies and techniques, household preferences, market prices, and the regulatory environment can all change considerably over the life of the structure.

We can adapt Rosen's (1974) analysis of implicit markets in house characteristics to the case of heating efficiency in New Zealand.[3] In Fig. 1, the curve labeled LRO (for long-run offer curve) represents the supply side assuming that all suppliers of new housing use similar technologies and face similar conditions in input markets: its increasing slope reflects the increasing marginal cost of supplying heating efficiency at construction. For example, installation of fiberglass wall and ceiling insulation during construction of the house costs relatively little per unit of heating efficiency, installation of double glazing and efficient heating systems is more expensive, and so on. Households vary in their willingness to pay, WTP, for additional heating efficiency as represented by household bid functions B_1 and B_2. HE_1 and HE_2 represent each household's optimal choice of heating efficiency, and P_1 and P_2 the prices they each pay for an otherwise identical house.

Building code requirements bind if the required level of heating efficiency exceeds a household's preferred level. Isaacs (1993) provides a history of the requirements for residential thermal performance in New Zealand. To summarize, minimum insulation standards were first proposed in 1950, but not implemented. Domestic manufacture of fiberglass insulation commenced in the mid-1960s, and suppliers promoted its use. The first local legal requirements for insulation were implemented in the vicinity of Christchurch in 1972 largely in response to high levels of particulate air pollution from residential wood burners. Also in 1972, the Building Research Association of New Zealand, Inc. (BRANZ) recommended modest insulation levels for new construction that were calculated to pass a financial cost–benefit test (specifically, that minimized estimated capital plus running costs). In 1975, the New Zealand central government began providing interest-free loans for installing insulation that met slightly higher

[1] Averaged monthly for the 1971–2000 period from data reported by the National Climate Centre, NIWA.

[2] Dollar values are in New Zealand dollars, which in 2005 exchanged for about 70 US cents.

[3] Heating efficiency can be measured by the amount of purchased energy required to maintain a given level of indoor temperature. So a more efficient heater, better insulation, an airtight building enclosure, and better exposure to solar energy all contribute to heating efficiency.