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Low hanging fruit? Regulations and energy efficiency in subsidized multifamily housing

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ABSTRACT

The U.S. government has invested in multifamily housing through an array of subsidized housing programs. These programs provide a venue for understanding how regulations governing multifamily housing can affect an owner's incentive to make energy efficient investments, and a tenant's desire to reduce their energy consumption levels. This paper empirically tests the impact of subsidized housing regulations on the energy efficiency of multi-family housing for low-income households. We begin by constructing a unique database that integrates actual energy use with physical, socioeconomic, and regulatory characteristics of all large multifamily properties in New York City, focusing on whether a property receives a federal rental subsidy. We employ multivariate regression models to examine the factors that influence energy consumption in multi-family buildings and compare subsidized housing to market-rate housing, controlling for a range of building and household characteristics. We find that subsidized properties are associated with higher energy consumption than similar market-rate properties and, of the subsidized housing programs, Public Housing tends to consume the most energy. Our results suggest that despite the potential for retrofitting multifamily properties, and associated cost, energy, and carbon emissions savings, regulatory factors constrain investment and consumption decisions in the case of subsidized properties. Reducing energy use in subsidized housing, therefore, rests on modifying existing regulations.

1. Introduction

Cities across the globe are implementing plans to reduce greenhouse gas (GHG) emissions, and often cite the retrofitting of existing buildings, and multifamily housing in particular, as one means to achieve this goal. Following the Paris Agreement in 2015 and the United Nations Framework Convention on Climate Change, many cities, including Berlin, Sydney, Yokohama, New York City, and Vancouver, have committed to reducing GHG emissions by 80% by 2050. For high-density cities like New York, where buildings represent the largest source of GHG emissions (City of New York, 2014b) and multi-family housing accounts for more than 40% of the 3.25 million residential units across the City (Furman Center, 2010), the retrofitting of multifamily housing could be a highly effective way to reduce emissions, energy use, and household utility costs. It is projected that multifamily properties across the country could be approximately 30% more energy efficient using existing technologies (Brown et al., 2008; Benningfield Group, 2009). For lower income households, the federal government has invested in multifamily housing through an array of subsidized housing programs. In theory, these subsidized properties are "low hanging fruit" for increasing energy efficiency in multifamily housing because the government has regulatory levers to require certain efficiency levels and can create new financing programs targeting these properties. In practice, these programs present an important venue for understanding how regulations governing multifamily units can affect an owner's incentive to make energy efficient investments, and a tenant's desire to reduce their own energy consumption levels.

Market failures that lead to a socially sub-optimal investment in energy efficiency have been well-studied (Jaffe and Stavin, 1994; Gillingham et al., 2009). These market failures include information asymmetries, ineffective pricing signals, environmental externalities, and the split-incentive problem. The split-incentive problem is of particular importance in the multifamily housing context, as it emerges between tenants and owners with respect to who bears the cost of energy efficiency improvement and who realizes the benefits of new savings. Traditionally, owners are able to capitalize the market value of energy improvements (Fuerst et al, 2015). However, in subsidized

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housing, an owner's ability to capitalize this value is constrained because rent levels and escalations are typically fixed. In addition, energy expenses add to the cost burden of low-income, subsidized housing tenants, which should increase tenant demand for more efficient units, depending on the utility allowance scheme of the particular subsidy program (Pazuniak et al., 2015; Dastrup et al., 2012; Hernández and Bird, 2010).

In this paper, we examine the previously unexplored question of whether existing subsidized housing programs – and the regulations that determine utility allowances – create dis-incentives to greater energy efficiency. We begin by developing a theoretical framework for why regulations governing subsidy programs affect investment and consumption incentives. We then combine several unique datasets to analyze actual energy use data for all large (greater than 4500 m^2) subsidized and market-rate multifamily properties in New York City for the first time. This unique dataset, consisting of more than 4000 properties, is then used to model the variation in energy consumption across the multifamily rental housing stock and test whether regulations result in higher energy consumption in subsidized properties than in comparable non-subsidized properties. Using several multivariate regression models, we find that subsidized properties are associated with higher utility consumption than market-rate properties and, of the subsidized housing programs, Public Housing tends to consume the most energy. The findings in this paper suggest that despite the potential for retrofitting multifamily properties, there are often regulatory factors that constrain investment and consumption decisions in the case of subsidized properties.

2. Background and literature review

There is relatively little understanding of how regulations in the multifamily housing sector affect energy consumption levels or how consumption levels in subsidized properties compare to those that are market rate. One study finds that utility costs for the U.S. Department of Housing and Urban Development (HUD) increased by 35% between 2004 and 2010, from US$6.3 to US$8.5 billion (White, 2012). However, that report is limited to HUD properties and does not analyze whether these increases are due to program structure, tenant or building characteristics, or escalations in energy prices. There is only one study that compares utility costs across subsidized and unsubsidized properties; it finds that, on the whole, subsidized properties have higher costs than similar market rate properties, but these difference largely disappear when controlling for household characteristics (Dastrup et al., 2012). The study uses American Housing Survey data, which has limited information on the type of rental subsidy and therefore conflates all subsidized units into one larger “subsidized” category. In addition, the study is a national analysis and has low statistical significance when all of the building, household, and spatial controls are included. The lack of differentiation between subsidy programs, combined with a limited sample size reduce the scope and significance of the findings.

There are numerous studies that model or analyze the determinants of energy use in residential buildings. Most tend to focus on single-family structures and use simulations or physical models to estimate consumption patterns when actual use data are unavailable. Swan and Ugursal (2009) present an overview of modeling approaches for residential building energy use, focusing on macro-scale and building-scale models. In general, the review highlights the coarse and relatively low resolution analysis of residential building energy use in the literature, either using historical data at a neighborhood or city scale, or using prototypical buildings to estimate aggregate consumption. Several studies use statistical methods and actual building consumption data to understand the factors that impact building-level consumption and predict energy use across residential buildings. Yohanis et al. (2008) conduct a study using a small sample of just 27 dwellings to understand the effects of unit size and occupant density on energy use. Kontokosta (2012) examines residential energy use using robust statistical methods applied to actual energy use data for more than 6000 residential buildings in New York City. The author finds statistically significant coefficients for several building bulk and size variables, building age, geospatial characteristics, and building amenities, such as laundry facilities. In a study of approximately 4000 residential buildings in Ireland, McLoughlin et al. (2012) find that the size of the dwelling and socioeconomic characteristics of the household impact energy consumption.

In our comparison of subsidized and market-rate residential buildings, we explore several factors that may influence differences in energy consumption patterns. It can be expected that building quality and systems in subsidized housing are inferior, on average, to market-rate properties, and that these deficiencies will negatively impact energy efficiency. Building quality is affected by both building systems (age and efficiency of boiler, for instance) and construction materials, such as the R-value of wall assemblies and glazing efficiency (Pérez-Lombard et al., 2008). We anticipate that the variation in building quality will be a function of the subsidy program category for a particular building. Specifically, we expect that housing quality should be on par with market-rate housing in some programs where the buildings are newer and the program leverages private capital, whereas older subsidy programs may exhibit lower levels of building quality due to development budget constraints and inferior or deferred maintenance, among other factors.

Occupant behavior has been shown to have a significant impact on energy consumption in residential buildings (Lutzenhiser, 1993; Ouyang and Hokao, 2009). Studies have found that factors such as occupant density (Kontokosta, 2015); occupant behavior (McMakin et al., 2002; Santin et al., 2009), and socioeconomic and cultural differences (Kontokosta and Jain, 2015) affect consumption behavior. Accounting for occupant characteristics has been shown to be an important, although challenging, component of understanding relative energy efficiency. With the exceptions of the citations above, most studies of the impact of occupants on consumption behavior are derived from models, simulations, or surveys rather than actual energy use data (Langevin, Gurian, and Wen, 2013). While these methods are useful for cross-validation and estimating potential impacts, the empirical analysis of actual use data provides an opportunity for new insights into the effects of these factors on building energy efficiency.

3. Theoretical framework

We motivate our empirical analysis by formalizing a theoretical framework for the drivers of energy use in subsidized housing, shown in the function below. This allows us to identify the drivers of energy use and where they differ between subsidized and similar market-rate properties. For our consumption model, energy use in subsidized housing is given by:

$$\hat{y}_{it} = f(H, O, M, S, W, P) \tag{1}$$

Where y is the expected annual energy use intensity (EUI, in kbtu per square meter) of building i at time t, H is the quality of housing in building i at time t, O is the occupant characteristics of building i at time t, M is the metering arrangement of building i at time t, S is the subsidized housing program that building i is a part of in year t, W is the weather at time t, and P is the price of energy for building i at time t. The price of energy is a function of the types of energy consumed (e.g. natural gas, fuel oil, electricity, etc.) and can vary as price expectations fluctuate over time (Amstalden et al., 2007). By controlling for these factors in our empirical model, we can isolate the impact of the programs on relative measures of energy efficiency, operationalized here as the annual, weather-normalized EUI of the building, accounting for all energy consumed in the building divided by its total gross square meter.

In all rental properties, owners have control over housing quality,