

## **Chapter 6: Conclusions & Future Research**

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### **Research Problem Summary**

According to the US Environmental Protection Agency and Department of Energy, more than 1.5 million homes have been Energy Star certified since 1996. The USGBC's database indicates that more than 13,000 homes have earned some degree of LEED certification over the same time period. Adding regional systems such as Greenpoint and Earthcraft the total number of eco-labeled homes in the US can roughly be estimated at 1.5 million units. Within individual markets, the ratio of Energy Star homes to the total number of homes in any CBSA remains below 12%; the majority of markets have ratios below 3%. In the context of the increasing volume of the national and global discussion about green consumer durable goods, corporate social responsibility, hybrid-electric vehicles, climate change, and the volatility of energy prices, it seems that green and energy efficient home certifications are lagging—or at least suffering from slow diffusion in many markets. Perhaps some of this can be explained by residential construction's status as an innovation laggard, but certainly not all of it can.

This dissertation generated research questions to explore the frictions and obstacles to the broader diffusion of high performance, energy efficient homes into the US housing market. Specifically, the research investigated what diffusion patterns markets might expect under the condition of missing information about the value proposition of high performance homes and in the context of the comparable sales valuation method. Further, the dissertation explored current real estate appraisal practice for existing methods of analysis used to overcome obstacles to high performance home valuation. Finally, the dissertation offered a temporary valuation tool to help break the vicious cycle of limited data—> mis-pricing of high performance homes—> limited diffusion.

Where previous research focused on the diffusion of green and energy efficient building technologies into homes or building certifications into the commercial property

markets, this dissertation focused on the unit of analysis of the high performance house. The dissertation appears to be the first to analyze high performance homes in the context of Moore's Chasm, a tactic that allowed the authors to address McCoy's request in his 2008 dissertation to identify and explore the role of champions or gatekeepers of innovation within residential construction. By using Moore's Chasm as an intellectual framework for analysis, the authors identified the real estate appraiser as the most likely gatekeepers of information. Further, the research differentiated itself by using qualitative methods of analysis to analyze current appraisal practice vis-a-vis high performance single-family homes. In doing so, the authors were able to confirm that among real estate appraisers, there is not a common analytical framework for estimating the value of high performance homes. Further, this lack of consensus has bled over into a sub-method of analysis where the authors discovered that that appraisers do not hyperbolically overestimate discount rates relative to energy savings cash flows the way they appear to do relative to other products.

### **Research Questions and Methods of Analysis**

The first article of the dissertation analyzed the problem of limited diffusion and responded to the question 'what diffusion patterns would we expect based on the problem of valuation of green homes in the absence of comparable attribute data supporting their value proposition?' Further, it identified the problem in the context of the diffusion theory and the condition of inadequate information about the performance of these innovations. High performance homes reflect a type of green building innovations that involve non-trivial costs. As early-stage innovations, diffusion theory helps researchers to identify the challenges faced by innovations including those faced as they move from early stage markets across Moore's chasm into more mainstream markets.

The authors employed literature review across several disciplines to develop a new theoretical understanding of the effect of valuation on the diffusion of innovation. First, the authors reviewed the diffusion literature focusing on definitions of innovation to understand the extent to which high performance homes met existing definitions of innovation. After confirming that high performance homes met the definition of early-stage innovations, they reviewed the diffusion of innovation literature focusing on

diffusion patterns of consumer goods and services across a range of industries including building construction and real estate. Following this review, the authors identified the real estate appraiser as the most likely gatekeeper in the diffusion process for high performance homes. Building from this, the authors reviewed the literature to analyze how scholars have estimated the value of innovations across the automobile, biotechnology, securities, and property industries and identified the need for a temporary valuation tool to break the vicious cycle caused by missing information.

The second article responded to the findings of both the first and second articles and offered a temporary valuation method based on a net present value formula. The solution is only temporary, as the traditional methods of appraisal should work well once there is sufficient data available in the market place to conduct comparable sales analyses. At the point in time where a market has documented a sufficient number of high performance homes from which to conduct comparable sales analyses, then the temporary method could be converted into a method of reconciliation. Following this article, the authors analyzed data generated from a series of semi-structured interviews conducted with residential real estate appraisers from across the US with green appraisal training and/or experience.

The third article sought to answer the research questions, 1) at present, how do residential with green experience and training appraisers estimate the contributory value of high performance building technologies within high performance homes; and 2) how are the methods and processes used substantively different from those used to appraise non-high performance homes? To answer this question, the authors first reviewed the appraisal literature, interspersing findings from the construction and real estate literature where necessary. They then conducted eighteen semi-structured interviews with real estate appraisers and discussed how they would or have conducted the appraisal of high performance homes and how that differed (if at all) from the appraisal of traditionally built homes.

## **Conclusions**

Using the intellectual framework of Moore's Chasm to analyze the diffusion patterns of high performance homes showed evidence to support the claim that high

performance homes have not yet crossed from the early market into the mainstream market. The literature review across the innovation, finance, and appraisal literatures identified the real estate appraiser as the most likely gatekeeper for increased high performance home diffusion. Identifying a gatekeeper is important insofar as gatekeepers are individuals, firms, or processes (e.g., policy) that funnel, filter, and block the transfer of information about the value proposition of various innovations.

The appraiser as gatekeeper logic is primarily supported by the fact that most home purchases rely upon the use of mortgage debt. As such, lenders require a third party, the appraiser, to estimate the value of the collateral upon which they are making mortgage loans. Where the appraiser cannot gain access to, discover data, or substantiate the value proposition of a performance of a high performance home, they cannot substantively differentiate the value of a traditional home from a high performance home. As high performance homes contain technologies and systems designed to operate more efficiently than their traditionally built counterparts, this could seriously blunt broader diffusion.<sup>1</sup>

The review also indicated that appraisers appear to need a temporary solution to help them break the vicious cycle. The SAVE Act, proposed and rejected several times over the last three years has recently gained new traction in the US Senate. It proposes to convert energy savings from energy efficiency at a discount rate of 4% over a 20-year period of analysis. Research from other industries where energy saving innovations exist suggest that using some version of a present value calculation can help estimate the value of these innovations. However, the literature noted that buyers typically are unable to accurately estimate discount rates to use to present value energy savings based cash flows. So, given the static nature of the SAVE Act methodology and the lack of consensus among practitioners on the selection of a time period or discount rate, the

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<sup>1</sup> Though we conclude that the most likely gatekeeper is the appraiser, we perhaps give them too much primacy and instead should consider the Lender as an alternative gatekeeper. The Lender could encompass any actor in the capital allocation process from mortgage origination (the step that includes initial credit scoring of the buyer, analysis of potential loss given default, appraisal of the collateral, and pricing of the loan) to securitization. Each of these analyses are influenced by the availability and completeness of information about their subject. Lenders with greater access to high performance housing information would gain a competitive advantage over their competition and also likely be able to underwrite and issue better loans for securitization. Suspecting the Lender as a potential gatekeeper does not challenge the original conclusion of the dissertation but instead broadens it and allows future research to move in a wider trajectory.

temporary solution should suggest an easy to use but disciplined method of generating assumptions.

The data from interviews with appraisers indicated that while there were few, if any, procedural differences between the appraisal of a traditional home and a high performance home, the methods of estimating value within the appraisal process were markedly different; despite the fact that within the sample, there was limited consensus as to what methods were most useful. In practice, most appraisers used two methods. The first was a modified version of the comparable sales method that made an adjustment for the quality of construction and increased economic life of high performance building technologies and systems. The less air and moisture moving across the building components, the longer the house would last. Further, as these systems and technologies were considered more difficult to install, they were perceived to be of higher quality. The second approach focused on discounting the estimated future energy savings of the home to create a cash flow based adjustment of value to the home appraised in the absence of the high performance technologies. Despite consensus that these two methods were useful in low data environments, there was limited consensus on the details of use. For example, there were nearly as many variations of the method respondents used to estimate a discount rate as there were respondents in the sample. This variation can lead to significant variation in price adjustments.

Finally, building from the findings of both the first and third articles, we created a temporary solution to appraisers for the valuation of high performance homes that addresses some of the problems highlighted by the literature review and interviews. The method uses the build up method to select an appropriate discount rate. The build up method for a high performance home includes a risk free rate, an equity premium for the market, a climate adjustment, and the HERS index of the subject property. The method then estimates the cash flow savings generated by the high performance technologies by converting the HERS score of the property from BTUs into KWHs using a tool from the Department of Energy. These two elements are then combined into the present value of an annuity formula. The method we advanced in this article attempted to provide some guidance from other industries such as securities and firm valuation where discount rate construction is a regular and structured process. Further, the proposed method draws on

the present value of an annuity formula that can be adjusted for taxes and depreciation or changes in the growth rate of the cash flows over time. In suggesting that appraisers use these two tools, we contributed to the conversation of high performance valuation a method that appears to be superior to the method prescribed by the SAVE Act and helps to bring some consensus on inputs to practitioners.

### **Future Research**

There are a number of future directions that this work could take to make a more significant contribution to the fields of housing, planning, and real estate. Perhaps the lowest hanging fruit is an analysis of the economic factors, policy instruments, and market attributes that influence the diffusion of energy efficiency in housing. At present, several papers have explored the factors associated with increased diffusion of energy efficiency in the commercial property market. However, at present, no work has been completed on those factors associated with increased efficiency within the housing market. Policy makers, builders, and developers would likely be interested to know more about the levers that have been pulled successfully or the market factors that help explain how diffusion has occurred to date. They may also be able to interpret this research to identify future opportunities to deploy policy or leverage market factors to increase future diffusion of energy efficiency within the housing stock.

An additional direction future research could take would be to expand the analysis of current appraisal practice into a survey allowing for more quantitative analysis of the methods of analysis appraisers are using to overcome high performance home appraisal obstacles. Existing practitioners and policy makers would benefit from the nuanced understanding of practice and could use the data and analysis to inform iterations of methods of analysis and policy.

Future research could also expand the analysis of gatekeeper to investigate the role of the mortgage underwriter in broader diffusion of high performance homes. The appraisal and the appraiser sit within the mortgage lending process and provide a service that is integral to its success. By expanding research into the lender as a gatekeeper, I would be able to address a number of additional frictions associated with high performance homes including the role and shortcomings of existing automated

underwriting systems and credit scoring models with their use surrogate variable models in place of more empirical cash flow based variables. Additional frictions include agency issues related to home ownership (e.g., owner as investor/tenant), the concept of loss given default for a high performance home versus a traditional home, and finally the role of capital availability via the securitization process. Under the topic of securitization of high performance home mortgages, there has been little research to suggest how the flow of capital has created a more stable pathway for innovation into the housing market as it allows buyers to express demand and builders to build to it (and occasionally suggest what new features might look like). This topic is likely to be important given two critical mis-matches: the mis-match of the duration of capital (e.g., lenders tend to fund mortgages with short term capital though they are longer term assets) and the mis-match of the flow of capital to buyers who do not need the benefits of energy efficiency and the lack of capital available to lower income buyers where increased cash flow from energy savings could prove most valuable given a trigger event such as job loss or illness.