Buying Green

by

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ABSTRACT

Green development has received much attention over the past decade, with the greatest interest coming from designers. However, the development and investment communities have been slower to adopt green principles, and the author claims that this hesitancy is related to an information gap around the costs and benefits of green building. When researchers do quantify cost or value differentials, they do it on a case study basis. By focusing on a few extraordinary examples that are ultimately placeless, these case studies create an information gap between the extraordinary performance of a few buildings (what is possible) and the ordinary performance of a typical green building (what is expected). Through the development of a simple real estate market model, the author argues that information on what is expected drives decision making in real estate, and market-based studies that are segmented by place and product type would provide more pertinent information to these industry players. If green buildings create greater value over a building’s lifecycle, then green building owners should expect superior returns over time. However, no one has tested this hypothesis for a particular real estate market with a large number of green buildings. To that end, the author develops a methodology that could be used to complete such a study. This methodology is then tested on the market for green single-family homes in the Austin, Texas metro area. The author finds that homes rated as green by the Austin Green Building Program sell at a 9-10% price premium over unrated homes (further research by the author has shown that this premium is likely related to a spatial concentration of green homes in high cost areas and not due to the green rating).

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BIOGRAPHICAL NOTE

Will Bradshaw has been looking at houses in Massachusetts, Texas, North Carolina, and Indiana for the last 28 years. Sometimes, he would look unwillingly, as a captive in his father’s car, more recently he looks with much greater interest and alacrity, often with his own captives in tow. He appreciates their patience.

He is a graduate of Davidson College in Davidson, North Carolina, and he lived in Davidson for three years after graduation. During the seven years he spent there, he learned at least three important things:

1. Houses are really fun to develop and build;
2. Experimental Physics, while interesting to think about, is often done in a dark room, underground;
3. Going to work does not seem so much like going to work if you like what you do and the people are nice.

He has thought (briefly) about tattooing these lessons somewhere on his person, but they’re a bit wordy and he may be too skinny. He is also a coward when it comes to needles. Instead, he has enshrined them here, where there is some small possibility of sharing.

Prior to enrolling at MIT, he was the Organizational Director of the Davidson Housing Coalition, a small non-profit affordable housing developer based in Davidson, North Carolina. He now lives in Cambridge with his fiancée, Julia McNabb and their dog, Nina Azi. He loves them, very much.
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INTRODUCTION

Buildings shape the spaces where we carry out our lives. They inspire, mark territory, tell us something about where we are. Catch a glimpse of Trinity Church reflected in the Hancock Tower and one knows she is in Boston. Find, dog-eared in a long-forgotten shoebox, a picture of the home where you grew up, and you will pause, let the memories return. The real estate around us serves as touchstone and anchor, providing space to live, work, meet, worship, and carry out all types of human activity.

Buildings also carry a different legacy that speaks to our performance as stewards of our communities and our planet. Over forty-percent of our energy is used in buildings. One third of the solid waste in landfills is demolition waste and nearly three quarters of this construction waste could be recycled. The most widely used paints, cabinetry, cleaning supplies, and varnishes produce toxic fumes, which are often recycled

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into the conditioned air we breathe. The vinyl used as floor covering, piping, and siding in our homes and offices is toxic to produce and toxic to burn. Whole communities have disintegrated around abandoned industrial buildings that once provided opportunity but now only provide an environmental hazard. Most Americans live in increasingly automobile-dependent communities separated from centers of transit, shopping, employment, culture, and education.

“Buying Green” springs from an abiding interest in the conflicting legacies of buildings and from the conviction that we are not building what we should. Part of this conviction is the sense that development practice can and must enhance the beneficial, aspects of buildings while minimizing threats to human health, ecology, and opportunity. Projects are too rarely conceived in this ideal – an ideal that also represents the sentiment behind the green development or green building movement. The group of practitioners that make up this movement, practitioners who overlap considerably with advocates for New Urbanism, pedestrian-friendly development, neo-traditional development, conservation development, cluster development, sustainable development, New Towns, brownfields re-development, and what Chris Leinberger calls “progressive development,” believe that design, planning, construction, and real estate practice must seek to correct and prevent environmental and community damage through the building process. In some measure, this movement reflects a tension between the largely private benefits of development (safety, warmth, comfort, private space, profit), and the largely public costs (habitat destruction, increased energy use, traffic, degraded air quality, a low-quality built environment) associated with common development patterns. Green development represents a middle path whose central claim is that these negative public costs or externalities can be minimized while preserving or enhancing private benefits.

**Defining Green**

Many different people have offered many different definitions for green building and green development. Some focus on environmental goals alone, while others focus on environment and community health. Other definitions center on balancing community, financial, and environmental concerns in what is often called a triple bottom line or “triple E” framework, which stands for
equity, economy, and ecology.

Environmental Focus

The US Congressional Office of Technology Assessment offers a succinct description that says green building is “a design process in which environmental attributes are treated as design objectives, rather than as constraints.” 8 While others place an important emphasis on “systems innovation in design and construction” 9 saying that “green building addresses four major areas: energy, materials, indoor environmental quality, and site development.” 10 The Leadership in Energy and Environmental Design (LEED) criteria promulgated by the US Green Building Council (USGBC) expands these four areas into six, rating buildings in Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials and Resources, Indoor Environmental Quality, and Innovation and Design Process. 11 Others emphasize interactions with nature that mimic ecological systems, such as this eloquent description from David Orr. “Ecological design means maximizing resource and energy efficiency, taking advantage of the free services of nature, recycling wastes, making ecologically smarter things, and educating ecologically smarter people. It means incorporating intelligence about how nature works into the way we think, design, build, and live. When human artifacts and systems are well designed, they are in harmony with the larger patterns in which they are embedded. When poorly designed, they undermine those larger patterns, creating pollution, higher costs, and social stress.” 12

Community and Environment

The LEED system and Orr’s comment begin to bleed into a green building consciousness that also measures development impacts on people and community. As Rocky Mountain Institute founders Amory and Hunter Lovins and their co-author Paul Hawken describe in Natural Capitalism, “green development fuses a biologically and culturally informed appreciation of what people are and want, and a tool kit of technologies to fulfill those needs.” 13 Some place an even more overt emphasis on human health, saying that green building minimizes “impacts on the occupants and on the globe” 14 or that “green building includes three important components: resource conservation during design and construction; resource conservation during operations; and
protection of occupants’ health, well being, and productivity.”15 Others emphasize the protection of more ephemeral things like “community and cultural sensitivity”16 saying that green projects “blend in with the natural environment and protect open space; increase a sense of community, and address cultural issues.”17

Economy, Ecology, and Equity

In my estimation, the most complete definitions of green building also add a financial emphasis, embedding the claim that more effectively utilizing human and natural capital will reap financial rewards. The Green Development Services arm of the Rocky Mountain Institute says green development is a “field in which the pursuit of environmental excellence produces fundamentally better buildings and communities – more comfortable, more efficient, more appealing, and ultimately more profitable.”18 Presenters to the US Environmental Protection Agency claimed that “green development balances urban development impacts and site design features while enhancing lot yields, reducing development costs, and encouraging development and economic growth. The overall goal is to achieve a balance between economic growth, quality of life, and environmental protection.”19

With this diversity of voices, the last thing that the green development movement needs is another definition. But an old one that helped birth the current green development ethic can shed some light on the central relationship between these varying representations. In a comment describing what good architecture should do, Ian McHarg summed up the heart and soul of the green development movement.

“If you go to a pueblo you know perfectly well you’re in an arid environment. You know something about the culture, too. The building expresses this... The beginning of a modern architecture, an appropriate architecture, and landscape architecture, and planning... should have to engage people who know about the land: how it came to be, how it works, what the implications upon that land are of making any adaptation, being able to discriminate about where are appropriate places and most of all, being able to find appropriate locations and appropriate form.”20

McHarg’s conception claims that good development is the best-fit intervention for a
particular human and natural environment. This is the clearest and most succinct exposition of what green development should do. It also claims that standard development practice, in its attempt to belong every place, does not fit any place. One should not build the same house or office building in Denver and Long Island.

The View from Deer Park

There is an old joke about subdivisions--you name them after the thing that you destroy. Quail Run, Canyon Creek, Deer Park. These places are never hard to find. Your first clue is the tear in the fabric of the landscape. The place where the forest stops and the homes are pressed too close together so they look fit to burst. Each house has at least one skinny tree placed in the same spot in the front yard, just off center with the door so that it greets you as you come up the walk.

My Deer Park, the one I helped to develop, is in Davidson, North Carolina, a sleepy southern town just off Interstate 77. Nestled on the shores of the man-made Lake Norman and home to one of the finest liberal arts colleges in the country, the Town has transformed under development pressure from an expanding Charlotte-region. As population has boomed, subdivisions have sprung from the rolling farm and pasture lands which surround the Town. Residents have recoiled in the face of this growth, fearing a loss of the small-town character and diversity which were hallmarks of Davidson since its founding in the 1830s. These concerns have manifested themselves in many forms, including a complete overhaul of town planning and zoning guidelines, the development of a lands conservancy, and the birth of the Davidson Housing Coalition (DHC), an affordable housing developer and support services provider that I helped lead for almost three years. These concerns have also bubbled over in heated public debate and three bitter, divisive election cycles where a community-wide sense of decorum was often checked at the Town Hall steps. The short time that I spent as a participant in this debate has changed my outlook on the interplay between planning, development, and the political process. It has also left me with a nagging sense that our development system is broken in a fundamental way.

My Deer Park, Davidson’s Deer Park, reflects both the possibility and the problems
inherent in our development system. It is a large, master-planned community nestled between the Interstate, a 1930s residential neighborhood, and Lake Norman. DHC was involved because we were working with the builder/developer of a fifty-five unit, single family portion of the project--co-developing and selling ten of the homes to low-income buyers. With a mix of residential, retail, and commercial space, a waterfront promenade, and a large public open space, Deer Park did many things that “better” development was supposed to do. It created mixed-income housing on an infill site with easy access to shopping and office spaces. It left a significant portion of the site as public amenity and created a walking trail that would provide public access to the lakefront. In many ways, it was a model, and I will forever be proud of the role we played in helping to develop it.

On the whole, the Town is a better place because Deer Park was built. But, when we were finished we had replaced a forest with mixed and matched homes, complete with postage stamp lawns and skinny, leafless trees guarding the front walk. There was still a bronzed statue in the park that would forever commemorate the deer that once passed through here before they were replaced with tricycles.

One should not interpret my nagging concerns about Deer Park as a sign that I would rather preserve animal habitat than provide safe places for families to live and play. Instead, what I find troubling is the zero-sum nature of the equation. Do deer have to lose so kids can win, or can we find a third path that allows us to preserve and protect our ecosystems while still providing safe, healthy, and affordable communities?

My initial attraction to green building and green development grew from its promise that one can find a more appropriate harmony between immediate needs for our society and the long-term needs of all species, our eco-systems, and our planet, and I was quick to embrace the set of goals that define green building in a somewhat slippery fashion. These goals, such as resource efficiency, habitat conservation, improved occupant health, better pedestrian environments, and a commitment to high-quality buildings, were easy to embrace, but much harder to employ. Many of my colleagues in the affordable housing world were single-minded in their advocacy, affordability was the only goal worth fighting for and environmental concerns were better left to hikers and
hippies. Others, like most of my board, were sensitive to the environmental and community impacts of development practice, but felt that our work was already too difficult to afford the luxury of addressing green development concerns. A precious few saw housing affordability, sprawl, indoor environmental quality, loss of habitat, loss of community character, and resource and material waste as a set of interconnected problems calling out for more comprehensive solutions. Some of us even managed to conceive of green projects, but this presented a new set of problems. One could find good designers, whose knowledge of green development practice, materials, and systems led to a better designed building. But lenders, investors, and contractors either didn’t know what we were talking about or eschewed such techniques as too expensive, time-consuming, and risky. They held fast to this position, even when we pointed out that advocates made exactly the opposite claim about cost and risk in all of their literature. Most of us found that we needed a contractor and banker more than a white paper.

Since leaving North Carolina, I have spent a great deal of time thinking about the caution voiced by these contractors and bankers. At first, I wrote them off as people lacking the creativity to see a better idea when it came in their door. Now, I think such a conception is unfair. Instead, their response was the only logical conclusion in a state where good money was being made by people building well-understood, commodity products. It made no sense for a banker or a contractor to take on a new type of real estate project when they had fifteen other deals on their desk that they already knew how to finance or build. To take on the green project was too risky and too expensive.

Part of the problem was that too few developers were bringing green projects to them. The green development movement has done nothing to disabuse me of this notion. In fact, at every conference and green development gathering that I attend, one thing has struck me as true: there are very few developers in green development. A quick search of the membership in the US Green Building Council (USGBC) supports this impression. As of June 2004, there were 4,500 institutional members of the USGBC, and 70 of these organizations identified themselves as developers. This is a significant problem. “Buying Green” is my investigation of that problem, and it presents an
argument about how research promoting green development should change to more effectively reach the real estate development community. Chapter one presents a simple model of the real estate development industry, building intuition for the questions and concerns that a developer must address before investing in a certain project. Chapter two reviews the green development literature and highlights how the existing research fails to address developer concerns. Much of this critique revolves around the tension between public and private costs and benefits discussed earlier in this introduction. Green building advocates often claim that green buildings provide public and private benefits to communities and occupants alike, but, as I will show in this chapter, many of the claims about private benefits are not investigated in a comprehensive or convincing manner. Chapter three presents an alternative research model using hedonic modeling that addresses the weaknesses pointed out in Chapter two. Chapter four concludes the work by outlining two green building studies that employ methodologies like what was described in chapter three.
Introduction notes

1 Roodman and Lenssen (1995) estimate that 36.4% of primary US energy consumption occurs in residential and commercial buildings. This does not account for the portion of industrial energy use (36.5% of total primary consumption) that is related to heating, cooling, and illuminating industrial buildings. Environmental Building News (2001) shows a similar result.


3 Many claim that the quality of our indoor environments is directly linked to higher incidence of allergies and asthma (for a good summary of this work, see Kats, et. al. 2003). Both have been on the rise since the 1980s, as documented in Environmental Building News (2001).


5 Environmental Building News estimates that over 425,000 brownfields exist in the United States alone. Shutkin (2000) profiles, in part, how several communities rebuilt themselves by cleaning up and re-using brownfields that had been the center of community deterioration and neglect.

6 Environmental Building News shows that vehicle miles traveled has been growing more than three times faster than population between 1980 and 1996 and that in 1999 traffic congestion cost Americans 4.5 billion hours of lost time, representing 6.8 billion gallons of wasted fuel and $78 billion in lost productivity.

7 See Leinberger (2001).

8 See US Congress. Office of Technology Assessment.

9 See Yost (2002).

10 Ibid.


12 See Orr as quoted by Mark Bundy.

13 See Hawken, Lovins, and Lovins (1999)

14 See Lewis.

15 See Rodman Smith and Weintraub (1998)

16 See the US Department of Energy, Smart Communities Network website.

17 Ibid.

18 See Rocky Mountain Institute website.

19 See Frederick, Pryor, and Cogan (1996).


21 The irony of Deer Park is that deer have actually thrived in a sprawling suburban pattern due to the loss of predators. However, Deer Park is a subdivision I helped to develop while working in North Carolina. For purposes of personal historical accuracy I chose to use this name despite its problematic function as metaphor.
CHAPTER ONE: INSIDE THE DEVELOPER’S HEAD

This chapter builds intuition about what a developer needs to know to make informed development decisions. To do this, it lays out a simple model of the real estate development process that enumerates the key questions confronting a developer: namely what are the expected development costs, the expected future rents or prices, and the expected operating and selling costs for the market (place and product) of interest. Taken together, this information helps a developer figure out how to proceed with a given project. The chapter begins with two basic scenarios that might confront a developer. It concludes with a discussion of why the developer perspective is important in considering green development advocacy and research.

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Scenario 1: Homebuilder

Imagine for a moment that you are a speculative home developer. You currently have an opportunity to purchase multiple house lots on the outskirts of a quickly growing city. Another developer has already graded the lots, installed infrastructure, and obtained all the necessary permits. But you need to decide how many house lots you want to buy and how much you are willing to pay for them. These decisions will be based on several things. First, you need to know something about the people who would buy the houses that you plan to build. How many potential buyers would be interested in this area, how much would they be willing or able to pay, and how should you structure your development in order to capture as big a share of this group as possible. You will also need to know the prices of similar houses that are selling in the area and how those prices are changing or expected to change. All this information will help you build an expectation for how quickly you can sell the homes and the prices at which you can sell them. But that is not the only part of this equation. You also need to know how much it will cost you to design, develop, and build the homes that you plan to put on these lots, and you need to know when those costs are expected to occur. Once you know how much it will cost to build the houses and how much they will be worth when they are done, establishing a price for the lots is easy. You will pay up to the difference between the expected price at which you sell the homes and the expected cost to build, once those payment streams are discounted into current day dollars. This relationship can be written in the following form:

Equation 1-1:

\[
\text{Price of lots} \leq \sum \text{PV (Home prices)} - \sum \text{PV (Home Development Costs)}
\]

But our thought experiment can go a little farther. The other developer, the one who prepared the house lots that we are buying, also has to agree to our price for the lots. He has already invested money developing the lots in the hope that he could recoup those costs plus any necessary profit to make his investment worthwhile. How much he is willing to accept is based, to a certain extent,
on how much it cost him to prepare these lots. From his perspective, the price of the lots should be equal to or exceed the accumulated value of the costs to develop them. This relationship can be stated as follows.

Equation 1-2:
Price of lots $\geq \sum PV (\text{Lot development costs})$

From this relationship we can also see that for the market to have any stability, the cost to develop lots must equal the price of homes minus the home development costs. This can also be stated in the following relationship.

Equation 1-3:
$\sum PV (\text{Lot development costs}) = \sum PV (\text{Home prices}) - \sum PV (\text{Home Development Costs})$

In short, you and the lot developer agree on a price where the accumulated value of the lot development costs equals the present value of future home prices minus the present value of the costs to develop and sell the homes. We will build on this intuition with another example.

**Scenario 2: Develop an office building, and sell when occupied**

You plan to develop an office building and sell it after it has been fully leased. You are looking for land to purchase on the outskirts of the same growing city. How do you begin to think about this decision? Again, you need to start with the local market, but this time it is the market for office buildings. What firms are operating in your area, what amount and type of space do they require, what specifications (if any) do they prefer, and what are the future trends in office space--will more or less be needed, of what type, etc.? Beyond this, you need to look at the rents that are charged in office buildings and whether reported rents include taxes, utility payments, and other common operating costs. From this information, a developer understands what he can expect to receive in rents once the building has been completed, and how quickly he can expect to fill the building. In addition to this, you also need to know the expected operating costs associated with
office buildings like yours. How much does it cost to own, maintain, and operate such an office building and how are those costs expected to change in the future. By figuring out what to expect in rents and what to expect in on-going operations, you can determine what you expect the developed building to be worth, and the relationship is not much different than what we saw above with the house lots. Anyone wanting to buy your office building should be willing to pay up to the present value of the future stream of rents minus the present value of the future stream of operating costs once the building is developed and operating. The equation below shows this relationship:

Equation 1-4:
\[
\text{Price for building} \leq \sum PV (\text{Future Rents}) - \sum PV (\text{Future Operating costs})^5
\]

But this is not the entire story. You still have to figure out how much you expect it will cost to develop the building. To do that, you need to know how much similar buildings cost to develop, and how prices have changed for design, construction, financing, and other inputs between the time that these similar buildings were constructed and when you expect to build. By understanding these things, you can determine whether or not you expect to earn the necessary return for you to enter into the development project. In effect, you have now changed roles from the original scenario. You are much more like the home lot developer before he made the decision to develop the lots. You need to know how much you expect the building development process to cost and how much the building will be worth at the end of that process. You are willing to take on a deal when you believe that the building will sell for an amount that at least covers your costs and provides for a reasonable profit (you are perfectly happy to earn a more than reasonable profit, but this has to come from somebody else’s pocket), but you will not begin the deal if you do not expect the developed building’s value to meet this cost plus profit hurdle. The equation below shows this relationship, where profit is included in the discount rate that you use to determine the present value of the costs.

Equation 1-5:
\[
\text{Price for building} \geq \sum PV (\text{Total building development costs})
\]
Again, we see something interesting in this situation. The only way that this market can be stable is for the total building development costs to equal the difference between the stream of future rents and future operating costs. The equation below shows this relationship.

Equation 1-6:

\[
\sum PV (\text{Total development costs}) = \sum PV (\text{Future Rents}) - \sum PV (\text{Future Operating costs})
\]

An extension of our thought experiment should show that this is true. If total development costs are greater than this difference, then no one will develop office buildings because they would be losing money. If no one develops office buildings for a long enough time, then office space will become scarce in the area, office rents will increase and office building development will be more profitable. At some point, the equation will balance out again and people will begin developing office buildings earning normal profits. The opposite will happen if total development costs are less than the difference between future rents and operating costs. Because office building developers will be earning super-normal profits, more people will build office buildings. The extra supply will drive rents down, and the equation will balance out again where office building developers are earning normal profits.

**General Model of the real estate development process**

These scenarios lead towards a general model that describes the development process, and that reduces to either scenario when appropriately applied. To understand that model, we need to think about the lifespan for buildings. Every building has a lifespan that can be divided into at least three stages: development, operations, and destruction/conversion (see Figure 1-1, below).

These stages have different risk characteristics (discount rates) and can be thought of as follows:

- **Development** - Includes steps from the initial conception of a building through design, development, construction, and initial lease-up or sale. This is the phase where a future vision
of the world is converted into a physical reality through the production of a new building, and that new building is transferred to its initial occupants. Depending on the size and complexity of a building or project, development can take 1-10 years.

- **Operations** - Far and away the longest stage, the operations stage is the period where a building is used by its occupants. During this period, an office building is worked in, a home is lived in, an industrial facility is used to make products. This stage can last as little as one or two decades and as long as several centuries.⁸

- **Conversion or disposition** - During this stage, an old building is changed into a new type of building--old office space converted into housing units, an old train depot converted into a retail facility, etc--or the building is abandoned, taken apart, torn down, and/or destroyed. This phase marks the end of the original building’s intended life, and it can be a very short period or (in the case of abandonment) a very long one.

As we saw in both scenarios, people are willing to pay a price for a building equal to or less than the time-dependent stream of future benefits from owning the building minus the time-dependent stream of future costs.⁹

_**Equation 1-7:**_

\[
\text{Price}_n \leq \sum_{t=n,m} \text{PV}(\text{Benefits}_t) - \sum_{t=n,m} \text{PV}(\text{Costs}_t) + \sum_{t=m,d} \text{PV}(\text{Benefits}_t) - \sum_{t=m,d} \text{PV}(\text{Costs}_t)
\]

In effect, developers and investors are a peculiar type of seer. They make their living by predicting
a series of future states of the world, betting on them, and then doing their best to turn these possible future states into reality. It is this continued control that separates a developer from other types of seers. Developers do not simply look into the future, invest, and then sit back and watch the world go by. They manipulate and shape the assets that they hold in order to affect the reality that they have predicted.  

There is another important assumption in a well-functioning development market. The stream of total development costs that a developer pays to build a project should equal or be less than the initial price that people are willing to pay in that market, when we account for normal profits and developer fees in the total development costs. Again we saw this in both scenarios, and it makes sense that it would be true. If it were not true, then a developer would be losing money every time she built a project, and she would not stay in business for long.  

Equation 1-8:
\[
\sum_{t=c,n} PV(Total\ Development\ Costs) \leq Price_n
\]

These two relationships can be combined into a single relationship that describes the equilibrium state for a real estate market.  

Equation 1-9:
\[
\sum_{c,n} PV(TDC) = \sum_{n,m} PV(Benefits) - \sum_{n,m} PV(Costs) + \sum_{m,d} PV(Benefits) - \sum_{m,d} PV(Costs)
\]

Scenario 1 and Scenario 2 are reduced forms of this general equation, each with a unique starting point (t=0). That starting point can be placed anywhere along the continuum shown in figure 1-1, and cash flow streams can be appropriately discounted or accumulated to arrive at an expected price. While the mechanics of that process are important, they do little to further the arguments presented in this paper, and I will leave them to the readers’ curiosity.

**What does this have to do with green?**

These two scenarios present two very different development decisions--how many house
lots should you purchase versus should you develop a new office building—but they illustrate that similar information is needed to make an informed decision in each case. Both developers need to understand the market for their product—how much customers are willing to pay, how many potential customers there are in the area, and how the market is changing. Both developers also need to understand the cost to develop their product—what are expected design and construction costs in the area, how have those costs been changing, and how long does it take to complete a project of this type in this place. Several things jump out of this analysis.

1. Real estate markets are segmented along lines of place and product. As Geltner and Miller say: “Users in the market for built space generally need a rather specific type of space in a rather specific location. A law firm needs an office building, not a restaurant or retail shop or warehouse, and it may need the building to be in downtown Cleveland, for example. If so, office space in downtown Detroit, or even office space in suburban Cleveland, will probably not satisfy the firm’s needs” (4). This illustrates the importance of this segmentation in defining the real estate market. There are very different people in the market for office space in Cleveland than there are in the market for single-family homes in Marin County, California. To make informed decisions about one or the other, one must pay attention to this market segmentation.

2. Developers are concerned with ordinary or average behavior. As a developer, you want to know the expected total development costs, the expected rents, the expected sales prices, and the expected operating costs. These expectations are built from the average outcomes of similar buildings in your area. As a developer or investor, you are not as interested in the extraordinary outcomes of extraordinary buildings, because they tell you little about what to expect in the future.

The green building movement and green building advocacy has largely ignored these two points. With regard to the first, there is very little attention paid to place and product in green building research. The seminal work in this field is a textbook, Green Development, put out by the Rocky Mountain Institute in 1995. This textbook uses cases from around the world that represent widely
varying product types and uses. Other research projects follow in this mold. The most thorough costs and benefits study that the author has found was completed in 2003 by Greg Kats and his team from Triple E. This research looked at over 30 institutional buildings from around the country. In this case, they focused on similar building products, but paid no attention to location. The author is currently involved in another costs and benefits report that looks at green affordable housing. This report suffers from the same problems as the Kats study. In the next chapter, we will look at green development research in more detail, but at this point, it’s important to say that no study of which the author is aware has investigated green building for a single place and single product. In effect, all research and advocacy to date has ignored the markets where green buildings trade.

Beyond this, green building research rarely focuses on ordinary behavior. Almost all green building research has been case study based, focusing on the very best examples of greening that the research team could find. But case studies reveal little about expected behavior. They do a great deal to illustrate what is possible. They incite, instruct, and inspire, but they do not provide good information about average performance. Developers and investors are much more interested in the average than the extraordinary. They make money by having their investments perform as expected, and green building research has not done a good job helping developers and investors understand how they can expect green buildings to perform in the market. To do this, a new methodology for research must be developed, and it must produce information about expected construction costs, expected rents and sales prices, and expected operating costs for green. Chapter 3 will present such a methodology, and chapter 4 will illustrate several locations where that methodology can be employed.

There is one other important point to be made here, which has to do with the claims of the green development advocacy community. The central story in green development research is that green buildings provide public benefits (reduced temperatures in and around buildings, reduced energy consumption, investment in already developed areas, habitat preservation) and private benefits (better health for occupants, lower operating costs, higher values at sale) that conventional development does not generate. While green development research has effectively
told the public benefit story, the private benefit story is less clear. In effect, the private benefit story claims that green buildings have a small premium in total development costs, provide large returns in operating savings, and those operating savings are not fully priced into buildings. By this logic, green development research argues that someone in the development process is receiving a windfall because the market is not efficiently pricing green buildings. This is a difficult pill to swallow for most developers and investors. By and large, developers and investors believe that given a big enough pool of buyers and sellers that the market will determine an efficient price. And if markets don’t determine an efficient price, then a few leading edge individuals will figure out how to take advantage of the market’s inefficiencies, they will do quite well, and others will adjust their behavior to remove the inefficiency and opportunity for super-normal profits. The model presented earlier in this chapter predicts exactly the same adjustment (remember the argument made about market stability or equilibrium). When a group of projects show that super-normal profits can be earned with a given approach, investment flows to this approach until super-normal profits are reduced to normal levels.

So, says the skeptical developer, if green building is such a great thing, then how come we do not see green buildings trading at much higher prices and green developers earning above average returns? And the answer from the green building community has been silence. No one knows, and no one has designed a study to address these questions, until now. The author’s current research aims to break that silence. This paper argues for a research framework that can address questions about the private benefits of green development. A forthcoming paper, to be completed in the fall of 2005, will use this framework to test the green building market for new, single-family homes in Austin, Texas, looking at expected sales prices and expected utility costs associated with green homes.
Chapter One Notes

1. I have just distilled a huge amount of market analysis into a few short sentences. There is obviously much more to this than what is mentioned here. However, I have included this “thought experiment” for the purposes of building a model, which should, by its nature, simplify a more complex world. What is important to take away from this discussion is the following: 1) a home developer needs to know future expected prices and how quickly those prices can be obtained (often called absorption), and 2) she also needs to know how much the home she plans to build will cost and when those costs will occur.

2. There is a note on present value and accumulated value included in the appendix for any reader not familiar with the concept of present value discounting.

3. This is not always true. Often expectations don’t match reality and the real estate world is full of projects where people invested a certain amount of money and then couldn’t get that money back out because the market changed in ways that they did not expect while development was occurring.

4. See the note on accumulated value and present value in the appendix if you need help with these terms.

5. As David Geltner and Norman Miller show in their canonical model of the real estate development process, which this model closely resembles, future rents and future operating costs are not the only features of importance. Any purchaser that plans on selling the building before the end of the building’s life will also need to estimate the building value at the point of sale, less any expected selling costs. However, the building value at that point will be equal to the stream of future expected rents less future operating costs, all appropriately discounted. In effect, this equation holds in its simplest current form if one assumes either of two things: 1) that the future sales price is counted as a future rent and the future sales costs are counted as future operating costs, or 2) the future rents and future operating costs extend into the future to the point that the building is torn down or converted.

6. There is much good evidence that this is not exactly true. DiPasquale and Wheaton show that real estate markets are mean reverting and they overshoot their equilibrium points (i.e. they keep building for too long and don’t start building soon enough). They explain this effect as being the result of a time lag between the decision to build and the point where the building is constructed and ready for use. Their time-lagged model is an improvement on the one presented here for predicting future behavior in markets. However, it adds unnecessary complications to the general intuition, which is all that is important for this paper. I recommend their work to interested readers who wish to pursue this topic further.

7. See the appendix on present value, accumulated value, and discount rates if you are uncomfortable with this idea.


9. The equation below extends the stream of benefits (rents, sales prices, etc) and costs (operating costs, selling expenses, vacancies, etc.) to include the benefits and costs of the building during its destruction or conversion phase. That stream is shown separately because it has a different risk and needs a different discount rate.

10. This idea is central to the sociological premise of the “city as a growth machine” popularized by Logan and Molotch, and used by many others.

11. Most developers will only care about the private benefit story. Their business has no mechanism for capturing these public benefits, and building a development with improved community benefits does not help them pay their bills. In effect, this private benefit story is the critical piece for developers.
This chapter provides an intellectual history of green building and a review of the current literature. In doing so, it highlights the weaknesses of green building research as it relates to the development community, namely that this research does not make a strong argument for the private benefits\textsuperscript{1} of green building. To make this private benefit argument, researchers need to focus on real estate markets and they need to identify and describe ordinary (rather than extraordinary) examples of green building. This framework leads to an exposition of what green building research for developers would look like.
Conservation and Green Building's Intellectual Underpinnings

The green building ideal has a long history dating back to the conservationist wing of the early environmental movement, led by Gifford Pinchot and Theodore Roosevelt. For Pinchot, environmentalism was about stewardship through development and utilizing the power of our vast natural resources in a sustainable fashion to improve the American standard of living. This stood in contrast to the preservationist ethic most powerfully voiced by John Muir and other late 19th century environmentalists. For Muir and the preservationists, development and environmentalism were fundamentally at odds. Heavily influenced by the Romantic poets, they endowed nature with a restorative power that would be despoiled by the encroachment of people.

Much of the early environmental movement focused on large-scale public works projects and the preservation of huge tracts of federal land through the Department of the Interior, established by Theodore Roosevelt. It was not until the rapid suburbanization of our country began to occur that environmental groups took notice of the significant threat posed by real estate development patterns. Publications like Silent Spring and Design with Nature, began to popularize the connection between the quality of our environment and community health, and provide alternative visions for how the country could develop while protecting important and sensitive eco-systems.

In fact, the central premise of Design with Nature stands today as one of the most clear and succinct expositions of what green development should do. In short, green development is about finding the best-fit intervention for a particular environment. This rejects the standard subdivision development pattern described earlier, where cookie cutter houses are punctuated with too-skinny trees. It also rejects the International Style promoted by Modern Architecture which claims that a single design is suitable for all places and all times. According to Ian McHarg, this idea is absurd and can only be held if one pays no attention to human history and the interaction between land-use, architectural form, climate, and culture. While green development has evolved and widely-expanded its reach in the last 35 years, this evolutionary concept of fitness and adaptation to the natural, physical, and cultural environment effectively encompasses the ideal. It also clearly portrays the conservationist roots of the green building movement. Fitness and adaptation presuppose that
there is a best-fit intervention, that development is necessary and desirable in the proper place and form. The measure of a good development becomes how well it adapts to the environment, both natural and human, in which it is placed.

McHarg relies on the pueblo to illustrate his conception of how better design should work. The form and function of a pueblo tells you a great deal about the climate and environment in which it is placed. Just from looking, one knows that this building comes from a hot, dry place where adobe is a more prevalent resource than wood. One also knows that a pueblo is inhabited by people of modest means with a strong connection to the surrounding land. The building expresses these things and one understands them from a single glance (see figure 2-1 below).

But green building is not about making everyone the owner of their own adobe house. McHarg provides a framework that informs the design and development process. This framework reflects sensitivity to the climate, ecology, and culture of a place, and has a more general application.
in green building. What is green in Santa Fe, New Mexico is not what is green in Poughkeepsie, New York. Appropriate green building approaches vary regionally, and the first thing that one must do to build a green building is understand something about where the building will be located. As a simple example, seasonal temperature variation and the number of days of sunlight encourage significant differences in window placement, the length and angle of eaves, and tree plantings around the outside of a home. Without understanding expected temperatures and the amount of sunlight that a particular area will receive, one cannot begin to make the “best” decisions about what trees to plant, where windows should go and how big they should be, and how big to make the eaves—let alone one thousand other complex and interrelated decisions about how to design and build the rest of the house.

The idea that buildings should respond more self-consciously to their environment, both natural and human, has led to a veritable explosion of energy and creativity, even a new set of institutions and development policies. The United States Green Building Council has formed as the central repository and resource for information, education, and branding of what “green building” means. This quasi-governmental agency is also responsible for the development and promulgation of the Leadership in Energy and Environmental Design (LEED) rating system. As the current standard for measuring and certifying the “greenness” of a building, LEED holds a particularly important place in the green building movement. It has also created a new class of professional, LEED certified, who can advise, consult, and help ensure that different buildings and development projects meet LEED standards.

After leaving MIT’s Center for Real Estate in 1991, Bill Browning helped found the Green Development Services arm of the Rocky Mountain Institute (RMI). Conceived as a consultancy within RMI, Green Development Services works with developers who choose to build green projects and they have been employed all over the world. In addition, they have developed an extensive body of literature that makes a business case for sustainability, showing through in depth case studies that by conceiving, designing, and building a green project one can save significant money on operating costs, pay little more in first cost (sometimes even less), and develop a higher
quality, healthier, more attractive building.

Before LEED had developed, a group in Austin, Texas began thinking about a municipal rating system that could describe and measure the “greenness” of a building project. Led by members of city government and the Center for Maximum Potential Building systems, this group developed the first municipal green rating system in the country, the Austin Green Building Program. Since its launch in 1992, a variety of other programs have been established in other places. Research carried out last year by Boston’s Green Roundtable identified over 80 municipal and state green building programs in the nation, and that number is growing all the time.

**Green Development Research**

These new institutions and players have grown from and generated a new line of research that I refer to as green development research. This field of inquiry investigates development practice and puts forward a set of alternative visions for how our communities can grow. Those visions generally fit into three categories which I call Honor Roll, Still-Life, and Saved by Green. These categories are fluid and the lines between them unclear. In fact, much research on the topic moves between two or three of them. However, this delineation still points out three important strands of thinking on green development.

Honor roll: Usually associated with an approach to “make the business case” about sustainability and involves case studies of pioneer projects that were generally great successes. This provides important praise for early adopters of green building, creates interesting examples for others to follow, and provides insight into problems that will be faced through the development process. In these roles, it is vitally important research. However, these cases are, by their nature, extraordinary. They provide no good evidence about how another building, even a similar one, will function in its particular location, and they do not relate to the local market in which real estate trades. Generally this market does not stretch beyond a metropolitan area; whereas case study sites may stretch across an entire nation or the world. These shortcomings make it difficult for honor-roll research to convincingly address questions about the private benefits of green development.
For example, Greg Kats, Leon Alevantis, Adam Berman, Evan Mills, and Jeff Perlman completed a 2003 study for California’s Sustainable Building Task Force. In this study, they analyzed over 30 commercial and institutional buildings, looking at total development costs as well as life-cycle costs associated with building operations, maintenance, and material or system replacement. These case-study sites stretched from one corner of the United States to another, and did not investigate how a given building type in a given region was expected to function. In many ways, this was not their goal. They set out to show that over a diverse set of green building projects, sponsors and project team members did not experience huge first cost premiums and they generally were realizing expected gains on operations. But, showing this does not answer the questions that arose from the developer thought experiment in Chapter 1. After reading this study, we are no more informed about how green buildings perform in any particular marketplace than we were when we began.

I am currently engaged in another study that has investigated green affordable housing projects around the country. We borrowed from the Kats, et al methodology to look at successful affordable housing developments with a significant commitment to green building. While this study will provide a wealth of valuable information about past experience, successful strategies, lessons learned, and a general frame for thinking about first cost premiums and other cost differences, it also fails to answer the principal issues raised in our thought experiment from Chapter 1. First, we have only looked at successful projects. Second, we have not focused on a market area. Beyond this, we have not looked at many starts in a particular market area in order to distill the extraordinary performance of the studied buildings into insight about the expected performance of similar buildings. In effect, our report will be highly informative, but anecdotal. If the green development advocacy community is going to make a convincing case about the private benefits of green building to developers and financiers, then we need something more than a really good story.

Still-life: These studies generally relate to the current state of the practice, and describe, in a qualitative fashion, the obstacles that one will find in trying to complete a green building.
This research also provides institutional, policy, and process related tools that can and have helped transform development practice. It provides a sense of what needs to be done, and a roadmap complete with potholes and pitfalls to be avoided. Still-life research has been most helpful in the policy arena by expanding the limits of conventional thinking, and encouraging places to become leaders and innovators in development policy and code enforcement. In this sense, it has helped convince communities to adopt green building practices because of the public benefits that such practices produce, and it has helped spur the creation of many municipal and state rating programs and the wide interest in greening public buildings. However, this line of thinking rarely helps a developer build a project. As a developer, you can not wait on the rules to change. Still-life research describes the landscape and how it ought to look, but does not help a developer that is ready to move on a project.

In his Masters’ Thesis from MIT, Bill Browning profiles how Michael and Judy Corbett completed the development of Village Homes in Davis, CA. Their initial plans included the development of drainage swales that would manage storm water on site and provide irrigation for fruit trees planted throughout the neighborhood. However, they could not get the City inspector to approve their storm water management plans. Ultimately, the Corbetts had to post a bond with the city that provided insurance that the drainage system would work. It has worked. Quite well, and the fruit trees that it irrigates are now a source of food and income for residents who sell the produce in local farmers’ markets. What is important in this example is that the city’s code inspection and enforcement division nearly stopped an otherwise worthy project because they did not understand how a different storm water management system would work. Many other researchers and scholars have identified similar difficulties as a barrier to green building practices, but recognizing code enforcement as a barrier does not help a developer build the project in question. In this case, the Corbetts were able to overcome the code enforcement challenge because of their wealth and personal commitment to green building. However, this approach could not be repeated by a more conventional developer that does not share that commitment or have the funds to post such a bond.
Much of the work of the Institute for Market Transformation uses the still-life approach, but from a different angle. They have focused their efforts on valuation techniques used by appraisers and other real estate professionals. By taking stock of common practice and educating appraisers about the benefits of green building, particularly with regard to energy use, they have helped change the way commercial building valuations are done in different areas of the country, most notably New York and California. This work is extremely valuable, but it is only indirectly related to the developer problems posed in Chapter 1 because it is not prospective. This highlights one of the largest limitations with still-life research; it is always retrospective or based on present perceptions. People making decisions about development deals are not making those decisions based on the past or present, but what they believe the world will look like in the future.

Saved by Green: This research frames arguments about green building in moral terms. It argues that buildings are the largest single user of energy, require huge amounts of materials, are often placed in terrible spots, and need infrastructure to support their operation. By building them in an inefficient, unhealthy, sprawling pattern in environments that cannot sustain their impacts, we are destroying the world and ourselves. On the flipside, the research presents green building as an antidote to the destructive development process currently employed, and argues that we can create buildings that are better located, use less energy, consume fewer resources, and create and preserve high-quality environments. Like Still-life research, Saved by Green research has had a significant impact on public involvement in green building. These arguments are quite convincing for governments who are charged with acting on behalf of an entire community and not the more narrow interests of a particular group or individual. By showing the impacts that green building can have on energy use, infrastructure, temperature, air quality, and traffic, many communities have been swayed in their thinking about green building.

Ian McHarg’s introduction to the second edition of Design with Nature includes one of the most extreme expositions of the moral terms around green building. At the end of the introduction, McHarg writes: “I am censorious Presbyterian. I like this imperative thing. You bastards, Design with Nature or else I will grind you up for dog food.” In this case, the example could not be
starker. One is either with the green builders and all that is good and right, or one is against them and in imminent danger of being made into pet vittles. Such attacks, while entertaining, do little to convince people of the efficacy of another development approach.

In a more common version of Saved by Green research, authors talk about green building as a way of highlighting and enhancing the innate value in landscape, ecology, and culture. One can see this in Green Development Services’ definition of green building, where they characterize green development as a “field in which the pursuit of environmental excellence produces fundamentally better buildings and communities – more comfortable, more efficient, more appealing, and ultimately more profitable.” The focus here is on doing things better--more effectively, with greater care, and with greater concern for ecology and human communities. In the end, the Saved by Green approach runs up against the central problem experienced by the Honor Roll researchers: they rely on extraordinary examples. These extraordinary examples do not answer the problems posed in our development thought experiment in Chapter 1. They only set the boundaries around the conversation.

It is important to note that this critique should not be considered a censure of much of the green development research carried out to date. That research has played a critical role in changing the debate around development and in creating an avenue and an ideal through which individuals and communities can advocate for more livable places. It has also convinced a growing number of governments and communities that the public benefits of green building outweigh the public costs. In no way is this critique intended to tarnish the importance of that accomplishment. But, the critique is intended to awaken a community of advocates to the idea that they have not made a strong case about the private benefits of green development. To make this case about private benefits we need a framework based on average and not extraordinary cases, and we need to focus on real estate markets. In short, we need a new type of green development research that responds to the concerns of developers.
Green Development Research for Developers

Green development research for developers needs to do three things: 1) focus on real estate markets; 2) measure total development costs, market prices or rents, and operating costs, and 3) ask simple, positivist questions that can be rigorously answered for certain places, times, and products. It is no accident that these three things mirror the central developer questions that we outlined in Chapter 1. Those questions included: “what are the expected development costs, the expected future rents or prices, and the expected operating and selling costs for the market (place and product) of interest.”

Focus on a real estate market because place and product are important: As mentioned in the Introduction, Geltner and Miller define several important characteristics of real estate space markets. Those characteristics emphasize the segmentation of space markets by product type and location. This place-based focus generally does not extend beyond a metropolitan area (if even that far), and is limited to a single product type (i.e. there is a different market for office space than for single-family homes). This makes sense when one considers that real estate markets are inherently local. Costs and values vary dramatically across space, product type, and time, and there is little helpful for a developer in an intimate description of the costs and value of a Pittsburgh, Pennsylvania office project if she plans to build homes in Marin County, California. The two markets are so different that they are almost independent of one another, and no one can understand the costs and value differences of Marin County housing through a thorough understanding of Pittsburgh’s office market.

Focus on total development costs, market prices or rents, and operating costs – The real estate market, while far from perfectly efficient, is made up of many buyers and sellers in a local area. The collective actions of many buyers and sellers describe ordinary behavior in a market, as compared to the extraordinary behavior reflected in the “Honor Roll” research described earlier. By measuring total development costs, market prices or rents, and operating costs over many similar buildings, one understands what the mass of buyers and sellers will demand due to the differences in a product. We already know many things about market behavior related to real estate. Homes
located in good school districts or near public parks are more valuable than those that are not. Office buildings with more corner offices are more valuable than those with fewer, all other things being equal. But we have never tested whether or not people in a particular real estate market will pay more for a green building.

Focus on simple, positivist questions because their answers lead to testable hypotheses about behavior in other markets and times – Questions like “are green homes worth more than conventional homes” have never been rigorously addressed in green development research. By employing statistical techniques to test questions about ordinary behavior in a particular market, the conclusions can be used to postulate behavior in other markets, locations, and times. By testing these hypotheses in other areas, one can begin to draw a picture about differences in behavior between real estate sectors, consumers, and geographies.

The following chapter will present a research methodology that can more effectively address these concerns than green development research produced to date.
Chapter Two Notes

1 The private benefit story from green building research is that green buildings cost less to operate, are worth more on completion, and cost only marginally more to build (if there is any premium at all), so the owner is getting a more valuable building and not paying the full cost of the increase in value. As discussed in chapter 1, this private benefit story is difficult to swallow for anyone who believes in reasonably efficient markets (green developers or owners of green buildings should be getting above average returns if this story is true) and the green building research community has never rigorously tested any part of the private benefits story (operating cost, value at sale, or construction cost differentials between green and conventional) for a particular product in a particular market. Beyond this, the green building research community has never tested to see if green building owners or green developers are earning super-normal returns, as would be expected from the anecdotal story presented on private benefits.


3 Ibid.

4 See Austin Green Building Program’s Sustainable Building Sourcebook.

5 As mentioned in the introduction, this group overlaps considerably with advocates for New Urbanism, pedestrian-friendly development, neo-traditional development, conservation development, cluster development, sustainable development, New Towns, brownfields re-development, and Leinberger’s conception of progressive development.

6 See Kats, Alevantis, Berman, Mills, and Perlman (2003); Bradshaw, Pauly, Fraser-Cook, Connelly, and Goldstein (forthcoming); Rocky Mountain Institute (1995); Hawken, Lovins, and Lovins (1999); Browning (1991); Chao and Parker (2000); Chao, Parker, Mahone, and Kammerud (1999); Donovan (2001); Harik (2002); Institute for Market Transformation (2002); Institute for Market Transformation (2003); Majersik (2003); Parker, Chao, and Gamborg (1999); Yates (2001); Barnett (2000); O’Reilly (2001); Roodman and Lenssen (1995); Pfeiffer (1999); Urban Environmental Institute (2002) for a wide spectrum of examples of honor roll research.


9 See Landman (1999), among others.

10 See Hawken, Lovins, and Lovins (1999); Shutkin (2000); Roodman and Lenssen (1995); Rocky Mountain Institute (1995); McHarg (1992); Maslan (2001); Chapman (2001); O’Reilly (2001); Pfeiffer (1999); Urban Environmental Institute (2002); Court (1990); Dyke (2000); Environmental Building News (2001); and Miller (2001) for examples of Saved by Green research.


12 See Rocky Mountain Institute website.

13 See Geltner and Miller (2001), Chapter 1.
The previous chapter provided an intellectual history of the green building movement and characterized green building research, grouping a selection of studies into three categories. These categories highlight important gaps in the argument that green building researchers have made about the private benefits that result from adopting green building practices. That gap has two important components:

1. Green building research has not focused on the markets where green buildings are developed, operated, bought, and sold. These markets are segmented by place and product type.

2. Green building research focuses on extraordinary examples at the expense of ordinary behavior. Extraordinary examples provide no good information about what is expected from a certain type of building.
in a certain place. To understand what is expected, research must focus on the average building of a certain type in a certain market.

This chapter describes a research method that would help one focus on that average building.

**The market for apples**

Consider, for a moment, the characteristics of a really good apple. What is it that you search for when you stand over the grocery display picking out Granny Smiths and Royal Galas? My fiancée values texture and sweetness over anything else. I like firmness and sweetness the most. Our dog seems not to care about any particular features, but just likes apples, especially if we are eating them.

Stretch this thought process further and imagine now that you are an apple seller as well as a consumer. As an apple seller, you might be very interested in knowing whether sweetness is the most critical variable for people purchasing apples, and how much more the average consumer was willing to pay for a sweeter apple. You might also be very interested in being able to predict the selling price of a particular apple based on its characteristics. Both of these things are fairly difficult to observe directly. One cannot buy or sell the sweetness of an apple, and directly measure its value. One has to buy or sell the whole apple. The purchase/sell decision is a complex analysis weighing price against the combination of characteristics that a particular apple provides. You cannot buy the redness of one apple, the firmness of another, and the sweetness of a third, and then meld them together into some type of super-apple. You can only pick whole apples, and the characteristics are not easily divisible. Hedonic price modeling is a statistical process that untangles this mess so we can quantify and analyze the decision-making process. If we have enough data on enough apple transactions, we can use hedonic price modeling to describe the implicit value of each characteristic. We can also sum these implicit values to estimate the total value of the apple.

**Hedonic Price Modeling as Algebra I**

Hedonic price modeling uses a statistical technique called regression analysis to model market transactions. In its most general sense, regression analysis is a method for finding the best-
fit curve for a given set of data.

Think back to your first Algebra class for a moment, when you had to deal with equations like these:

\[ y = mx + b \text{ where } m = \frac{y_1 - y_2}{x_1 - x_2}. \]

This basic algebraic technique for finding the equation of a line from two points is the simplest form of regression. As you add more points and variables, the process and mathematical methods employed become somewhat more complex, but the basic idea remains the same. In carrying out a regression, one is finding the conditional means that describe the relationship between a predicted variable and one or several predictor variables.

This image shows a regression line which follows a path that minimizes the distance.

Figure 3-2: Two Variable Regression Analysis
between the line and the set of data points shown. In this example, we have used statistics to unwind some relationship between the unnamed variable on the x-axis (independent or predictor variable) and the unnamed variable on the y-axis (dependent or predicted variable). We have carried out a simple regression analysis, but we do not yet know how to interpret or understand these results. If we assume that these data points represent information about market transactions and we re-name these axes to price and sweetness (as in Figure 3-2), then the slope of the line describes the average linear relationship between sweetness and price, in other words how much the average apple buyer in our sample is willing to pay for a sweeter apple. This is a simple hedonic price model.

Figure 3-2: Hedonic Price Model for Apples

Hedonics and Real Estate

Hedonic price modeling can be and is used in a huge variety of disciplines, but its central application in real estate price models grew from the work of Lancaster who theorized that it was the utility generating nature of characteristics that makes any product valuable, not the product itself. I buy an apple because the combination of sweetness, flavor, texture, nutrition, etc. will
increase my happiness in an amount equal to or more than the price I pay to obtain it. The term
hedonic price modeling\(^2\) grows from this theory – we are using regression to model the market
price of the pleasure- or utility- generating characteristics of a particular good.

From this simple, apple example, the potential application of hedonic price modeling in
real estate markets should be clear. Buildings are complex, unique goods with many non-divisible
characteristics, and these characteristics generate some utility that makes any building more or
less desirable. When someone purchases a building, it is not the sticks and bricks that she is after,
but rather the security, warmth, and comfort generated from the size, configuration, location, and
other characteristics of that building.\(^3\) But, one cannot observe the price of these utility-generating
characteristics directly. We cannot reliably test the market for a third bathroom in a single-family
home by buying and selling third bathrooms independently of the rest of a house. Nor can we test
the market for a fifth elevator shaft in an office building. But, if we have a large dataset, hedonic
price modeling can estimate the implicit price for a third bathroom or fifth elevator shaft and test
its marginal impact on total price. As Malpezzi explains: “At its simplest, an hedonic equation is a
regression of expenditures (rents or values) on housing characteristics. The independent variables
represent the individual characteristics of the dwelling, and the regression coefficients may be
transferred into estimates of the implicit prices of these characteristics.”\(^4\) In this light, hedonic
regression analysis is an extremely powerful tool for analyzing housing and other real estate
markets. Since much of my research relates to housing markets, the remainder of the discussion
about hedonic price modeling will focus on housing markets unless otherwise indicated. However,
all these concepts can be mapped directly onto other real estate product types; the difference is
that the details of importance (number of bathrooms versus number of elevator shafts) would be
different in different product types.

**Hedonic Price Modeling as Applied to House Pricing**

In building a hedonic equation, we are assuming that we know the features that determine
a building’s value. It is generally agreed that any good predictive model for house prices will
incorporate multiple variables including: the number and type of rooms, the square footage, the age of the unit, structural features (i.e. presence of garage, number of stories, presence of a basement), lot features, and general neighborhood variables. The type of structure is also important, single-family or multi-family, attached or detached, though in practice, many studies focus exclusively on a single housing type, in effect choosing this variable through setting up their study. As Miller suggests, it is helpful to organize these variables into categories as done in the following general form of the regression equation:

\[ V = f (L, S, N, A, R, t) \]

where:

- \( V \) = house value
- \( L \) = lot characteristics
- \( S \) = structural characteristics of the house
- \( N \) = Neighborhood characteristics
- \( A \) = Accessibility or Locational attributes
- \( R \) = Regulatory attributes (zoning, etc)
- \( t \) = time or transactional characteristics (when and how quickly a home sold is important)

The model is stated as a formula where chosen variables plus a constant term are combined to arrive at a price. The coefficients on each term (like the coefficient on sweetness in the apple example above) are conditional means based on the full dataset, and they can be interpreted to determine the implicit price for that feature.

A Simple Hedonic House Price Model

\[ \text{Price} = a \times \text{Rooms} + b \times \text{Lot size} + \text{error term} \]

In this equation, price is assumed to be a linear function of the number of rooms and the size of the house lot. The coefficients \( a \) and \( b \) represent the incremental value added by each additional unit of their associated characteristic (\( a \) = the incremental value of an additional room, holding lot size equal; \( b \) = the incremental value of an additional square foot of lot, holding number of rooms equal). By calculating a value for the coefficient \( a \), one is finding the average value of
each additional room based on the full sample of homes studied. The error term represents all the features of the house that you have not accounted for with your choice of predictor variables.

**Hedonic Price Modeling as a Measure of Ordinary Behavior**

One of my central critiques of green building research is that it fails to measure ordinary behavior. Ordinary behavior is exactly what hedonic price models measure. These models calculate a series of conditional averages (coefficients a and b in the simple model above) for the characteristics in question. In effect, hedonic price models are a tool for estimating expected private costs and benefits from development.

To illustrate the power of this type of analysis, we should return to our original thought experiment, where we are trying to decide how many house lots we should buy and at what price. In Chapter 1, we decided that we needed to know: 1) the size of the market for new homes in the area and how much consumers would be able and willing to pay for them, and 2) how much it would cost to design, develop, and build the homes that consumers wanted. Now assume that we have data on all the homes sold in the area over the last five years. In this data, we have information on price, date and terms of sale, neighborhood location, structural characteristics, and a photo of the finished product. How might we use this information?

First, let us consider how we would not use this information. We almost certainly would not thumb through the photographs and identify what we thought were the five prettiest houses, throw out the rest of the information and then investigate these five houses in detail, claiming that they were representative of the market. The idea seems outrageous, but part of my contention is that green building researchers have been doing this in a less direct way by just focusing on extraordinary buildings. When we ignore less successful or less attractive projects, we throw away large amounts of useful and important information that can tell us a great deal about a particular real estate market.

Instead of throwing all our transaction data away, let us assume that we keep it. How should we use the information? First, there are lots of important things that we can learn without any fancy
statistical techniques or high-powered analyses. We might look to see how many homes have sold in each quarter and whether that trend seems to be increasing or decreasing. We might look at what is happening to prices over time, and a whole range of other one and two-variable relationships. After we did these things, we could employ a tool like hedonic price modeling to get a much more fine-tuned view of what’s happening with the housing market in the area. Hedonic price modeling is good for answering two types of questions:

1. Hypothesis testing -- Answers questions about the average or implicit prices of any particular feature when all other features are held equal. In calculating these average prices, the model tells us whether the estimate is statistically significant. For example, we could determine the expected value added by a fireplace, information that would help us determine whether or not it made sense to include fireplaces in the homes that we would build. We could also look at whether or not consumers paid more for green buildings.

2. Mass Appraisal -- We could build a general model that would estimate the implicit prices for each of the features we specified in the model. By multiplying these implicit prices (coefficients) by the characteristics of a particular home, one can estimate the total value of that home. For example, we might determine that seventy-five percent of the variation in a home’s value is determined by lot size, number of rooms, number of bathrooms, neighborhood location, and pedestrian access to amenities. By determining the average or implicit value assigned to each of these features in the dataset, one could predict the future sales price of the homes that we intended to sell (because we would know the lot size, number of rooms, number of bathrooms, etc. to be included in this house). Now, we would have a rigorous answer to one of the central questions we faced in making our decision about house lots--what is the expected value of the home that we would build.

Both the hypothesis testing and mass appraisal examples show how hedonic price modeling can be used to model ordinary behavior.
Testing hypotheses around green building

In the previous section of this chapter, I presented the idea that we might use hedonic price modeling to test whether or not there was a price premium associated with green building in our hypothetical sample. This idea could be extended to deal with the common hypotheses of green building advocates about the private costs and benefits of green development:

1. There is little or no first cost premium for building green,\(^{10}\)
2. Green buildings trade at higher values (increased rents or prices) than conventional buildings,\(^{11}\)
3. Green buildings operate at lower costs than conventional buildings,\(^{12}\)

In much green building research these claims are put forward without any analysis of the markets that determine building costs and prices. Using hedonic methods, one could design studies to test each of these hypotheses in a more rigorous fashion. However, one would have to make an important variation from the simple hedonic price model presented earlier. In the simple model, we included lot size, rooms, and the error term. Lot size and rooms both have numerical values associated with them; whereas, whether or not a particular building is a green building has no associated numerical value. In order to measure this characteristic in our dataset, we would need to use a dummy variable.

Dummy variables are binary, on/off variables that serve as placeholders for the variable in question. There are several reasons one might substitute a dummy variable for direct measurement of a particular characteristic.\(^{13}\)

- There are significant outliers in the measurement of the characteristic and one wants to control the impact of those outliers on the results. Imagine that over 90% of the houses in our sales data have between 3 and 5 bedrooms. If we were to include bedrooms as a continuous variable, then the small percentage of homes with 1 bedroom or with 13 bedrooms would suddenly have significant weight in determining the implicit price of additional bedrooms. By including dummy variables, one can lump all these outlying values into a single variable, and focus the results on the more regular observations of the dataset.
• The variable is a binary characteristic and making it a dummy variable simplifies analysis. For example, whether or not a single-family home is one story or two stories is a binary characteristic. If you include a variable for stories and have the values 1 and 2, then one must appropriately interpret the results provided by the co-efficient for stories. By making stories a dummy variable and omitting the 1-story category (so a 2 story-building has a value of 1, and a 1-story building has a value of 0) the results of the regression equation are easier to interpret – the co-efficient of stories is the value of a second story as compared to a one-story home.

• The variable cannot be easily quantified. We are trying to test for the value of a green rating. Either a home has a green rating or it does not, but there is no direct numerical value associated with having a green rating. By including a dummy variable for green (a 1 means that the house is rated, a 0 means that it is not), one creates a variable that can test for the effect of a green rating on the predicted variable.

**Why has this never been done?**

One of the drawbacks with hedonic price modeling is that it has very high data requirements. To specify an effective model, one must have lots of information about market transactions, and that information has to be of high quality. Because green buildings are a small and growing challenge to the status quo in the construction and development industry, there have not been a huge number of green buildings constructed. In most markets, the idea of an “average green building” is anathema. By their existence, these buildings are extraordinary, and it is difficult to find a class of buildings that are similar enough to lump them together.

That being said, the significant successes of the first generation of green building research has been convincing for many civil society and policy advocates. In short, many people have been convinced of the public benefits of green. This has led to a change in the way that many zoning regulations and building codes have been structured and enforced, and to a significant commitment on the part of many governmental, philanthropic, and quasi-governmental groups to fund and support green building projects. In addition, civil society actors like the US Green Building...
Council (who promulgates the LEED standards mentioned in the introduction and Chapter 2) and Energy Star Homes (who manages a residential rating system for green buildings) have provided a national framework for understanding what it means for a building to be “green”. These efforts have helped to build momentum around the green building movement, and have led to a dramatic increase in green building starts around the country. In fact, there are areas that now have enough green building starts that the high data requirements for a study based on hedonic price modeling can now be met. The next chapter will explore two different markets where this line of research seems promising.
Chapter Three Notes

2 I will use this term interchangeably with hedonic price modeling throughout the paper.
3 Rosen (1974) continues this line of research, applying Lancaster’s framework to a model for market equilibrium. This is worthy of note here, but not critical for this paper.
4 Maplezzi page 2 (2002).
7 Miller page (2002)
8 Malpezzi (2002), Miller (2002), and Basu and Thibodeau (1998) all use similar representations to this one. The important aspect is not the categories but that value is seen as a function of ordered characteristics, and variables should account for each category of characteristic in some fashion.
10 See Kats, et. al. and Bradshaw et. al., among others.
11 See Hawken, Lovins, Lovins and Landman, among others.
12 See McHarg among others.
13 Malpezzi (2002) provides a fantastic overview of pertinent literature on hedonic house price studies in general. If one is particularly interested in hypothesis testing with hedonics, then Follain and Jimenez (1985) is a good supplement.
This chapter presents a green building research design that addresses the developer concerns raised in chapter one; concerns that revolve around the private benefits and costs of greening. In illustrating such a research design, I employ two examples, both for owner-occupied homes. The first and most complete example presents preliminary results from a forthcoming study by the author on Austin, Texas. The second discusses an area, Denver, Colorado, where the high data requirements of hedonic price modeling could be met due to the clear definition of green building and the large number of green starts in a given product type. This methodology could be easily applied to other areas and to a real estate product other than owner-occupied homes, but I have not been able to identify a market where there were sufficient green starts in another product type to specify a hedonic model.
The chapter will illustrate these two examples, and then distill them into a general framework that could be applied to other areas and product types if the data requirements for a hedonic price model were met.

**Example 1: Austin, Texas**

While attending the USGBC’s annual GreenBuild conference in 2004, I learned that the Austin Green Building Program had rated nearly 4,000 single-family homes as green between 1998 and 2003.\(^1\) The rating system, discussed in greater detail in the appendix to this thesis, provides system-specific information about green building features and groups this information into five categories--energy, materials, health, community, and water. This data systematizes and quantifies greenness for an Austin area single-family home, providing enough observations to build a hedonic model. However, the green building data does not include information on home sale transactions and structural features. I obtained this information from the Austin Board of Realtors (ABoR), who maintain transaction data for a similar time period. ABoR provided data for nearly 16,974 new home sales dating back to 1997,\(^2\) including sales price and closing information.\(^3\) Since the green building program’s residential rating system focuses on new construction and major rehabilitation, I selected these 16,974 transaction records as the base for my ABoR data.\(^4\)

Using Geographic Information Systems (GIS) software, the ABoR data and the Green Building data were mapped (also called geo-coding) onto a street grid of the Austin area. After mapping the location of each home, I used their latitude and longitude measurements to find green homes in the same location as homes with transaction data.\(^5\) Over 500 homes had both transaction data and a green rating (See Images 4-1 and 4-2 below).

The mapping procedure did not successfully identify locations for all of the homes in either dataset, and a higher percentage of green homes were located than homes from the ABoR data. This is likely due to the tendency for the ABoR data to have a wider geographic spread than the green building data. Since many of the new homes built in the Austin area are in outlying areas where new infrastructure is provided as part of the development, it is likely that the street grid provided by the City of Austin GIS would not have all the new streets. However, there should be
New Homes

As shown in the map above, the 15-mile radius of the city almost perfectly approximates the service area for the city of Austin. One can also see a concentration in new home sales to the northwest side of the city, near Lake Travis.

Green Homes

Almost all the homes rated by the green building program are within the 15-mile radius of the Capitol, as shown in Image 4-2.
no significant variation introduced into the study because I have only used mapped data. Figure 4-1 shows the variation in numbers of bedrooms and baths, as well as house prices between the full ABOR dataset, the mapped ABOR homes, and the homes in the 15-mile radius of the capitol.

Even with these two datasets combined, there were important missing variables that should be included to develop a pricing model for green homes in Austin. These variables include neighborhood amenities and location attributes associated with each house. Some of the critical factors are summarized in the table on the following page:

To fill in these gaps, data from the City of Austin Geographic Information Systems department, the US Bureau of the Census, and the Texas Education Administration was used and overlaid into the GIS maps of housing starts. School testing data was broken down by district and sub-district (The Austin Independent School District includes 7 sub-districts) and assigned to each house based on the district or sub-district in which that house was located. Census data for other variables was broken down by census tract, and assigned to each house based on the census tract in which the home was located.

Looking at Images 4-1 and 4-2, and overlaying school district information, and other neighborhood level characteristics showed that the city fringe could be approximated by drawing a 15-mile radius around the State Capitol building. The area outside this radius was not served by City services, had almost none of the green homes, was mainly in school districts for outlying

<table>
<thead>
<tr>
<th></th>
<th>Total Baths</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>Mapped</td>
<td>15 mile</td>
<td>All</td>
<td>Mapped</td>
<td>15 mile</td>
<td>All</td>
<td>Mapped</td>
</tr>
<tr>
<td>Mean</td>
<td>2.53</td>
<td>2.62</td>
<td>2.68</td>
<td>3.44</td>
<td>3.46</td>
<td>3.46</td>
<td>231,195</td>
<td>263,447</td>
</tr>
<tr>
<td>Standard Error</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>1,585</td>
<td>2,479</td>
</tr>
<tr>
<td>Median</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>169,900</td>
<td>191,980</td>
</tr>
<tr>
<td>Mode</td>
<td>2</td>
<td>2</td>
<td>2.5</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>250,000</td>
<td>215,000</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.75</td>
<td>0.81</td>
<td>0.88</td>
<td>0.77</td>
<td>0.82</td>
<td>0.89</td>
<td>206,398</td>
<td>243,581</td>
</tr>
<tr>
<td>Range</td>
<td>8.50</td>
<td>8.50</td>
<td>8.50</td>
<td>6.00</td>
<td>6.00</td>
<td>6.00</td>
<td>4,992,000</td>
<td>4,975,000</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>8,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Maximum</td>
<td>9.00</td>
<td>9.00</td>
<td>9.00</td>
<td>7.00</td>
<td>7.00</td>
<td>7.00</td>
<td>5,000,000</td>
<td>5,000,000</td>
</tr>
</tbody>
</table>
### Figure 4-2: Type of Variables Needed for Reliable Model

<table>
<thead>
<tr>
<th>House</th>
<th>Neighborhood</th>
<th>Locational</th>
<th>Green</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structural</strong></td>
<td></td>
<td></td>
<td>General</td>
<td>Sale Information</td>
</tr>
<tr>
<td>Bedrooms</td>
<td>Homeownership rates</td>
<td>Zip Code</td>
<td>Rated or Not</td>
<td>List price</td>
</tr>
<tr>
<td>Bathrooms</td>
<td>MHI</td>
<td>Census Tract</td>
<td></td>
<td>Original List price</td>
</tr>
<tr>
<td>Parking Spaces</td>
<td>Vacancy rates</td>
<td></td>
<td></td>
<td>List date</td>
</tr>
<tr>
<td>Pool</td>
<td>Unemployment rates</td>
<td></td>
<td></td>
<td>Sales Price</td>
</tr>
<tr>
<td>Square Feet</td>
<td>% housing built 1990- now</td>
<td></td>
<td></td>
<td>Closing Date</td>
</tr>
<tr>
<td>Fireplaces</td>
<td>% housing built 1980-1989</td>
<td></td>
<td></td>
<td>Time on Market</td>
</tr>
<tr>
<td>NumLivingSpaces</td>
<td>% housing built 1970-1979</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stories</td>
<td>% housing built 1960-1969</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YearBuilt</td>
<td>% housing built 1950-1959</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% housing built pre-1950</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lot</strong></td>
<td>Lot Size</td>
<td></td>
<td><strong>Cultural/Ethnicity</strong></td>
<td></td>
</tr>
<tr>
<td>% non-white</td>
<td></td>
<td></td>
<td>% non-white</td>
<td></td>
</tr>
<tr>
<td>Household size</td>
<td></td>
<td></td>
<td>Household size</td>
<td></td>
</tr>
</tbody>
</table>

**Educational**

- High School Test Scores
towns and rural areas, and had widely variable lot sizes – all of which implied a different sub-market for housing than the area inside this radius. For that reason, I defined the market as all homes within an existing core of city services – a 15-mile radius from the State Capitol building. The choice to use this 15-mile radius as the market is also supported by Figure 4-1, where one can see that number of bedrooms and bathrooms is similar inside and outside this radius, but price inside the radius is higher.

This filled the remaining data gaps. The final variable list is included below in Figure 4-3.

With this dataset built, I was able to specify a hedonic model that would test my main research hypothesis: New single-family homes rated as green by the Austin Green Building Program sell at a premium to homes which are not rated. I found that green homes sell at a 9-10% premium over unrated homes, all other things being equal. One version of this hedonic specification are included in Figure 4-4.

These results represent a major advancement in green development research. Instead of

<table>
<thead>
<tr>
<th>House</th>
<th>Neighborhood</th>
<th>Green</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>Socio-economic</td>
<td>General</td>
<td>Sale Information</td>
</tr>
<tr>
<td>3 Bedrooms</td>
<td>% Owner Occupied</td>
<td>Has green rating</td>
<td>Sales Price</td>
</tr>
<tr>
<td>4 Bedrooms</td>
<td>% neigh stock built before 1970</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 + Bedrooms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5 Baths</td>
<td>Cultural/Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Baths</td>
<td>% Black</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5 Baths</td>
<td>% Hispanic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4+ Baths</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Living Rooms</td>
<td>Educational</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3+ Living Rooms</td>
<td>% 10th graders pass state test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has Fireplace</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has Pool</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has 2 stories</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has View</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed in 2000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed in 2001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed in 2002</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed in 2003</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 4-4: Hedonic Price Model

This model is specified with a log-linear equation, and the coefficient on green rating (.100) is interpreted as the percentage change in house price in the sample that can be explained by having a green rating. The t score (7.67) shows whether or not this result is statistically significant at the 95% level (a score higher than 1.96 is statistically significant). In effect, this result says that according to my sample, green homes in Austin sell at a 10% premium compared to homes that are not rated, all other features in the model being equal. Other variations on this specification show a 9% premium.
being based on the five prettiest green buildings in Austin, the study is based on a sample of all the new single-family homes in the city. Instead of relying on the documented performance of an extraordinary case or handful of cases, hedonic modeling distills the performance of this sample into a representation of the average green and conventional building in the Austin market. The study answers, in a statistically rigorous fashion, one of the three central questions about the private costs and benefits of green development: will consumers pay more for a green product versus a conventional one.\textsuperscript{11} According to this study, single-family home buyers in Austin Texas will pay a 9-10\% premium for a green home, holding all other home features constant (further research by the author has shown that this premium is likely related to a spatial concentration of this sample of green homes in a high cost area and not a result of the green rating). This is an important result. First, it provides some expectation to a developer faced with a decision about whether or not to build green. Second, it provides some basis of comparison to other markets where similar tests can be run to see if such a premium exists in that place and product. Finally, it leads to a need for more investigation and speculation about why such a premium exists. If people are paying more for green buildings, are they buying a stream of utility savings? Do these buyers represent a niche market who wants to make an investment not just in private savings in ownership but also the public benefits of green? Or does the premium exist because of any one of a thousand other explanations for what might be happening in this area. As a way of beginning to address these questions, I am testing a sub-hypothesis: The premium that Austin homeowners pay for homes rated as green is equal to the present value of the future stream of actual utility savings. This research is still in progress, but the results should be available in the fall of 2005.

**Example 2: Denver, Colorado**

Focusing on the Denver metro area, Colorado set up a statewide green building program in 1995 called the Built Green program. Since its inception, Built Green has grown to be the largest metropolitan green building rating program in the country.\textsuperscript{12} According to the 2004 Built Green annual report, Built Green has rated over 25,000 houses in their first ten years and 27 percent of
new homes in the 8-county Denver metro area (14 percent of the homes in the state) were rated as green in 2004. Built Green has rated more than enough homes in the Denver area to carry out a study similar to the one I am currently completing for Austin. In addition, Denver may have enough data to expand on the study in several ways that were not done in my study on Austin.

1. A hedonic model looking at the re-sale of green homes could be developed. If Built Green has had a consistent rating system since it first started rating homes in 1996, then they may have enough green re-sales to test hypotheses around whether green homes resell at higher values than homes that are not rated as green.

2. If the Built Green data is of good and consistent quality and enough resale data exists, then a repeat-sale index could be built to look at the pricing of green homes over time. Hedonic models test for any impact that a green rating has on price at a particular time. However, they cannot test for the impact that a green rating has on the price of a particular house over time (i.e. do green homes appreciate faster or slower than homes around them?). To do this, one needs to build a repeat-sale index, and Built Green may have enough data over a long-enough time period that such an index could be developed.

3. Because Built Green is so closely linked to the Denver area Homebuilders Association, it is possible that construction cost data for the Denver area could be obtained or developed. The Austin study that I am currently doing will be able to test for a price premium associated with a green rating and whether or not this price premium is related to the present value of an average stream of savings on building utility costs. But it will not be able to test if green homes in Austin cost more than homes not rated as green. With construction cost data, one additional question from our Chapter 1 thought experiment could be answered: are the expected total development costs higher for a green building than a conventional one?

**Generalizing from these examples**

One of the reasons that hedonic modeling has never been used to analyze the market for green building is that data sources necessary to carry out a study of this type have only existed
for the last two to three years, if even that long. In that time, both Denver and Austin have rated sufficient green building starts to build a hedonic price model. To build such a model several data requirements need to be met, and several things must be assumed. The data requirements and assumptions are enumerated below:

1. The market (segmented by place and product) must have a large number of green starts (or green building stock). After all, hedonic price modeling is a statistical method for finding complicated averages, and the average price of 400 items provides much more information about expectations than the average price of 4 items. In addition, an appreciable portion of the building starts in a particular area must be green. Without some appreciable percentage of the housing starts being rated as green (even if there are a fairly large number of green starts over all), the results will be less reliable. This also works in the opposite case, where all the buildings in a particular area are built to a green standard. What is needed is a place that has a mix of green and conventional starts and a large number of each.

2. There must be an accepted local method for standardizing what green building means, and the green buildings included in the sample must adhere to this rating system. If no common definition exists or multiple definitions exist, then it is difficult to specify which buildings are green and which are not.

3. The Austin test has assumed that variation between green buildings is minimal in comparison to the variation between green and non-green buildings.\(^{14}\)

4. The hedonic modeling process assumes that green building rating systems are created equal. Hedonic modeling will not judge whether the systems are measuring the right things or measuring them well.\(^{15}\)

By making these assumptions and finding places that meet the data requirements for hedonic modeling, I have built a framework that allows one to test for the average performance of a green building in a particular real estate market. Such a test responds directly to the questions from our development thought experiment presented in Chapter 1. Specifically, we can use such a model to reliably test whether or not green buildings: sell at a price premium, operate at reduced cost, and
cost more or less to build than buildings which are not green. In the Austin work completed to date, I have already shown that homes rated as green sell at a 9-10% premium over unrated homes, all other things being equal. This information becomes much more valuable for developers than the more conventional green development research, because it generates expectations that are based on average performance and not the extraordinary performance of a few cases.
Chapter Four Notes

1 With the help of my advisors, I have constructed a dataset to test the thesis that new green homes in Austin sell at a premium in comparison to new homes not rated by the green building program. This dataset has been built with information from six sources, using geographic information systems (GIS) software to match and overlay these data. The two major sources are the Austin Board of Realtors (ABoR) and the Austin Green Building Program. I will refer throughout to the data from these sources as the ABoR data and the green building data, respectively. Other sources include the US Bureau of the Census (2000 Census data), the City of Austin GIS department, the Texas Education Administration, and the Austin Independent School District.

2 The Board of Realtors data is not a complete universe of all the transactions. For many new construction homes, the MLS system will not include the information because the builder/developer hires their own in-house sales team. In addition, the data from ABoR includes many transactions from some years and very few from others. This is likely due to changes in the data tracking system. From data collected by the Texas A&M Real Estate Center and conversations with ABoR representatives, the ABoR data includes between 15 and 20 percent of new home transactions in any given year.

3 Because of a special consumer protection in Texas Law, public records do not record the sales transaction of a home. Without this information, public agencies will never know the exact value of a house (they cannot obtain transaction data) and cannot adjust their tax values accordingly. However, it also means that finding any source with information on home sale transactions for Texas is difficult.

4 Malpezzi warns of possible selection bias by using home sales data to make predictions about the total housing stock. While important for the conclusions in this paper, I am only interested in the universe of homes that have sold. So any bias introduced by looking at sales transactions should be minimal.

5 Because of inconsistencies in both datasets, one could not use address or tax parcel number as a unique identifier for each house. Instead, the geo-coding procedure was used, a unique X and Y coordinate was generated through this procedure, and homes were matched based on their location on the street grid. The geo-coding procedure in GIS distorts actual location through the use of street segments. For example, if one wants to map a house at 50 Summer Street, the system will find the street segment that includes this address (say 30-100 Summer Street) and identify where 50 Summer Street would fall if each lot on the street segment had equal frontage. Obviously, this is not the case and 50 Summer Street might actually sit in a somewhat different location on that segment than what geo-coding would identify. This is unimportant for the exercise at hand, because I needed a unique identifier for each home, not a geographically accurate one. Since 50 Summer Street will always be placed at the same location on that street segment, any spatial distortion (which would be small) will be extraneous. In other words, I don’t care if the geographic placement is accurate, just that it’s precise. Special thanks to Daniel Sheehan for showing me how to identify latitude and longitude for each home, and to Raj Singh for suggesting that this was a possible way of matching the data.

6 One could look purely at descriptive questions without expanding this model further, but this thesis aims to go beyond description (saying that a rating from the green builder’s program has an impact on price or not) to address questions related to how much developers can expect Austin homebuyers to pay for green homes in the future. To do this, the model used needs to maximize its predictive power and incorporate variables shown to be important in previous home pricing studies, not just variables related to greenness.

7 10th grade test scores as reported by the Texas Education Administration were used for each School District in the Austin area. In the Austin Independent School District (since there were seven sub-districts) test scores were split up by high school, the high schools were mapped as to what sub-district they were located in, and then summed to represent the scores in the sub-district in which the high school was located. For example, sub-district 4 has 2 high schools McCallum and Anderson. By finding the scores for McCallum and Anderson and averaging them based on the number of students for each, a total achievement score for the sub-district was reached that was comparable to the manner in which scores were calculated for other districts with multiple high schools.

8 Lots less than 2,000 square feet and lots over 5 acres were removed from the database because they did not seem reasonable in size.

9 I used the displacement command to move the address point from the street centerline to the lot. Special thanks to Alison Mori and Sarah Williams for suggesting this technique to me.

10 This leaves something to be desired, and identifying better lot size information would be critical in a repeat or expansion of this study. Special thanks to Lisa Sweeney for showing me how to do this.

11 The other two questions, as discussed throughout this paper, are: 1) do green buildings cost less to own and operate, and 2) do green buildings cost more to build?
12 See Built Green Colorado’s website at www.builtgreen.org.
13 Austin probably does not have sufficient data to do this, yet, because the program changed their rating system after several years of operation. It is difficult to compare the system before and after this change, and there likely have not been sufficient re-sales since the change to permit a repeat-sales study.
14 With good enough data, this assumption could be relaxed, but on a first-pass one is trying to determine differences between green homes and conventional homes.
15 This type of policy analysis seems to be a particular strength of green building researchers to date (it characterizes much of the Still-life literature described in Chapter 2), and the strengths and weaknesses in particular rating systems and programs can be better left to their ample and able hands.
I contend that the lack of developers in green development is no accident, and that the green building message has not been tailored to respond to developer concerns. Part of this has been a lack of data (one cannot research average green building performance if an average green building is a nonsensical concept) but part of the problem has arisen because designers and developers think about the world in very different terms. Designers thrive on what is possible, on pushing the limits of knowledge, practice, and expectation. Developers thrive on what is expected--they succeed by creating a product that will be needed at a particular point in the future. Most green building advocates come from a design background,¹ and green development research to date has reflected this design worldview--it revolves around what is possible and uses exceptional examples to push the limits of practice. But, such an approach can only go so far.
Developers, as we saw in Chapter 1, need a different type of argument for why they should adopt green practices than what is offered by Honor Roll, Still-life, and Saved-by-Green research. If agencies, foundations, and civic groups organizing for sustainable development are interested in courting the involvement of more real estate developers and financiers in the process of promoting green development, then this research model should be supported. The research done to date has made a powerful case around the public benefits of greening, but has not made a convincing argument about the private benefits and costs. To do this, green building advocates need to be identifying, researching, and reporting on the value, costs, and benefits of particular real estate product types in particular real estate markets. This information underpins the way that developers and financiers make decisions about where and how to invest.

Beyond this, answering questions about the private costs and benefits also begins to answer questions about how to effectively advocate for better development. In the end, each question will have one of two answers. Consumers will pay more for green buildings or they will not. The benefits of green buildings will outweigh the costs or they will not. By beginning to answer these questions in a statistically rigorous fashion, we begin to put a face on the challenge before us. We will know more about whether or not the weight of the market can be used as a tool for promoting green development, whether there is a strong business case (as so many have claimed) for building green. If so, then more and more people will do it, and green building will become the industry standard. If not, then we must get at deeper questions about public policy, consumerism, and individual choice, developing a new set of strategies to shift our development outcomes. It is no longer enough to rail against the development industry or to lament the passing of a section of woodland in a small North Carolina town. As advocates for change, we need to know what we are up against. This thesis aims to fit the first piece into that missing section of puzzle.
Conclusions Notes

1 This personal observation is consistent with membership in USGBC.
2 Building Design and Construction News agrees more or less with this viewpoint. In their 2003 white paper on sustainability they argue that developers need to be more involved in researching the costs, value, and operations of green buildings.
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APPENDIX I: A NOTE ON PRESENT VALUE AND THE TIME VALUE OF MONEY

This note provides a brief introduction to the concept of present value and the time value of money. Anyone who wants a more thorough review of this topic should refer to the Harvard Business School case by John Hammond.

What's time dependency?

This model rests on the idea that real estate is a time-dependent asset. But what does that mean? In short, it matters when you own real estate, but, as is too often the case, the short answer is not elucidating unless one first understands the long answer. The value of any piece of real estate will vary in time with respect to a range of exogenous and endogenous factors. The exogenous factors may include things like the inflation rate, market borrowing costs, general production levels in the local and national economy, population growth in the area, changing consumer preferences, etc. The endogenous factors may include things like material and system choices, the quality of building design and construction, maintenance and upkeep, etc.

Time dependency is based on the concept of the time value of money. In simplest terms, this means that one dollar today is worth more than one dollar tomorrow. You could do a lot of things with one dollar today. You could invest it and make more money, you could buy a candy bar, you could put it in an old sock and bury it in the yard. In order to give up the right to having that dollar today (and all the things you could do with it presently) then you will need more than $1 tomorrow. The nature of time-dependent assets rests in this idea. One dollar today and one dollar tomorrow are not equal. But it's not clear how unequal they are. We need a way of comparing different values at different times so that we can judge which is better and how much better it is. To clarify this idea, think about two examples.

1. You pay $100 today. Then you receive $25 per year for each of the next 5 years.
2. You pay $100 today. Then you receive $60 per year for each of the next 2 years.
If we look just at total dollars, then in investment 1, you pay $100 and you receive $125 in return. In investment 2, you pay $100 and you receive $120 in return. However, in investment 1, you have to wait 5 years to get all your money. In investment 2, you only have to wait 2 years. So which one is better?

First let’s think through the situation. In both investments, you give up $100 in the beginning, and then the clock starts running. At the end of year 1, you have $25 from investment 1 and $60 from investment 2. You can do something with that money. Spend it, invest it, bury it in the old sock. The next year, you get another $25 from investment 1 and another $60 from investment 2. At this point, its preferable to have the $120 from investment 2 versus the $50 from investment 1, but investment 1 is not done paying you. You continue to get $25 per year for the next 3 years. What’s this worth?

Let’s assume that you had a third option. You could have invested your $100 in a bank account that paid you 5% annual interest. We’ll come back to this assumption in a little bit, but for now, we can assume that the 5% annual interest that you could have earned by putting your money in a bank account serves as the discount rate for evaluating future cash flows. The discount rate is the interest rate used to determine the value, in current dollars, of a future stream of cash flows.

\[ PV = \sum FV_t /(1+d)^t \]

Where PV is the value of an asset in today’s dollars, FV$_t$ is the future value of a given cash flow, d is the discount rate, and t is the time period in which the cash flow occurs.

It’s easier to see this if we go through the example. Let’s start with investment 1. At the end of year 1, we’ll receive $25. Putting this in the formula, we get:

\[ PV_1 = 25/(1+.05)^1 = 23.81 \]

For year 2, we get:

\[ PV_2 = 25/(1+.05)^2 = 22.68 \]
And so on for years 3, 4, and 5. Let’s ignore the cost of the investment momentarily and look just at the present value of the future cash flows. Summing $PV_1$ to $PV_5$ together will give us the present value of the full investment. It should equal $108.24. In effect, if the discount rate associated with this investment is 5%, then you are receiving a series of cash flows worth $108.24 for $100. This sounds like a good deal. But is it the best deal available to you? Let’s look at the second potential investment.

\[
PV_1 = \frac{60}{(1+.05)^1} = 57.14 \\
PV_2 = \frac{60}{(1+.05)^2} = 54.42 \\
111.56
\]

So investment 2 has a value of $111.56 and only costs $100. Both of these sound like good deals, but investment 2 is clearly better. If you can only participate in one, then (using 5% as a discount rate) you should choose investment 2.

**Discount rate and risk**

In the example above, we assumed that the discount rate was 5% - the hypothetical return you could have earned by putting your money in a savings account. The value of the investments discussed above was based largely on the measure for discount rate. How do we know that we have the right one?

We can think of the discount rate as a measure of the return you need in order to be indifferent between making a given investment and keeping your money. To understand this definition of discount rate, we need an understanding of risk.

*Risk* - expected variation in future cash flows.

Often risk is understood as the possibility that you’ll lose your money. This is not exactly right. Risk is related to one’s ability to predict an investment’s future value. Risky investments have a high probability of being worth a lot more or a lot less than one expects, i.e. they are volatile. Less risky investments are more predictable. Government bonds carry a fairly low cash flow risk (i.e. one can
predict with a high degree of accuracy what the future cash flows from a government bond will be). Stocks are much more risky, particularly stocks for a start-up company (i.e. it is hard to tell what future cash flows will be). One of the reasons that stocks earn a higher expected return than government bonds is that there is more risk (less predictability) in stocks. Risk can be broken into two components: the risk-free rate which is a market level characteristic not specific to any investment and the risk-premium which is a specific characteristic of a given investment. Those components are described in more detail below.

**Risk-free rate** - accounts purely for the time value of money. This is the discount rate that would be associated with a riskless asset. In other words, if I could perfectly predict (with no uncertainty) the future cash flows of a given asset, then I would still discount those cash flows at this rate, because the rate accounts for the time cost of making this investment. I am giving up the use of the invested funds for a given time in order to get those future cash flows. The 10-year Treasury bill might be used to approximate the risk-free rate.

**Risk premium** - the volatility inherent in any investment that one might make. The risk premium would include but not be limited to a measure of how unpredictable future cash flows will be and the probability of default on the payment of those cash flows.

The discount rate may also be thought of as the risk-free rate + risk premium for a given asset. The risk-free rate describes the cost of money in a given time period (measure related to financial markets). The risk premium describes the additional risk associated with the particular investment in question.
APPENDIX II: AUSTIN GREEN BUILDING PROGRAM

Austin has operated a publicly owned electric utility since 1839. By the 1970s, part of the utility’s power generating capacity came from the South Texas Nuclear Project, of which the City was part owner. Claiming faulty engineering, the City sued the project engineer, winning a settlement in the early 1980s. Austin used part of the funds from that settlement to create the Environmental and Conservation Services Department (ECSD) in 1983. Already showing a preference for cooperative programs over regulatory approaches, the Department’s Energy Services Division was charged with reducing the peak power demand in Austin through market-leading mechanisms and community outreach. In this capacity, the Energy Services Division established the Energy Star Homes Program in 1985. About 75% of the homes built in Austin between 1986 and 1992 were rated by this program, over 6,000 homes in total. But by the 1990s, there was a growing “sense that more could be done, not just to save energy, but to protect Austin’s natural environment and ultimately our citizen’s quality of life.” While the Energy Star program did a good job of measuring the energy impacts of buildings, it left out a wide-range of other interconnected building impacts that could be measured and improved.

Working with the Center for Maximum Potential Building Systems, the ECSD obtained a 1989 grant from Public Technology, Inc. to expand the Energy Star rating system to a comprehensive sustainable building program. Additional grants were obtained in 1991 and 1992 to compile information on green building practices, products, and suppliers into the first Sustainable Building Sourcebook (authored by Laurence Doxsey) and to carry out the Green Habitat Learning Project. The Green Builder program opened to the public in 1992 under the direction of Doug Seiter. In that same year, it was the only US-based program to be honored at the UN Summit on the environment in Rio de Janiero, where it was recognized as the first municipal green building rating system in the United States. Since then, it has served as an example for scores of other programs.

Austin’s program has not been satisfied simply with inspiring imitation. Almost immediately after introducing the residential rating system, the Green Builder Program began working to green municipal, commercial, multi-family, and remodeling projects. What became the municipal rating
system grew from efforts to lessen environmental impacts from a new airport. This project led to the three-volume Municipal Guidelines which laid out a process for the design, specification, operation and maintenance of green city buildings. Expansion into the commercial sector began in 1995 with a professional survey of architects, contractors, and building owners. Due to survey results, the early commercial system focused on design assistance, education, and energy efficiency. It also used a variety of monetary incentives to reduce building impacts around issues of site, energy, water, landscape, waste, material issues, and indoor air quality. The commercial system began in 1996, but financial incentives were discontinued in the fall of 1997 and the system was restructured and re-released in 1998. The residential rating system was adapted and applied to multi-family projects beginning in 1999 and more recently a remodeling system has been introduced.

Structure of Green Builder program

The Green Builder Program focuses on developer and builder education, providing information about green building strategies, products, and suppliers through the Sustainable Building Sourcebook, and promulgating their rating systems to effectively measure and compare the greenness of different building projects in Austin. In this light, they are not directly connected to code compliance, permitting, or planning features carried out by other city departments. This separation was deliberate. From the program’s inception, it has promoted green development through “consumer marketing and education and through technical training of residential and consumer building professionals”—working on the premise that such services will “pull the market toward green building.” This attitude has attracted the voluntary participation and cooperation of area building professionals. The following rating systems and services are offered through the program.

Residential Rating System

The first of the Green Builder Program services, the residential building program rates new construction homes by recording information on 136 different green features. This information is largely self-reported, though a commissioning phase is necessary to earn 4 or 5 stars under the
program. Since 1998, the residential program has rated almost 4,000 homes or roughly 15% of the new homes constructed in the Austin area. The chart below shows the different rating categories and the number of features for which information is recorded in each category.

Commercial Rating System

Working with designers, engineers, and construction professionals, the commercial component of the program works to green projects to benefit building owners and managers. These benefits include increased employee productivity, lower operating costs, and improved indoor air quality. Program staff provide expertise about resource efficient systems and building materials as well as practices that reduce waste in construction and operations. Financial incentives are available for both new construction and renovation projects that use sustainable building practices and materials.

Municipal Building Program

Though the Department of Public Works Architectural Management Division is responsible for implementing the city’s sustainable building guidelines, the Green Building Program provides technical assistance for project managers and clients. Any architectural firms working on City projects must demonstrate a strong working knowledge of green building practices, and the City Council has resolved that all public buildings funded through bond issues must meet the US Green Building Council’s Leadership in Energy and Environmental Design (LEED) Silver Rating.

Multi-family program
The multi-family program collects the expertise of many different city departments to assist construction professionals who are creating housing that is “easy to maintain, affordable for residents, and good for the community.” The program provides:

- consultations for developers, designers, and builders of multi-family projects,
- incentives for energy and water efficient appliances and systems, and
- marketing assistance for green projects.

### Manage It Green Initiative

The Manage it Green Initiative sends Green Builder Program staff members to serve as consultants for other municipalities, utilities and government agencies. It consults on policy and program development and specific projects.

### How the residential rating system works

The residential rating system records information on 136 different sustainable building features in five categories – water, energy, materials, health and safety, and community. Thirteen features are basic requirements that must be done for a home to be eligible for a rating. They include such things as the installation of two ceiling fans and low-VOC (volatile organic compound) paints used in the interior. The other 123 home features are assigned a point value, from 1 to 6 points depending on the feature, which is totaled by each category (energy, materials, etc). When a builder uses an eligible method or material to achieve one of these sustainable features, then he receives the associated points. The overall rating for the home, from 1 to 5 stars, is based on the total number of points scored. There are a total of 281 points available, although the maximum score is 266 points since some of the options are mutually exclusive. Builders/developers self-report the results, though specific tests (referred to as commissioning through the remainder of this paper) must be carried out by independent technicians to earn four or five stars. The chart below shows the breakdown of points and the associated star ratings.
Figure Appendix II - 2: Point Requirements for Star Rating

<table>
<thead>
<tr>
<th>Star Rating</th>
<th>Point Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Star</td>
<td>40-59 points</td>
</tr>
<tr>
<td>Two Star</td>
<td>60-89 points</td>
</tr>
<tr>
<td>Three Star</td>
<td>90-129 points</td>
</tr>
<tr>
<td>Four Star</td>
<td>130-179 points plus commissioning</td>
</tr>
<tr>
<td>Five Star</td>
<td>180+ points plus commissioning</td>
</tr>
</tbody>
</table>
Appendix Two Notes

1 See Hogan and Flanigan.
2 Ibid.
3 From “Selected Best Practices for Successful City Energy Initiatives” page 41.
4 Ibid p. 41, and Hogan and Flanigan.
6 “Pliny the Greener”.
7 Sustainable Building SourceBook acknowledgements. Hogan and Flanigan.
9 In 2003, the Green Roundtable in Boston identified over 80 programs in the US alone.
11 Ibid.
12 Ibid.
13 Ibid.
14 Ibid.
15 Ibid.
16 Ibid.
17 Ibid.
18 All rating systems and services offered under the Austin Green Builder Program come from the Green Builder Program webpage at http://www.ci.austin.tx.us/greenbuilder.htm.
19 Green Builder Program records.
21 From “Selected Best Practices for Successful City Energy Initiatives”
22 Ibid.
23 Ibid.
24 Ibid.
26 Each feature has a particular number of points associated with it, i.e. double pane windows are worth two points and tile or metal roofing is worth three points, and the points for each feature are awarded entirely or not at all. There is not a sliding scale by which one house might score 1 point for their windows where another house gets 2.