MODERATING INFLUENCE OF UNCERTAINTY ON THE ADOPTION OF GREEN BUILDING PRACTICES IN RESPONSE TO CLIMATE CHANGE - DETERMINING GREEN BUILDING PRACTICE INSTITUTIONALIZATION IN THE RESIDENTIAL CONSTRUCTION INDUSTRY

by

Larissa Mark
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Committee:

Dr. Sheryl Beach, Dissertation Director

Dr. David Armor, Committee Member

Dr. David Hart, Committee Member

Dr. Paul Schopf, Committee Member

Dr. Albert Torzilli, Graduate Program Director

Dr. Robert Jonas, Department Chairperson

Dr. Timothy L. Born, Associate Dean for Student and Academic Affairs, College of Science

Dr. Vikas Chandhoke, Dean, College of Science

Date:

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George Mason University
Fairfax, VA

Moderating Influence of Uncertainty on the Adoption of Green Building Practices in Response to Climate Change – Determining Green Building Practice Institutionalization in the Residential Construction Industry

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at George Mason University.

By

Larissa Mark
Masters of Science
Virginia Commonwealth University, 2004

Director: Sheryl Beach, Professor
Department of Geography and Geoinformation Science

Summer Semester 2012
George Mason University
Fairfax, VA

Dedication

I dedicate this dissertation to my parents, Luz and Larry whose constant sacrifices have driven me to strive for excellence in everything I do.

Acknowledgements

I would like to thank the many friends, relatives, and supporters who have helped me during this process. My parents provided a constant corner of support. A special thank you goes to Dr. D. Armor for his continuous work and support! Finally I would like to thank my dissertation committee for their continued support.

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Abstract

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Larissa Mark, PhD

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Dissertation Director: Dr. Sheryl Beach

The Earth's climate is changing, largely due to greenhouse gas emissions resulting from human activity. The building industry, like all manufacturing and construction industries, contribute to climate change through land-use changes, influencing transportation and product development and use.

The residential construction industry has been a staple in the United States economic market for decades. The industry provides millions of jobs and homes across the nation. The industry is fragmented and composed mostly of several small-specialized businesses, filling specific niches. When there is perceived environmental and regulatory certainty surrounding the decisions made by construction firms, builders construct homes traditionally based on regulatory compliance and consumer demands. With such a limited scope of influence, a

majority of the industry continues to develop homes in the same manner for generations. While such builders update the type of technology employed during the construction process, the method of construction has not. This has prevented many from voluntarily updating their operating standards and method of construction.

Increasingly the American Society is paying more attention to greenhouse gas emissions released during the creation of goods and services. This increased awareness, and subsequent demands for greener products and services, has led to environmental and regulatory uncertainty in many industry sectors across the country. As a result, stakeholders today are better able to exert influential pressure on the residential construction industry to adopt green building practices and practices. While resistance is ever present, increasingly the residential construction industry is adopting practices that result in more efficient homes.

There are several factors and internal values that influence the adoption and institutionalization of firm practices and values. This research focuses specifically on the type of stakeholder that is most influential to adopting green building practices and the degree to which the influence alters firm behavior.

Uncertainty, in this study, did not exert a significant influence on stakeholder pressure. Instead financial incentives provided by public and private entities most significantly influence the institutionalization of green building practices in the residential construction industry independent of the presence of uncertainty. This study also determined that as the number of annual projects goes up, the adoption of green building practices among firms go down.

Chapter 1 | Introduction

The earth's climate is changing, due largely to greenhouse gas emissions resulting from human activity. Emissions of greenhouse gases have progressively increased since pre-industrial times (EPA_r, 2009). The industrial revolution in the United States opened up new innovations and technologies that marked a turning point in history. The discovery, the availability and use of fossil fuels, resulted in profound innovations in agriculture, manufacturing, mining and transportation and changed the way people lived, worked and traveled. Since that time anthropogenic emissions of greenhouse gases (GHG) associated with industrial processes have been released at an exponential rate with unknown environmental effects unknown for decades as countries raced to become industrialized.

Research on GHG emissions has proven the adverse impact these gases have on regional and global climate (Smith, Cruce, and Seidel, 2010; Karl, Melillo and Peterson, 2009). Research has established a correlation between the increase in GHG emissions and human and environmental health degradation. While GHGs are also emitted naturally, recent studies have shown that emissions associated with industrial processes far exceed those emitted naturally (EPA_r, 2009; Jeswani, Wehrmeyer, and Mulugetta, 2008). There has been significant work done by scientists to determine how industrial activities impact climatic events. In response federal, state and local governments, multiple industries and various stakeholders have begun to develop mitigation practices to reduce the rate of GHG emissions. Many industries, government entities and citizens have begun to alter their work practices by reducing wasted resources, adopting efficient practices, and limiting pollution and emissions.

A 2006 Stern Review Report on the economics of climate change emphasizes that, even at more moderate levels of warming, climate change will have serious impacts on human life, the environment and food production. Growing consensus among scientists regarding the potential impacts of climate change has caused most industries to fall under increasing internal and external pressure to reduce their GHG emissions from their processes, products and services (Jeswani, Wehrmeyer, and Mulugetta, 2008). Increasingly various industrial sectors have begun to mitigate their impacts by not only changing their internal practices, but also by participating in external programs and practices as well. Often however, action is predicated on economic, technological, organizational and instructional drivers and barriers, which vary across industrial sectors (Jeswani, Wehrmeyer, and Mulugetta, 2008), including the residential construction industry sector.

The residential construction industry, like many other industries, has work and supply chain practices that result in GHG emissions. Building emissions associated with construction, use and demolition contribute to GHG emissions and climate change. Many firms have begun to adopt green building practices for a variety of reasons including to minimize GHG emissions from their construction projects. The factors that will influence firms adopting of green building practices have not been definitively determined and vary due to environmental and regulatory uncertainty. This study will evaluate how uncertainty affects the level of influence various factors have over firm adoption and institutionalization of green building practices.

Statement of the Problem

According to Environmental Protection Agency's (EPA) 2012 U.S. *Emissions and Sinks Report* , in the United States, the industrial, transportation, residential and commercial (collectively the building sector) and agriculture sectors are the five major sectors found to contribute the most to anthropogenic GHG emissions (EPA$_{l}$, 2012). The U.S. building sector is the second largest emitter of GHG emissions, contributing both directly and indirectly to the generation and release of GHGs at approximately 40% of total US emissions (EPA$_{h}$, 2010). A majority of the emissions generated by this sector are directly related to electricity consumption (EERE, 2008).

Industries experience considerable uncertainty surrounding the short term and long term environmental and regulatory impacts of GHG emissions and climate change. This uncertainty is a pervasive problem across the nation. Consumer and regulatory expectations regularly change and there is now an increased demand that products have less environmental impact. To combat this uncertainty, many industries, including the residential building industry, have begun to address their GHG contributions by creating proactive management plans, operating procedures and programs.

In the context of this research, this investigation focuses on how environmental and regulatory uncertainty moderates the ability of different of stakeholders exerting pressure to influence the adoption and institutionalization of proactive environmental management techniques, specifically green building practices, by residential construction firms. Institutional theory evaluates the influence that internal and external pressures have on the institutionalization of firm values (Delmas and Toffel, 2003). Traditionally, incorporating practices and behaviors into a firm's management plan goes through a process of being presented, tested, diffused and finally institutionalized in a firm (Lawrence, Winn, and Jennings, 2001). Stakeholders impact the institutionalization of values by exerting pressure on firms during all stages of the institutionalization process. This research evaluates pressures exerted on firms to determine which pressure or combinations of pressure types are most influential during periods of environmental and regulatory uncertainty. For the context of this research, environmental uncertainty is defined as the uncertainty associated with climate change and its impacts on societal and economic development. Regulatory uncertainty is defined as the uncertainty associated with climate change mitigation policies and their potential impact on the regulated community. This research takes one step further to test whether perceived environmental and regulatory uncertainty shifts the influence of pressure categories over others.

Previous research on institutional theory has established the influential role pressure plays on the adoption and institutionalization of proactive environmental values (Meyers and Rowan, 1977; DiMaggio and Powell, 1983; Jennings and Zandberger, 1995; Khanna and Anton, 2002; Delmas and Toffel, 2003). Evaluating previous research has revealed that the moderating impact of uncertainty on the adoption and institutionalization of green building practices to date has not been studied. This research works to address this gap and provides insight into the institutionalization of advanced environmental management practices when faced with uncertainty. As consumers and regulators continue to become more environmentally aware and cost conscious, it is necessary to identify what factors most influence the adoption of green building practices in the residential construction industry as they strive to stay viable. This research contributes to understanding green building practices and those factors influencing the adoption of advanced firm environmental management practices when firms operate in an environment made uncertain because of climate change.

Chapter 2 | Background

Buildings and land use are able to contribute to climate change, influence transportation and human and environmental health through the materials utilized, decisions about sites, electricity and water usage, and landscape surroundings. The development of buildings, both commercial and residential, modifies the landscape, uses natural resources and impacts the surrounding environment. The construction phase is a very labor-intensive process but does not adversely impact climate change as much as post construction use. The difference in impact is associated with the use of energy. After buildings are constructed, energy must be used for heating and cooling, cooking, refrigeration and the use of electronic products.

Residential buildings account for approximately 93% of the total U.S. building stock and are responsible for contributing 17% of the total U.S. GHG emissions (PewCenter, 2009; EPA_c, 2010). The residential construction industry is fragmented, composed of multiple subindustries that design, develop and/or provide general contracting, remodeling, and renovation services for residential buildings, including single-family homes, multifamily housing, townhomes, apartments, and modular housing (NAHB, 2009). Outside of basic state, local and federal environmental regulatory requirements, a complex network of not-for-profit associations and agencies shape the standard operating practices used in the residential construction sector (Barr, 2003). As a result, institutionalizing environmental protective behaviors have been heavily influenced by a variety of internal and external pressures, rather than one distinct pressure type. This is a significant digression from pressures where consumer pressure often prevailed as the most influential factor when firms operated under conditions of market, regulatory and environmental certainty.

Today however, growing concerns over changes in climate directly associated with anthropogenic GHG emissions and increasing federal, state and local policy changes have increased uncertainty surrounding the ability of firms to mitigate its short and long term impacts. Climate change is the result of the impacts associated with natural and anthropogenic GHG emissions (EPA_b, 2010). These industrial manufacturing by-products are known to stay in the atmosphere and cause the retention of solar heat and energy resulting in increased temperatures and fluctuating weather patterns. Many U.S. governmental agencies, in particular the Environmental Protection Agency (EPA) have promoted the use of practices and technology to reduce the anthropogenic release of GHG emissions such as energy efficient products and Low Impact Development (LID). Outside of environmental regulations associated with the home goods manufacturing, goods and services were produced without any thought of their direct and indirect environmental impact when used in home construction. Today many homes and home goods are produced to reduce environmental impacts. More and more products are certified environmentally friendly through federal programs like the Department of Energy's EnergyStar program or EPA's WaterSense program. Fueled by many factors, including uncertainty, the increased availability of green products and more firms are developing, adopting and institutionalizing environmentally friendly practices to not only mitigate their environmental impacts, than ever before.

These changes enhance a firm's viability and staying power in an ever-changing environment. The construction industry, as with most industries, releases GHG emissions which typically adversely impacts climate change during the construction and post-construction use of its projects. Unlike most industries that are able to use technologies to reduce the amount of GHGs emitted, the residential construction industry has few options available that would enable it to reduce emissions associated with its projects. Minimizing the environmental impacts associated with construction projects are often done by incorporating resource efficient technologies, reducing waste, controlling environmental degradation and promoting performance and efficiency (NAHBgreen, 2009). This strategy, often referred to as green building, is defined as the practice of creating and using healthier and more resource-efficient models of construction, renovation, operation, maintenance and demolition in every step of the home building and land development process (NAHBgreen, 2009; EPA_q, 2010). Green building practices use a whole-house systems approach in order to reduce the environmental impact of construction projects.

Using green building is the best option available to the residential construction industry for reducing emissions and environmental conservation. While the use of green building practices has become more widespread, there are few studies that analyze the influential factors driving the change. Due to this lack of information, it is important to study which factors and scenarios most influence adopting and institutionalizing green building practices.

Chapter 3 | Climate Change Science and Policy

The Earth's climate is composed of and created by a number of complex and connected physical, chemical and biological processes occurring in the atmosphere, land and ocean (IPCC, 2007). Climate change is an environmental problem that results from the excessive emissions of long-lived greenhouse gases and has significant social, economic and ecological risks. Climate change science first emerged in the 1970's and 1980's when scientists first sounded the alarm to its potential long term and short-term impacts (Shwom et al., 2010). It wasn't until the 1990's that climate change became considered to be one of the greatest environmental threats today and research has shown that the global climate is changing, altering weather patterns, precipitation rates, sea level rise, elevating temperature and wind speed (Younger, Morrow-Almeida and Dannenberg, 2009; Shwom et al., 2010).

Global climate change is "often referred to as a global "commons" problem, whereby individuals are unlikely to take responsibility for global accumulation of atmospheric greenhouse gases" (Lutsey and Sperling, 2008: 673). EPA (2009_k:1) defines climate change to be "any distinct change in measures of climate lasting for a long period of time" and is the result of both natural processes and human activities and is aggravated by the unprecedented annual release of the anthropogenic emissions consisting of mainly carbon dioxide, methane, nitrous oxide, and fluorinated gases (Younger, Morrow-Almeida and Dannenberg, 2009). GHGs trap heat in the atmosphere and reflect it back to earth, heating the earth's surface. For several decades there has been increasing concern and research about the environmental impacts of GHG emissions.

Decades of atmospheric research has contributed to a growing body of evidence linking accelerating climate change with observed changes in both atmospheric and terrestrial systems. Research has show the association between climate change, rising sea levels, the melting of the cryosphere, the alteration of precipitation patterns, and the increased frequency and severity of storms (EPA_k, 2009; Baede *et al.,* 2001; Karl and Trenberth 2003). Climate change does not impact equally. The degree of climate change vulnerability differs across counties, communities, and even households. Climate change has direct implications and impacts on the local, state and federal economies, resource protection and long term human and environmental health (EPA_k, 2009). One of the greatest challenges facing the United States today is the ability to substantially reduce global greenhouse gases (CRS, 2007). Mitigating the impacts of climate change involves actions by individuals, businesses, governments, research entities and others and helps reduce vulnerability of human and environmental systems to unavoidable impacts. But on the federal level, political and industrial resistance has effectively hampered a national response. Congressional bills failed to become law due to limited bipartisan support. Instead states, localities and individual businesses have independently taken steps to reduce their impacts.

Previous research has identified carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), water vapor and hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) as the main GHGs adversely impacting global climate. While these gases are released through both natural and anthropogenic sources, natural contributions are often seen as short-term, high frequency changes that temporarily impact the environment such as volcanic eruptions for example (O'Hare, 2000). For example, unlike natural emissions, anthropogenic emissions are often associated with long term, low frequency atmospheric changes. Human activities, such as fossil fuel generation and consumption, industrial processes and agricultural activities have exploded over the past century resulting in the emission of pollutants into the atmosphere. The explosion of anthropogenic emissions has begun both to interfere with the natural flows of energy, and to change the composition of the atmosphere.

Greenhouse Gases

Greenhouse gases are necessary for life on earth because of their ability to insulate the earth. French mathematician Jean Batiste Joseph Fourier in 1827 originated the concept of greenhouse gases by theorizing that the earth's atmosphere absorbs heat that would otherwise radiate out into space. This theory was further investigated in 1860 by British scientist John Tyndall who discovered that it was not the oxygen and nitrogen in our atmosphere that absorbed heat but in fact the greenhouse effect was the result of water vapor, carbon dioxide and methane (King, 2005).

Greenhouse gases (GHGs) are gaseous chemical compounds in the atmosphere that contribute to the warming of the earth's atmosphere by reflecting infrared radiation from the earth's surface (EIA, 2008) are comprised of water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and ozone (O_3) (Figure 1). GHGs allow short-wave radiation from the sun, but absorb part of the long-wave radiation (heat) emitted from the earth back into space. Maintaining a constant flow of GHGs allow the Earth to shed heat into space at the same rate it absorbs energy from the sun.

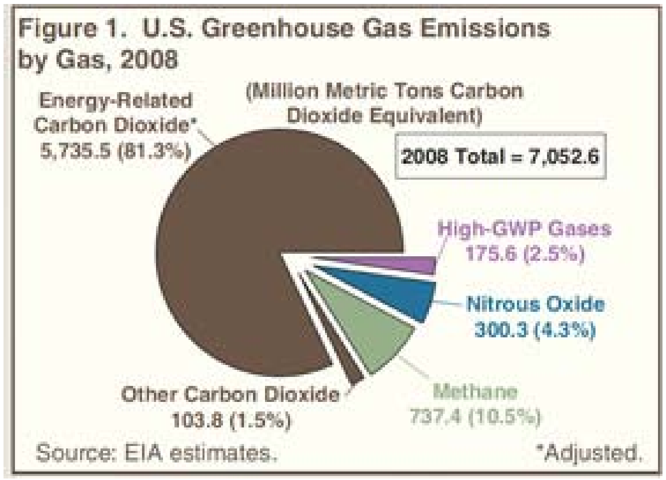

Figure 1: U.S. Greenhouse Gas Emissions by Gas (EIA, 2008

Scientific evidence supporting the impact of GHGs on climate change has strengthened over the years. Research has shown that the excessive emissions of GHGs, due primarily to anthropogenic activity, are adversely impacting the earth's atmosphere (Bartnett, Adam and Lettenmair, 2005; Barker et al., 2007; CRS, 2007; EPA_c, 2010). Scientists have been able to link pollutants to changes in atmospheric composition that subsequently causes climate change. Problems arise when the atmospheric concentration of GHGs increases and traps more heat in the atmosphere than is released, resulting in increased mean surface and tropospheric temperatures. While most greenhouse gases are a necessary component of our atmosphere, the greenhouse effect caused by increased anthropogenic GHG emissions has been magnified beyond natural levels, resulting in changes environmental conditions particularly severe weather events (Younger, Morrow-Almeida and Dannenberg, 2009).

Research has shown that GHG emissions have increased 70% since 1970 (Younger, Morrow-Almeida and Dannenberg, 2009; EPA, 2011). The atmospheric and climatic impacts of the six main GHGs vary depending on their chemical makeup and quantity. Some gases, when combined with other gaseous elements, adversely impact the atmospheric composition while others are hazardous due to the sheer volume released. Of the six gases, CO_2 is the most emitted gaseous byproduct and therefore the gas of greatest concern. While beneficial to earth systems, in excessive quantities CO_2 is the most damaging to the Earth's atmospheric, terrestrial and aquatic systems (Balat, 2010). As illustrated in Figure 1, CO_2 is released most frequently, both nationally and globally, accounting for 81% of the total GHG emissions and 77% total global emissions. The other gases, while not released in equitable quantities, are also able to adversely impact regional and global atmospheric conditions as well (Dale, 1997;Brown, Southworth and Stovall, 2005; Cohen and Miller, 2011).

Sources of GHG emissions

Greenhouse gases are emitted from both natural and anthropogenic sources of GHG emissions. While natural emissions can release significant amounts of short lived GHGs, anthropogenic emissions far surpass that emitted naturally. Anthropogenic greenhouse gases are produced as a byproduct of combustion of chemicals and fossil fuels. These emissions have increased dramatically since the beginning of the industrial age. Today anthropogenic GHGs result from a variety of sources including, manufacturing processes, electricity generation, deforestation and land use change. Removing natural sinks such as forests, and converting the land for non-carbon sink purposes such as development and farmland also increases GHG emissions. The most significant source of anthropogenic GHG emissions comes from the combustion of fossil fuels in the generation of electricity in power plants, transportation, and industrial processes (Fung et al., 2005; EPA_b, 2010).

Research has found that a majority of GHGs are long lived in the atmosphere (with the exception of CO_2). Increased concentrations of GHG emissions, while allowing the sun's rays to easily enter into the earth's atmosphere, effectively prevents reflected infrared radiation from leaving the earth's atmosphere. Instead the infrared rays are reemitted back to earth, where it is absorbed resulting in warming the planet and the atmosphere, thereby adversely influence atmospheric and earth systems.

Carbon Dioxide

Research conducted over the last decade has found CO_2 to be the most significant GHG emitted, accounting for more than 70% of the total emissions emitted annually (IPCC, 2007; Younger, Morrow-Almeda, and Vindigni, 2008). In the United States CO2 from fossil fuel combustion processes is the number one greenhouse gas emitted (EPA, 2012, Pg 2-1). CO_2 is essential to living systems and while naturally released by animal respiration, decomposition of organic matter, CO_2 is anthropogenically released by the combustion and burning of fossil fuel. When in equilibrium, the amount of CO_2 released is balanced by various sinks including oceans, forests and living biomass (EPA, 2012). Since the industrial revolution changes advances in technology, combustion of fossil-fuel products and changes in land use and forestry practices have altered this progress.

According to the IPCC (2007), since the Industrial Revolution, global atmospheric concentrations of CO_2 have risen by approximately 36 percent. In the United States, CO_2 emissions are derived from commercial, residential, industrial, transportation and energy generation (EPAc, 2010). Energy is the top emitting category of GHG emissions and represents over 50 percent of total US emisisons followed by transportation and industrial processes representing 32 percent and 26 percent of total US CO_2 emissions respectively (EIA, 2011; EPA 2012). Since1990 emissions from these sectors grew by over 662.1 Tg (EPA, 2012). In contrast emissions from the residential sector grew approximately 11 Tg during the same period of time (EPA, 2012). CO_2 Residential CO_2 emissions from fossil fuel combustion accounted for approximately 22% of total US emissions (EIA, 2011). Of the emissions associated with electricity, the residential emissions has been shown to account for thirty percent of the total emissions since 1990 and has been primarily associated with residential lighting, heating, cooling and operating appliances and gas for heating and cooking (EPA, 2012).

Methane

The discovery of Methane (CH_4) dates back to the late 18^{th} century. CH_4 is a trace gas produced by anaerobic processes associated with both natural and anthropogenic processes and is one of the most abundant trace gases in the atmosphere. In nature, CH_4 is emitted via enteric fermentation, wetland nutrient cycling and anaerobic decomposition. A majority of methane emissions however are associated with anthropogenic sources. Currently between 55%-70% of CH_4 emissions are the direct result of anthropogenic activities (IPCC, 2001). Since pre-industrial times, the concentration of methane has increased rapidly and has been primarily associated with natural gas systems, enteric fermentation, landfills, coal mining and manure management.

Used as both an industrial and domestic fuel source, CH_4 is the second most important anthropogenic greenhouse gas (after CO_2) emitted into the atmosphere. Despite its availability as a lower-carbon energy alternative to coal and oil, CH_4 has a significant influence on the oxidizing capacity of the atmosphere and on the lifetime of trace gases. In 1996 the IPCC found that CH_4 is more than 20 times as effective as CO_2 at trapping heat in the atmosphere (Balat, 2010).

Nitrous Oxide

Nitrous Oxide (N_2O) is a trace gas that is produced by "biological processes that occur in soil and water and by a variety of anthropogenic activities in the agricultural, energy-related, industrial, and waste management fields" (EPA, 2012: ES-10). N_2O is a natural byproduct of organic decomposition, typically associated with microbial digestion within the nitrogen cycle. While originally only present at a trace level in the Earth's atmosphere, continued and increased emissions of N_2O have resulted in more N_2O emitted than removed via natural processes (Smith, Cruce and Seidel, 2010). Even in trace amounts, N_2O has the ability to absorb infrared radiation at a rate 300 times greater than that of carbon dioxide and therefore has the ability to significantly contribute to global warming.

The increased generation of N_2O is the result of the release of inert forms of N_2O found in the soil when agricultural land is converted to developed land. N_2O is also released as a byproduct of the burning of organic material, agriculture production, and industry and atmospheric decomposition of nitrogen (Balat, 2010). In the United States the most significant anthropogenic emissions of N_2O are contributed to agricultural processes and livestock and human manure management (EPA_u, 2010; Smith, Cruce and Seidel, 2010). Synthetic nitrogenous fertilizers and animal manure are often applied to agricultural soils to enhance the yield and longevity of crops grown. While these products are taken up by plants, excess N_2O

has been found in stormwater runoff and is emitted during plant decomposition. N_2O, along with other anthropogenic emissions of gases such as carbon monoxide, and hydrocarbons are able to chemically react in the atmosphere to produce ozone (IPCC, 2007).

Fluorinated Gases

Anthropogenic releases of these synthetic chemicals are often associated with the substitution of Stratospheric Ozone depleting substances, HCFC production, electrical transmission and distribution, semiconductor manufacture and aluminum and magnesium production and processing (EPA_c, 2010). These substances were first addressed under the Montreal Protocol of 1987 (Velders et al., 2007) and have been regularly monitored since.

Global Warming

Global Warming is refers to the anthropogenic impact on global climate patterns that is demonstrated through increases in atmospheric temperature (Houghton, 2005). Solar radiation powers both life on Earth and the Earth's atmosphere. Of the total solar radiation to hit the Earth, 1/3 hits the top of the atmosphere and is immediately reflected back into space (IPCC, 2007; Archer, 2006). The remaining solar radiation is absorbed primarily by the Earth's Surface and to a smaller degree by the Earth's atmosphere and converted to infrared energy (IPCC, 2007). A balance of incoming solar radiation and infrared radiation emitted must be maintained on earth (Archer, 2006).

The greenhouse effect occurs when the emitted infrared radiation is unable to escape and is instead absorbed by the clouds and the atmosphere and reradiated to the Earth altering the delicate energy balance. The reradiated energy causes temperature increases and an overall warming of the planet (IPCC, 2007; Archer, 2006). Anthropogenic and natural forces can alter how much heat is reflected or absorbed by the Earth's surface, research has shown that the increased presence of GHGs traps more infrared energy, making the Earth's surface warmer (IPCC, 2007; Archer, 2006; EPA_t, 2010) Figure 2.

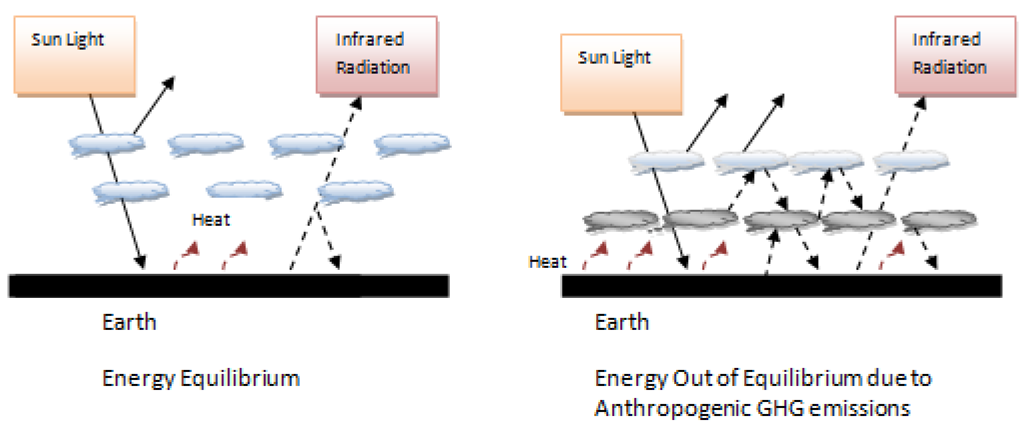

Figure 2: Comparison of Natural and Anthropogenically Altered Greenhouse Effects

The current rate of warming internationally has been approximately three times greater within the past 30 years than the rate over the last 100 years (EPA_h, 2010). This has caused international alarm and has encouraged businesses, industries and governments to begin the process of altering not only their role as environmental stewards, but their operational plans as well (Quiggin, 2008).

Atmospheric Conditions

The atmospheric system is a system of organized circulation, chaotic motions, and random turbulence, which forms the most variable and rapidly changing part of the climate system (Baede *et al.,* 2001; Karl and Trenberth 2003). The Earth's system is driven by driven by the sun's energy forces (IPCC, 2007). The lowest level of the atmosphere, the troposphere, contains the majority of the earth's weather, and its circulation is dependent upon imbalances between radiative heat at low and high-latitudes (Archer, 2006; Salby and Garcia, 1994).

Both the greenhouse effect and GHGs are necessary for the planet to exist and sustain life. Without them, the planet would be roughly 33ºC cooler (Baede *et al*., 2001; IPCC, 2007; Karl, Melillo, and Peterson, 2009). However, the increased emissions has caused increased reradiation of infrared rays emitted into the atmosphere which has resulted in the cooling the earth's upper troposphere, altering weather patterns, causing increased warming of both the earth's surface and lower troposphere and altering the length of seasons across the globe (Karl, Melillo, and Peterson, 2009). Recent research has studied the relationship between climate patterns and climate change and has determined that the increased emissions have adversely impacted atmospheric and surface heat resulting in an increase in observations in extreme weather events that previously recorded (IPCC, 2007; Hansen et al., 2006; Karl, Melillo, and Peterson, 2009).

Over the past 30 years, the rate of warming across the globe has been approximately three times greater than the rate over the last 100 years (Hansen et al., 2006). For example, the average temperatures across the United States have increased more than 2ºF over the last 50 years and are projected to increase at least an additional 4ºF by the end of this century (Karl, Melillo, and Peterson, 2009). Most climate models predict that the buildup of GHGs are likely to lead to increases of 1.5ºC to 4.5ºC for surface air temperatures (Hansen et al., 2006) in the next century. This change in temperature is projected to further change the atmospheric system.

The excessive atmospheric and surface heat caused by increased levels of GHGs increases the severity of weather patterns and also results in magnifying already existing climatic conditions (Karl and Trenberth 2003). Severe weather events noted by high winds and increased precipitation cause excessive water runoff, land erosion and reduced water infiltration. In areas with snow and ice packs, increased frequency of rain can adversely impact the amount of snow packs which reduce the amount of surface UV absorption (Barnett, Adam and Lettenmaier, 2005; EPA_k, 2011). Increased temperatures and decreased snow packs results in increased exposed surface areas that will absorb UV radiation, further warming the surface area. Reduced snow and ice packs also lead to drought downstream of the snow and ice pack areas (Barnett, Adam and Lettenmaier, 2005).

Not only are there increased instances of severe weather patterns, but there are also increased periods of drought in many areas already experiencing shortage. For example, in the high altitude wetlands of Colombia called the Páramos, recent shifts in climate has resulted in a decrease in the size and health of these lands. This change adversely impacts the survival of not only local flora and fauna, but ecosystems downstream and dependent on the Páramos as well (Buyaert et al., 2006). The influence exerted by GHGs over the earth's atmospheric system impacts not only the atmospheric system but also triggers a series of feedbacks within and between regional and local environmental feedback systems as well.

Hydrologic Cycle

Increased temperatures often result in impacting the hydrologic cycle with increased surface water temperatures and increased evaporation. The hydrologic cycle is composed of several interacting aquatic systems including oceanic, subsurface and surface water bodies are integral components of the hydrologic system (Chahine, 1992). Oceanic circulation depends on both winds and density contrasts caused by thermal and salinity gradients (Baede *et al.*, 2001) and is currently the largest sink for carbon dioxide. Increased levels of carbon dioxide continue to be emitted and absorbed into the world's oceans has resulted in ocean acidification and warming (Cao, Caldeira and Jain, 2007). Ocean acidification, if low enough, can adversely impact both shallow and deep aquatic ecosystems, ocean currents and circulation and sea ice formation (Cao, Caldeira and Jain, 2007).

The cryosphere is a key part of the hydrologic system, consisting of all the snow and ice in the climate system. The cryosphere has high reflectivity of solar radiation, low thermal conductivity, and high thermal inertia and stores large quantities of fresh water (Barnett, Adam and Lettenmaier, 2005). Research has shown that the cryosphere is being severely depleted because of climate change (Baede *et al*., 2001; Good *et al*, 2011; Gosling *et al*, 2011). The increase of atmospheric and surface temperatures has caused a significant loss of land and sea ice (Van den Broeke *et al*, 2009). This loss not only directly contributes to sea level rise and reduced availability of fresh water but most importantly the loss of sea and land ice increases the potential amplification of reflectivity as land surface is exposed (Hansen *et al*, 2008).

Precipitation

Global precipitation has changed dramatically in recent years and can be directly related to the increase in global temperatures. The increase of surface level warming and increased rate of evaporation has resulted in areas receiving more precipitation events in some areas while others receive significantly less. As a result, there is significantly more water in the atmosphere across the globe now than in recent history (EPA_t, 2010).

Local, regional and global distribution of precipitation events has become more intense, leading to more rainfall over shorter periods of time and more days without rain (Smith, Cruce, and Seidel, 2010). As Figure 3 shows, the rate of extreme events has progressively increased resulting in significant changes in precipitation rates. Such changes in precipitation rates are likely to continue as a result of climatic shifts associated with climate change and the earth continues to warm.

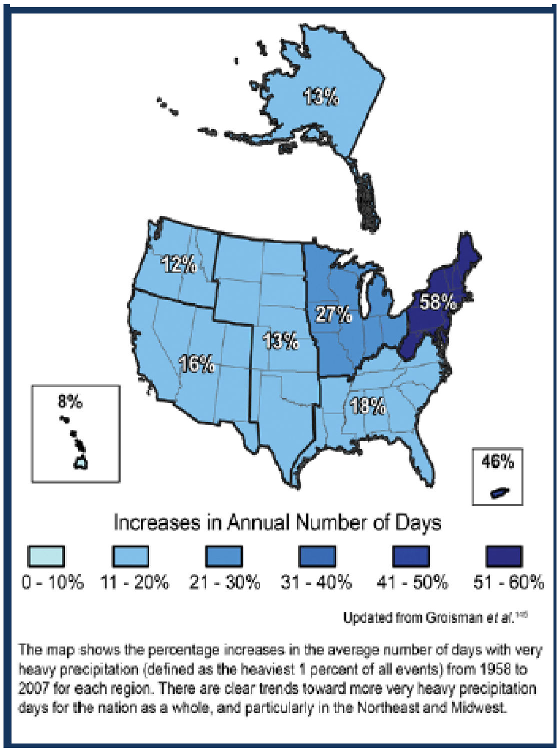

Figure 3: Increases in Annual Number of Days with Very Heavy Precipitation (USGCRP, 2009)

Terrestrial Systems

The terrestrial system, as with the aquatic systems, has been impacted by global climate change. There have been observations in changes to vegetation cover, soil properties, land surface texture and the amount of dust generated. Anthropogenic activities have reduced the vegetation cover in many parts of the world which has been further aggravated with climatic changes. Degraded vegetative cover, exposed and degraded soil qualities influence the transfer of solar radiation from the surface to the atmosphere (Melillo et al., 1993, Baede *et al*, 2001), further warming the atmosphere. As a result of global warming and the resulting climate change, increased desertification, increased wildfires are occurring across the globe (Solomon, 2009).

Land cover serves as reservoirs, sinks and sources of carbon (Turner, Lambin and Reenberg, 2007). Changes in land cover has been found to directly influence surface heat fluxes (Pielke, 2002) and therefore are able to impact energy, soil health, carbon sequestration and the reflectance of the earth's surface (Dale, 1997). The level of CO_2 and other GHGs in the atmosphere depends on the efficiencies of the aquatic (primarily oceans) and terrestrial (primarily forested land cover) in absorbing and storing excess CO_2 (Fung, Doney, Lindsay, and John, 2005). While recent studies have linked land use changes with impacts of regional and global climate change, rarely are these changes taken into account by policy makers (Dale, 1997; Pielke, 2002; Fung, Doney, Lindsay, and John, 2005; Turner, Lambin and Reenberg, 2007). This lack of accountability may be due to the varying interactive effects of different local land-use surface changes and with the subsequent effects of changes in atmospheric composition (Pielke, 2002).

Climate Change and Policy Making

Climate change policymaking has struggled to gain traction in the United States because of political uncertainties, delayed time frame for tangible impacts, and the global nature of the problem (Tompkins and Adger, 2005). The first climate change policy was developed internationally by the United Nations in 1992. The 1992 United Nations Framework Convention on Climate Change (UNFCCC) called for and ratified international efforts to reduce GHG emissions to prevent dangerous anthropogenic interference with the climate system (UNFCCC, 2007; Balat, 2010). As a result of the framework, 160 nations initially met in Kyoto Japan in 1997 and negotiated an international treaty establishing greenhouse gas emission limits for the developed nations (EIA, 2002_b; Bryne, Hughes, Rickerson, Kurdgelashvili, 2007).

The Kyoto protocol required developed countries to reduce the total amount of GHGs emitted by 5% from 1990 levels by 2008-2012 (Saunders and Wreford, 2003; UNFCCC, 2007). Despite the final ratification of the protocol by a total of 184 countries, the United States declined participation in the international treaty. The Bush Administration expressed strong opposition to the exemption of major population centers such as China and India from significant emissions reduction targets, presumably at the expense of the U.S. economy (White House, 2001). Rather than fully adopt the prescribed measures, the United States only agreed to reduce its emissions from "1990 levels by 7 percent during the period 2008-2012" (EIA_b, 2002: 1).

Today the United States federal government has both failed to reduce its emissions as agreed and has failed to develop a comprehensive approach to combat climate change. Instead Federal agencies have sought to adopt climate change mitigation, green building and efficiency policies. The overall limited response by the federal has undermined the seriousness of the movement and has left many industrial sectors unsure of where they fit in and how they can most effectively minimize their impact. Federal political deadlock has long forced progressive climate change mitigation efforts in the U.S. to target GHG emissions and reduction options at regional, state, urban and local levels. Most climate policy has often been dominated by states, city and county governments but has used institutions such as universities, nongovernmental organizations (NGOs) and businesses to effectively research and develop mitigation practices. For example the EPA, in conjunction with the Department of Transportation (DOT) and the Department of Housing and Urban Development (HUD), are among many other federal agencies that, while initially slow to respond, have begun their campaign to reduce national, state and local emissions by enacting policies on the federal level that require big industries to reduce and account for its admissions. They also provide grants and technical assistance on the state and local level to improve and retrofit communities to be more sustainable.

Over the last decade the federal and state governments have diverged in their response to climate change. The balance of environmental activism has shifted toward state and local action on climate change through policy creation (Lutsey and Sperling, 2008). State and local communities have found pathways to support their beliefs in green policy agendas despite the federal government's refusal to ratify the

Kyoto Protocol, enact national GHG mitigation policies or mandate the use of renewable energy and energy efficiency. In the absence of federal leadership, regional, state and local policy makers have tended toward the creation of sustainable climate change mitigation practices with the goal of enhancing both the environment and their economies through policy experimentation, local tailoring of specific actions, testing political and stakeholder response and utilizing local expertise and experiences (Byrne, Hughes, Rickerson, Kurdgelashvili, 2007; Lutsey and Sperling, 2008). Policy makers have begun to confront anthropogenic impacts on the environment by looking for new ways to limit GHG emissions in all sectors of the economy mitigate the impacts for current and future impacts and encourage building firms to upgrade buildings, products and business practices.

Rather than addressing climate change as a whole, many federal, state and local entities have begun to address climate change through the many pathways by which GHG emissions are generated. By addressing energy, resource and material efficiency in the built environment separately from the climate change moniker, government entities are able to pass and use a mixture of voluntary and mandatory programs to achieve the same goal of emissions reductions.

Federal U.S. Policy

Unlike the majority of the industrial and industrializing countries who agreed to the terms of the Kyoto Protocol and have enacted GHG mitigation practices, the legislative arm of the United States has failed to systematically address GHG emissions. The closest the United States Congress has come to address climate change is through the passage of the 2007 Energy Independence and Security Act (EISA) of 2007 which focused on several practices to improve energy efficiency across several industry sectors, particularly the construction sector (GPO, 2007). While EISA contained provisions to improve fuel efficiency for vehicles, the Act focused a significant amount of attention on energy efficiency requirements construction, appliance efficiency and efficient lighting. The requirements for building energy efficiency called for voluntary and mandatory green building programs targeting federal and nonfederal buildings. Federal buildings were mandated to participate in energy efficiency retrofits and new construction while non-federal green construction was supported through a series of federal grant and incentive programs (GPO, 2007).

Federal programs focusing on the efficiency of federal construction projects and providing financial incentives and grants were developed as a result of EISA and have since been used to promote independent research and development in many climate change mitigation categories, namely renewable energy and energy efficiency for nonfederal entities. Federal agencies, led by the Administration's Council on Environmental Quality (CEQ) have taken this incentive one step further and have implemented policy specific GHG mitigation. Mitigation planning and programmatic implementation practices began in 2009 when the Obama Administration enabled the CEQ to develop climate change compliance regulations for implementation across federal agencies via its Climate Change Adaptation Task Force (referenced as 'Task Force' henceforth) (White House, 2009). Since its creation, the Task Force has developed a series of recommendations and guidelines for federal agencies to help update their policies and programs to better mitigate the impacts of land use change and climate change while incorporating conservation techniques to adapt to the changing climate. The result of this effort can be seen not only in the increased creation of climate change initiatives within federal agencies such as the Sustainable Communities Program and the Department of Energy's Energy Star Program, but also through increased research and increased policy modification to better address the impact of agency specific new and redevelopment land use project proposals on greenhouse gas emissions (USGCRP, 2012).

In 2007 the Department of Housing and Urban Development (HUD) developed a voluntary partnership program with leaders of the homebuilding, product manufacturing, insurance, and financial industries entitled Partnership for Advancing Technology in Housing (PATH). PATH was a joint NAHB and HUD program that cataloged the best resources on advanced building technologies and practices to emerge from the decade-long public-private partnership, which ended in 2008 (pathnet.org, 2008). PATH participants targeted issues and barriers related to technology development in the housing industry and assisted in the development of cost-effective solutions. This program ended in 2008.

In 2009 the U.S. Administration enacted a community level program to assist communities in prepping for climate change mitigation (White House, 2009). The Administration has appropriated millions of dollars in an effort to spur state and local redevelopment. Under this leadership the EPA created the "State and Local Climate and Energy Program" which provides technical assistance, analytical tools, and outreach support to state, local and tribal governments seeking to improve their environmental footprint (EPA_n, 2011). Distributed funds have gone towards many sectors in a community, especially the residential sector. Several recipients have used funds to not only educate the community on energy efficiency, but to also provide financial assistance for energy efficiency retrofits.

Another federal community-based program initiated in 2010 to reduce the contribution of the residential sector on climate change was the *Partnership for Sustainable Communities,* a partnership between the Housing and Urban Development Agency (HUD), Department of Transportation (DOT) and the EPA (Obama, 2010). This program was developed to ensure that the agencies' policies, programs, and funding consider environmentally friendly and energy efficient affordable housing, transportation, and environmental protection together using a holisting community approach when possible (EPA_t, 2011; HUD, 2012). The three agencies subsequently developed aligned programs, policies and funding systems to encourage state and localities to develop or redevelop their land use plans that better address smart growth strategies (EPA_t, 2011). The changes made among the federal agencies, while often progressive, lag behind many state, local and nonprofit policies and programs previously enacted across the country.

State and Local Policy

Most States and localities are able to effectively manage their environmental and economic environments independently of the federal government. Nationwide, states and localities are taking action to strengthen standards for sustainability protecting their natural environments and fighting climate change. Research has shown that the characteristics of the population (average income, level of education and the average participation in environmental pressure groups) are directly related to the degree of environment-friendly policies approved and enforced (Vachon and Menz, 2006). As incomes rise within a state and/or local population so does the support for protective environmental regulations (Frediksson, Neumayer, Damania and Gates, 2005). Cities, due to their limited environmental and economic opportunities are particularly vulnerable to climate change. Changes in precipitation adversely impacts water supplies, while sea level rise, flooding and severe weather can severely damage local infrastructure (Cohen and Miller, 2011). As a result local governments often act as laboratories for experimentation when challenged by the high-energy costs, water and air pollution, and climate change.

Climate change mitigation policy on the state and local level has progressed rapidly over the past decade. Localities have lead the way in climate change mitigation by adopting policies and programs aimed at adaptation and mitigation (Cohen and Miller, 2011). In fact, some states and localities have already put in place building code regulations requiring reviews of development proposals to determine possible adverse impacts on the environment. They have also crafted other innovative, cooperative, and increasingly bold strategies to address climate change to encourage the use of renewable energy and energy efficiency (Byrne, Hughes, Rickerson and Kurdgelashvili, 2007). Many state and local initiatives emerged from state Climate Action Plans (CAPs) developed in the 1990's (EPA, 2012). To date there are 34 counties representing 25 states that have active CAPs plans with targets of increasing alternative fuel fleets, increasing public transportation, encouraging climate-neutral land-use, increasing energy efficiency, waste management and recycling (Byrne, Hughes, Rickerson and Kurdgelashvili, 2007).

Another popular state and local program, ICLEI (Local Governments for Sustainability) has created the most extensive city-based network through its Cities for Climate Change (CCP) campaign (ICLEI, 2012). This program is partnering with approximately 1,220 local governments worldwide, 534 of which are US municipalities and have set emission reductions targets, local mitigation action plans and GHG reduction practices. Many of the US municipalities participating in ICLEI are simultaneously part of the US Mayors Climate Protection Agreement which commits to meet or exceed the US Kyoto reduction target while lobbying state, regional and federal officials to take more aggressive action on climate change (USCM, 2012). With a current commitment of 1,055 cities across the US, these nonfederal but national programs have spurred many states and localities to work toward mitigating their environmental impacts.

In addition to inter-state and inter-locality agreements, many states and localities that have adopted other policies aimed at targeting reducing GHG emissions both individually and within their regional networks. For example, California in 2006 passed the Global Warming Solutions Act of 2006 (Assembly Bill 32) which required the California Resource Board (CARB) to develop regulations that will reduce California GHG emissions to 1990 levels by 2020 (Hanemann, 2007; Byrne, Hughes, Rickerson and Kurdgelashvilli, 2007). Other prime examples include King County, Washington and the state of Massachusetts. King County took an aggressive approach to climate change mitigation. The County developed a climate plan with the goal of improving environmental quality through the mitigation of

GHGs while building community resilience against future climatic changes (Lutsey and Sperling, 2007; Saavedra and Budd, 2008). Both implemented policies that mandated the quantification of GHG emissions (both during the construction phase and the estimated emissions from owner use) (Lutsey and Sperling, 2007; MaDEP, 2008) and based on the quantification of current and future emissions, residential construction firms in these areas are mandated to pay an impact fee based on these projections.

Duplicative policies seen across states and localities are often the result of effective policy diffusion where climate change policy adoption is predicated on successful adoption of similar polices in other states, localities and communities (Mooney, 2001). The spread of efficiency and climate change policies are often the result of external pressure and the spread of innovative techniques and products. Research has found that diffusion of policies among state and local governments occurs via four primary methods: (1) learn from early adopters; (2) economic competition; (3) imitation; and (4) coercion (Shipan and Volden, 2008). In the absence of federal mandates, the most substantive policy information is usually derived from another's implemented regulatory experience and may spark regional adoptions if the policy is found to benefit the state's interests (Mooney, 2001).

Due to the complexity of climate change, state and local policy makers often target specific areas that increase GHG emissions, learning from early adopters while following the trends set by neighboring governments. States and localities are able to create localized solutions because they have direct authority over transportation systems, community development, energy efficiency measures, and renewable energy investments (Cohen and Miller, 2011). Increasingly these states and localities target energy, water and resource efficiency policies and programs. The mayorEnergy generation and consumption are two of the most significant contributors to GHG emissions. Today approximately 41 states have adopted energy and water efficiency codes that establish efficiency standards for residential and commercial use (Byrne, Hughes, Rickerson, Kurdgelashvilli, 2007). These energy efficiency codes have specific requirements for "thermal resistance" in the building shell and windows, minimum air leakage, and minimum heating and cooling equipment efficiencies (Laustsen, 2008). These prescriptive standards have spurred many in the residential construction industry look at green building as not only for compliance, but for a competative edge as well. The efforts made by state and local governments to address their impacts on climate change, while independent of actions of the federal government, may be eventually passed to the national level, providing the ability to spotlight the vetted practices employed across a range of industry sectors.

Chapter 4 | Residential Construction and Policy

The residential industry is a very diverse industry composed of small, medium and high production firms (Allen and Thallon, 2011). The construction sector creates a built environment that develops the major components of people's surrounds including roads, sidewalks, green spaces and transportation systems (Younger, Morrow-Almeida and Dannenberg, 2008). The built environment consumes a conservable amount of raw materials during construction and produces a significant amount of waste during both the construction and demolition processes (Chau and Chung, 2012). Not surprisingly, the built environment has become a major focal industry for those seeking to encourage sustainable industry practices. The construction industry has worked to minimize both the raw materials used and waste generated associated with construction projects while maintaining a standard of excellence for the products built. But despite the increased interest, policy and management literature has paid little attention to the residential construction sector but has instead focused on the more 'glamorous' sectors, such as the chemical, electronic and automobile industries (Pries and Jenszen, 1995).

Due to limited in-depth research, little is known about the inner workings of not only the residential construction industry as a whole, but also the hundreds of thousands of individual firms operating across the country (NAHB, 2010). What is known is that the US residential construction industry includes hundreds of thousands of firms (single-location companies and branches of multi-location companies), with a vast majority having fewer than 10 employees (National Research Council, 2009). The residential construction is traditionally a very labor-intensive process. As a result the residential construction industry has employed approximately 8 million people (BLS, 2009) on an annual basis and accounted for nearly 4.4% of the nation's GDP for several years prior to the economic recession (National Research Council, 2009). The recent downturn severely impacted the housing sector in both negative (massive job and economic loss) and positive encouraged builders to reevaluate internal decision making procedures resulting in a shift in the manner in which builders construct homes) manners.

While a majority of builders across the nation are small businesses who construct single family homes, many firms also construct multifamily homes, remodel homes, and high production portfolios (National Research Council, 2009; NAHB, 2010; Allen and Thallon, 2011). These firms build huge communities and hundreds of homes across the nation. Each home and community built requires multiple unique actors vital to the planning, development and post development processes. This often results in each project is unique and decentralized.

Structure of the Industry

The residential construction industry is driven by economic and population growth, which results in, increased housing demand and has been keenly influential to the United States economy for decades (Emrath and Fei, 2007; Allen and Thallon, 2011). For example, from 1980 – 2005 there has been a 30% increase in population growth across the nation (DOE, 2008). Homes of some type are required by everyone and a home is the single largest purchase most consumers make. The health of the residential construction industry, which includes the building of new structures and the remodeling of existing ones, can indicate how the American economy is performing.

The structure and operation of the home building industry is both unique and diverse, with many companies filling specific niches by specializing in specific techniques (Eccles, 1982). The industry in general is characterized by the great number of small enterprises with varying collaborations but where project partnerships hardly exist (Pries and Jenszen, 1995). This loosely coupled design is exemplified in home design and production where successfully executing of a project requires the participation and contribution of various entities that work independently of one another. The use of specialized services and products results in industry fragmentation but has proven profitable for small businesses seeking to fulfill a niche.

This is exemplified in firms that focus on specific services such as developing land, constructing specific types of homes, and products for homes under construction. Most homes built are constructed on site and require a variety of specialized subcontractors, whose work is inclusive of electrical, plumbing and carpentry work (Hart, 2009). Workers are employed to directly engage in construction activity. Jobs are generated in the industries where lumber, concrete, lighting fixtures, heating equipment, and other products that go into a home are produced, sold and installed. Additional jobs are created when real estate agents, lawyers, brokers and financial institutions provide services to homebuilders and homebuyers.

Builder Characteristics

There are two primary groups of residential construction builders, single-family builders and multifamily builders. Of these two major groupings, the single-family builder is further subdivided into the custom builder, small volume builder and high production builder. Many builders who build new construction also engage in remodeling single-family homes. It does not include apartments, duplexes, or condominiums. The primary interface that single-family homebuilders have with regulating entities is with their local building officials. Single-family building firms typically have the owner function as the president or CEO and are mostly family-run operations containing few employees and relying heavily on subcontractors to provide needed services.

Single-family custom builders build unique, generally higher-end homes designed by or for and built specific client. These homes are generally built on land that the customer owns. Custom homebuilders are small firms and typically have small staffs that are responsible for fulfilling the complete array of tasks associated with the firm, including marketing, administrative, and construction duties. Custom builders, on average, build 5-10 homes per year (NAHB, 2009).

Single-family small volume builders build standard or semi-custom homes that generally span multiple price points including starter homes, move ups and luxury homes. While some of these homes are sold prior to construction, many of them are built "on spec," meaning the builder is taking a risk and speculating that a buyer will come along (NAHB, 2009) after the home is constructed. The builder also typically purchases the land on which the house is to be built from a developer or other entity within an existing community. Small volume builders generally build 5-10 homes per year.

Single-family production builders build standard and semi-custom homes at all price points, but build several homes using the same (or very similar) set of floor plans. They both build on land that they own, as well as purchase lots from other builders and developers in a community. They are mostly regional firms, but also include large national firms. Production builders average 50-150 homes per year, with some producing more than 1000 (NAHB, 2009).

Multifamily builders build multifamily residential housing units that consist of either high-rise apartments, townhouses, condominiums, and medium-to-high density homes. Builders of these types of homes will either sell or rent the individual units (NAHB, 2009). Multifamily construction firms design and build communities on land they own and develop. Typically there is only one multifamily firm building in a community.

Innovation

The residential construction industry often faces both support and obstacles that affect firm level innovation. Innovation is typically associated with internal motivation, competition, compliance or the result of copycat behaviors while costs, product suppliers, and relevant information on innovative techniques hinder innovation. Innovation is associated with a firm adopting techniques, technologies or programs that have been previously unused by the adopting business. Traditional community design practices adversely contribute to global climate change (Younger, Morrow-Almeida and Dannenberg, 2008).

Materials and practices used during construction generally depend on the type of house being built, the target market sought, and the geographic location of the home. Although the materials used in home construction have changed over the past century, the essential construction and development process has not. Homes are constructed in a specified order, from land grading and development to the construction of the home. Innovation in the industry modifies this behavior and encourages alternative behaviors.

Increasingly residential construction firms have begun to use innovative land and home construction techniques. Many have changed how they develop the land, the materials used when constructing the home and how the home is constructed and positioned. These processes not only minimize environmental impacts, but it also has the ability to be environmentally beneficial. For example, builders in the far north and south build more efficient homes due to the dramatic changes in climate. The use of energy efficient heating, ventilation, and air condition (HVAC) systems and products not only benefits the consumer, but reduces the amount of GHG emissions as well (DOE_a, 2008). Increased innovation and the subsequent development of more efficient homes have helped control residential emissions despite the increase in U.S. population. From 1990-2008, while the U.S. population grew by an average of 1.1 percent per year, the residential sector carbon dioxide emissions grew by an average of 1.3 percent for the same time period (Pew Center, 2009). The consumption choices of households play a major role in determining current and future GHG emissions. Energy consumption in the residential sector occurs in two stages: the embodied energy of buildings and the operational energy use. Embodied energy addressed the energy needed to construct the building while operational energy use includes household heating, air conditioning and other household activities. As Figure 4 demonstrates, there has been a dramatic increase in the number of homes, size of the home and the energy used over the last several years (DOE, 2008). This trend, while stunted due to the recent recession, has the ability to continue to significantly contribute to the increase in the GHGs emitted in the building sector.

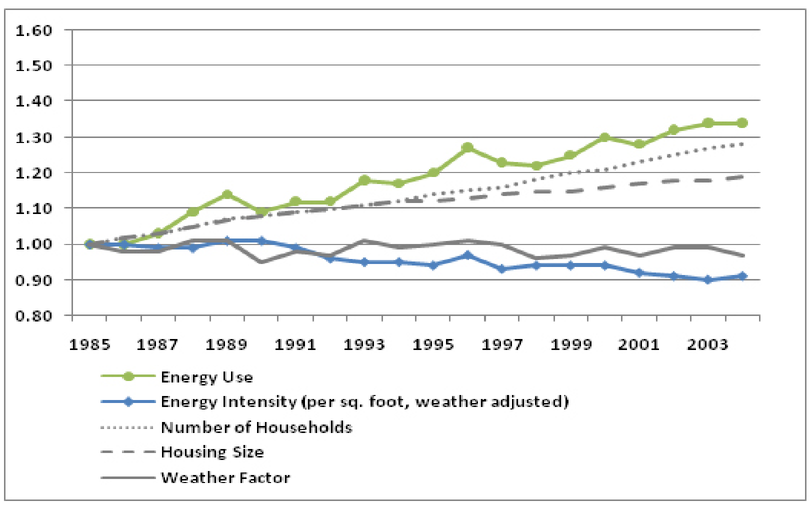

Figure 4: Residential Energy Use, Energy Use Intensity, and Energy Use Factors (DOE, 2008)

Regulatory Authority

The construction of residential homes must comply with federal, state and local regulations. In order to build a home, a residential construction firm must comply with a series of state and local building codes, safety codes and environmental regulations. In recent years the industry has experienced increased deregulation and decentralization with construction codes and standards while simultaneously experiencing a dramatic increase in environmental regulatory oversight on the federal, state and local level.

Environmental regulations often vary across the federal, state and local governments. Building codes across the nation have recently begun to include environmental and efficiency requirements to address the current and future environmental impacts associated with not only construction but use of the home as well. Builders across the nation are now required to minimize land grading as much as possible, limit stormwater runoff, use native plants and preserve existing tree stands EPA$_{o}$, 2008). The latest trend on the federal, state and local level is a push to increase sustainable development of homes and communities. Sustainable development is generally defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987: 1) and typically requires a builder to implement practices that conserve natural resources and lessen the effect of other environmental threats, including greenhouse gas emissions and climate change (Sathaye et al., 2007). While the federal agencies may provide baseline compliance strategies, environmental regulations allow and encourage state policy development and self-regulation. This open-ended format has often lead to inconsistent policy formation on the state and local level.

The lack of consistency has enabled several groups to develop building codes that are voluntary, recognizable, vetted and accepted by the residential construction industry across the nation. These residential building codes which include the International Residential Code (IRC), the National Green Building Standard, the International Green Construction Code and LEED for homes have all attempted to standardize and stabilize green construction codes in a recognizable manner across multiple states if not the country. While many programs encourage voluntary firm implementation, a majority of the states and localities across the country have adopted these building codes as mandatory compliance programs as part of their mitigation plan.

Chapter 5 | Green Building

Residential building performance is the result of the age of the home, how the home was constructed and how it is used. The age of residential homes inherently impacts the efficiency of the home with older homes being more inefficient than new construction. The EIA conducted a survey in 2009 that showed that pre-1991 homes, consists of a majority of the housing stock, account for 82% of the nation's residential energy consumption. Of this, home heating and cooling system use the largest area of building energy demand, accounting for approximately 42%-68% of end-use energy demand for residential buildings.

Sustainable development and green building practices have grown in popularity over the last several years. Green Building is characterized as "integrated building practices that significantly reduce the environmental footprint of a building in comparison to standard building practices" (Fischer, 2010: 1) and promotes resource conservation, water conservation, site impact minimization and energy efficiency through the reduction of heating/cooling loads, improvement of efficiency of conversion/distribution and the employment of passive designs where possible for higher quality conditioning (Mohareb, et. al, 2011). The share of homes being built in the U.S. with environmentally friendly features jumped to 16% of all single-family starts last year, a dramatic increase from 2% in 2006 (Bernstein, Russo and Laquidara-Carr, 2011). Green homes generally cost more than a typical home depending on the features included. Recent research has shown, however, that the gap between the costs of green and traditional homes continues to decrease as green products become more commonplace. The use of green building products and practices is seen by many as the most effective way the residential industry can mitigate its greenhouse gas emissions and contribution to climate change.

The residential construction industry directly and indirectly influences the amount of GHGs emitted annually (Younger, Morrow-Almeida and Dannenberg, 2008). While direct GHG emissions from the construction phase are minimal, indirect GHG emissions based on home use can be significant. According to a 2009 EIA Residential Consumption Survey, over the past three decades the share of residential electricity used by appliances and electronics in U.S. homes nearly doubled, increasing from 17 percent to 31 percent without alternative products and techniques, this rate of use would increase dramatically. For example, household behavior, such as how long lights are left on, may have as great an impact on residential electricity consumption as the number of built-in appliances or other amenities provided by homebuilders. As a result, the largest categorical GHG emission contribution is the result of producing and using electrical energy (EIA, 2011). With minimal mitigation opportunities, green building and its multiple areas for climate change mitigation techniques have increasingly been used as a tool for the residential construction industry to mitigate its climatic impact.

The residential sector is responsbile for 17% of US GHG emissions (EPA_c, 2010; Brown, Southworth, and Stovall, 2005; EIA, 2011). Buildings affect the potential and actual GHG emissions through their design, location, orientation, and use, including material composition, and energy use and water resources used by occupants. Carbon Dioxide emissions from this sector are primarily caused by electricity to provide heating, cooling, lighting, water, information management and entertainment systems and account for over 70 percent of US building sector emissions are caused by electricity consumption (Younger, Morrow-Almeida and Dannenberg, 2008).

Resource and material efficiency are also very important to the green building strategy. Federal, state and local regulators did not have specifications on the quality of materials used as long as they complied with applicable codes and standards. As a result, newly built homes, unless otherwise requested, were not made to maximize natural lighting, be resource and material efficient or conserve energy.

The Substance of Green Building

Green building enables firms to adopt practices that implement resource, material and energy efficiency techniques. Green building practices not only increase the efficiency with which buildings and their sites use energy, water, and materials; it also reduces a building impacts on human health and the environment, through better sitting, design, construction, operation, maintenance, and removal– the complete building life cycle (NAHBgreen, 2009; EPA_c, 2010). Green buildings typically encourage the use of not only environmental friendly products but locally produced materials as well that support local economies and reduce emissions associated with transportation (Younger, Morrow-Almeida and Dannenberg, 2008). For years most firms regarded green building as a novelty or a project done on demand but infeasible in the general home building world for the average customer due to costs and limited availability of materials. This view has changed as green products become more affordable.

Since originally presented on the consumer market, green building products and practices have evolved and continue to evolve to reduce costs and increase availability to consumers. While prices have come down, green building materials continue to be more expensive but offer long-term savings to building owners and occupants (Younger, Morrow-Almeida and Dannenberg, 2008). Today the green building approach is comprehensive and focuses on a building's complete environmental footprint, from its initial design through to its eventual demolition. As a result green building continues to gain ground in the residential construction industry and currently represent an almost $50 billion industry in the United States today. Drivers of the green building expansion include federal initiatives, state and local statutes and building codes, public and private financing requirements, utility demand response programs, and consumer demand.

Green building continues to provide many opportunities to reduce the environmental impact of the residential sector both during construction and with post construction use of the home. Minimizing the impact during the construction process is done by implementing environmental site design practices that encourage the use of low impact techniques for phased construction, home placement, alternative permeable covers, and maximizing vegetative buffers and landscaping. Important green building practices require the installation of water, and resource and energy efficient products and materials. Green building can also use natural lighting, highly efficient heating, ventilation, and air-conditioning (HVAC) systems and low- volatile organic compounds (VOC) materials like paint, flooring and furniture to create enhanced indoor air quality. Green building practices assist in reducing the post construction resource energy consumption by making the home more efficient.

Green building has been shown to not only minimize a building's environmental footprint, it can also minimize its contribution to air pollution, GHG emissions and ultimately climate change (Deuble and de Dear, 2012; Chau and Chung, 2011; Fischer, 2010; Brown and Southworth, 2008; Hoffman and Henn, 2008). Green building encompasses practices, techniques, and construction products that are less resource-intensive or pollution-producing than regular construction techniques (NAHB, 2008; Brown and Southworth, 2008).

Components of Green Building Programs

A green home is composed of several independent components which, when planned and fully considered, can work together to increase performance and efficiency (NAHB, 2008). The installation of water, resource and energy efficient products and materials is seen by many policymakers and utility regulators as the most cost effective strategy to help maximize resources used while minimizing environmental impact (Brown and Southworth, 2008; Vine, 2007).

Water efficient homes use less water due to water efficient products and techniques installed in the home. Resource efficient homes use recycled or composite material that is less energy and pollutant intensive during the manufacturing process. Energy-efficient buildings inherently use less energy due to the installation of energy efficient appliances, encourage home placement to maximize natural light, installation of upgraded insulation and the preservation of large shade trees on the property. These techniques are seen by climate change experts as the most cost effective approaches to mitigating greenhouse gas emissions (Brown and Southworth, 2008) because of its ability to reduce products used, resources needed and a buildings carbon output for the financial investment.

Environmental Site Design (ESD)

Environmental Site Design minimize on-site grading, save natural resources by using alternative building materials, and recycle construction waste. These techniques enable firms to reduce deforestation (thereby maintaining some or most of the carbon sink capabilities), increase the retention of native plants, strategic position homes to maximize natural lighting and solar energy, retain and use of storm water, and minimize impervious surfaces.

Traditional land development practices have had significant impacts on a site's hydrology and ecology. Environmental site design is used to develop a site plan that can mimic the natural hydrologic runoff characteristics and minimize the impact of land development on the environment (Beer and Higgins, 2005, EPA_q, 2010). These building practices created impermeable surfaces with substantial impacts on stormwater management. Often synonymous with Low Impact Development (LID), Green Infrastructure and Sustainable Site Design (SSD), ESD strategies encourage conservation practices by optimizing and preserving the natural features of the property (for example drainage patterns, vegetation and soil), minimizing impervious surfaces (thereby minimizing runoff and maximizing infiltration and evapotranspiration), phasing of land clearance, protecting environmentally sensitive areas, and planning for post construction management of the project (Beer and Higgins, 2005; Davis, 2005; EPA_q, 2010).

LID is an important tool under ESD to minimize the environmental impact of construction projects. By addressing stormwater runoff and water retention issues on site, LID is able to focus on maintaining predevelopment hydrology thereby reducing compaction and other adverse impacts associated with land development (Rushton, 2001; Davis, 2005). Similar to ESD, LID integrates green space, native landscaping, natural hydrologic functions, and various other techniques to generate less runoff from developed land and to infiltrate rainfall water to groundwater, rather than exporting it as a waste product down storm sewers (Davis, 2005). Firms are able to customize strategies according to site conditions in order to reduce pollutants and control runoff. LID is particularly effective when integrated into a series of linked, strategically placed design elements that each contribute to the management of stormwater.

Energy Efficiency

Energy consumption and demand for services has one of the highest levels of environmental impact than any other human activity and is dependent upon culture and human behavior. Energy generation is carbon intensive and is the result of the combustion of coal, oil and/or gas. To effectively distribute energy across the country, the U.S. has invested billions to improve the infrastructure for several decades. As a result most Americans are afforded the luxury of space conditioning, and use of appliances that electricity affords. As a result, in the United States the principle type of energy consumption is from electricity (EIA_a, 2008; EPA_l, 2012).

The current process of procuring, manufacturing and the use of coal, oil and/or gas to generate energy results in significant amounts of GHG emissions, air pollution and acid rain. These emissions not only adversely impacts terrestrial and aquatic environments but also contribute significantly to the atmospheric build-up of GHGs (EPA_l, 2012). Over 70 percent of U.S. electricity is generated by CO_2 intensive products including burning coal, petroleum, or natural gas (Deuble and de Dear, 2012; EERE, 2008). The combustion of fossil fuels for electricity generation makes buildings responsible for one of the largest shares of U.S. carbon dioxide emissions (Deuble and de Dear, 2012). Many government agencies and industries have recognized that a majority of the electricity generated across the nation is used and wasted in residential buildings and as such have begun to encourage the use of energy efficient products and techniques.

Electricity use in the residential sector, as Figure 5 illustrates, is driven by a variety of factors directly related to the in-home electricity consumption associated with lighting, heating and cooling, water heating, electronic entertainment, and refrigeration and cooking. Space conditioning (heating and cooling) is the largest form of building energy use and accounts for 42 – 68 percent of end-use energy for residential buildings (Mohareb, et. al, 2011). Energy use in the residential building sector accounts for 22 percent of the nation's energy use (DOE, 2010) and is driven by population growth; economic growth; building size; service demands and real energy prices (EERE, 2008).

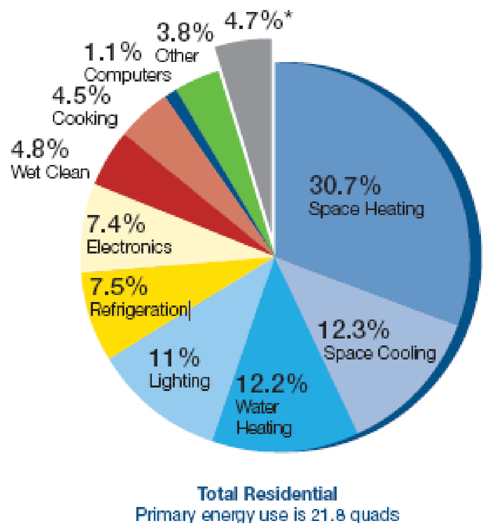

Figure 5: Residential Primary Energy End-Use (EERE, 2008)

Reductions in a home's energy footprint is one of the most significant aspects of green building (Fischer, 2010) and is seen by climate change experts as one of the most cost effective approaches to mitigating greenhouse gas emissions (Brown and Southworth, 2008). Green building practices are able to improve the efficiency of energy conversion and distribution and employ passive designs where possible for lower input and higher quality conditioning, thereby reducing heating and cooling loads (Mohareb et. al, 2011). Energy efficient products and home improvement practices have been shown to costs, reduce building sector GHG emissions and improve local air pollution.

The United States has not adopted a national energy efficiency building code standard. Instead, over the last decade Congress established minimum energy efficiency standards for several major residential appliances ($EERE_b$, 2005; EISA, 2007). Since then several subsequent polices by federal agencies have further improved the energy efficiency requirements associated with most household appliances. For example, federal efficiency requirements for the standard refrigerator, freezer, washer/dryer units, dishwashers ranges and ovens and water heaters have made these products much more energy efficient than they were several years ago (Meyers, McMahon, McNeil, Liu, 2003). These efficiency standards have begun to fill the gap left by the lack of a national baseline building energy code.

The lack of federal requirements for residential energy efficiency building codes has left the development and implementation of energy efficiency building codes to state and local jurisdiction. In the absence of federal oversight, states have made efforts to stimulate energy efficiency improvements while simultaneously going beyond early efforts of adopting high-efficiency appliance standards (Byrne, Hughes, Rickerson and Kurdgelashvili, 2007) by incentivizing advanced technologies and appliances. Increasingly more and more states and localities have begun to develop state-funded rebate programs to encourage the purchase of a wide range of energy efficient products. In addition, many state and local jurisdictions have looked towards several national energy efficiency policy programs developed by the International Code Council (ICC), the American National Standards Institute (ANSI) and the International Energy Conservation Code® (IECC®) among others. While all of the energy efficiency programs across the nation are voluntary, increasingly federal agencies, states and localities have adopted and are mandating the use of these voluntary building codes, particularly those reviewed and approved by the ICC.

On the Federal side, the Department of Energy (DOE) encourages the adoption of the IECC® 2009 residential energy code to state and local agencies developing their own set of energy codes. The 2009 IECC® is a national, consensus-based, model code with strategies that result in a 12 to 15% annual energy savings by requiring improved window solar heat rejection, high efficiency light fixtures and low leakage ducts and building structures (ICC, 2009). There are currently twelve states and one U.S. Territory that have statewide codes while a total of thirty two have met basic IECC standards as set forth in the Energy Policy Act of 1992 Figure 5 (EERE, 2008).

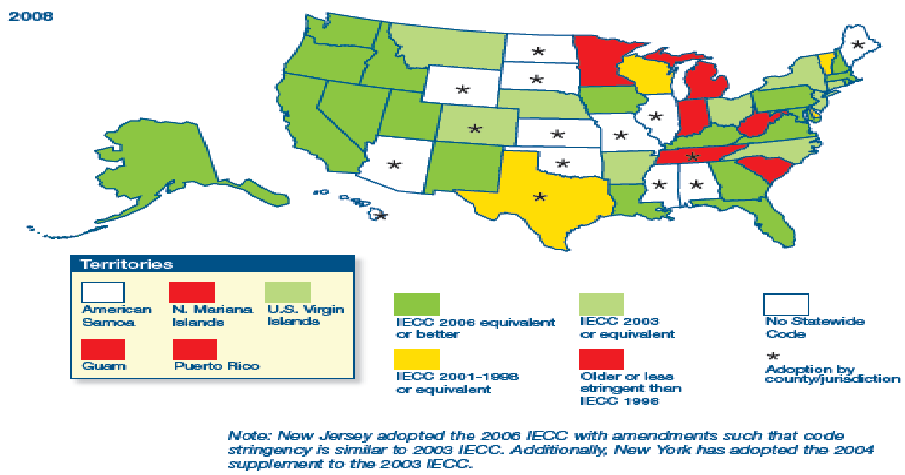

Figure 6: Residential Energy Codes by State as of August 2008 (EERE, 2008).

The use of energy efficiency requirements is one of the principle ways builders and building owners are able to voluntarily mitigate GHG emissions. The increased tendency for energy efficiency mandates for products and home construction is the latest trend to ensure more efficient home construction and use.

Water Efficiency

Encouraging water conservation and reducing residential water usage are also important components of green building. Water efficiency has been defined as "the long-term ethic of saving water resources through the employment of water saving technologies and activities" (EPA_b, 2010: 1) such as reduced – flow plumbing fixtures, recycling of wastewater, and landscaping designed to reduce irrigation requirements (Fischer, 2010). Water efficiency practices also include Low Impact Development (LID), rain gardens, vegetated rooftops, rain barrels, and permeable pavements have been shown to reduce not only water consumption, but reduce energy consumption as well (Fioretti et. al., 2010; EPA_b, 2010; Cheng, 2003). Recently federal agencies, states and localities have encouraged the use of indoor and outdoor water conservation technologies and practices to offset water consumption rates.

The use of water efficient products within the building sector is critical because consumption has risen 25% between 1985 and 2005 (Fischer, 2010) and is the result of a variety of factors. On average, most homes today have more bathrooms, appliances and larger yards than homes previously built which require increased water allottments. A majority of the water used by the building sector has been shown to go towards outdoor water use, particularly landscaping irrigation (WaterSense, 2009). EPA has found that the average single-family suburban home uses up to 30% of its water use for outdoor purposes (EPA_b, 2010). Due to this degree of usage, many water efficient products address not only indoor products, but outdoor products for residential and commercial construction as well.

Materials and Resource Efficiency

Historically products and materials used in the residential sector were not built and installed to minimize a homes' environmental impact. Instead homes were built based on the aesthetic appeal and often resulted in the use of materials that were not sustainably produced. The use of material and resource efficient products works to reverse this practice and instead encourage continuous selection of construction materials. Material efficiency encourages reusing and recycling construction materials and products can be made from renewable resources or can be created with processes that use low amounts of energy, and produce low amounts of pollutants (Bribián et.al, 2011; Chau and Chung, 2010; EPA_c, 2007). In addition material and resource efficiency also incorporates materials harvested from sustainably managed sources which have been certified by an independent party and minimizing the transportation distance of materials thereby reducing the emissions and energy use over the life of the material (WRAP, 2010).

The typical lifecycle of a home goes from its original construction through multiple families and multiple renovations until its deconstruction. Types of materials used during home construction affects the rate of resource depletion, pollution, and energy and resource consumption. The use of efficient materials and resources reduces the amount of raw materials needed; energy consumed and can encourage the reuse construction and demolition (C&D) debris. C&D materials often contain products and materials that can be repurposed and reused (for example concrete, wood, metals, glass etc) but currently is not effectively being done. C&D debris accounts for nearly 26 percent of the total non-industrial waste generated in the United States of which only 20 to 30 percent is recovered and recycled (EPA_e, 2009).

While the reuse of materials enables firms to minimize the amount of required raw materials and energy; minimizing waste disposed to a landfill, creating jobs and reducing costs associated with avoided purchase/disposal costs (EPA_a, 2010), this practice is not mandated or encouraged with incentives. Instead firms have begun to incorporate these practices when possible as part of their efforts to reduce a project's environmental footprint.

Indoor Environmental Quality

Indoor Environmental Quality refers to the quality of the air within a building and are increasingly an area of concern within the green building movement. Indoor environments are complex and often have a variety of pollutants from a variety of indoor and outdoor sources. Due to limited air flow, indoor air pollutants are often found in substantially higher concentrations when compared to outdoor environments (Field, 2010). Recent studies show that on average indoor levels of pollutants are two to five times higher than outdoor levels and are contributed to the combustion materials; the off-gassing from building materials and furnishings; household cleaning; and gases from HVAC systems and outdoor sources (EPA_e, 2009) Figure 6.

The quality of the indoor environment is important because people spend over 90% of their time indoors (EPA_d, 2010). As a result, there are increased health risks due to prolonged exposure to inadequate indoor environmental quality, chemical contaminants, poor lighting and temperature has been shown to result in adverse human health and productivity impacts (Fisk, 2002; EPA_d, 2010).

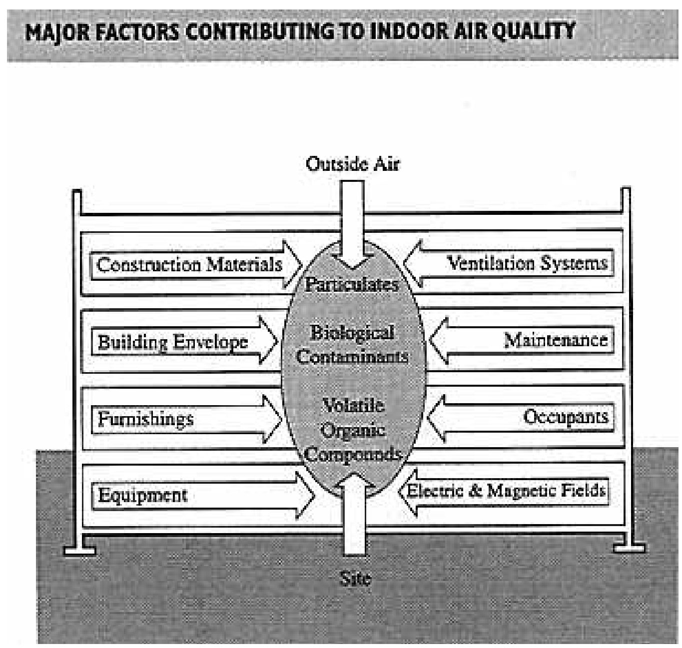

Figure 7: Major Factors Contributing to Indoor Air Quality (USGBC, 1996)

The adoption of green building practices can positively impact the physical and psychological health of building occupants through improved technology. Many green building programs encourage the use of HVAC system designs that effectively control indoor humidity, developing a building envelope design that prevents the intrusion of moisture, and the creation of high performance luminous environment through natural and artificial light sources while avoiding the use of materials high in pollutants, such as volatile organic compounds or toxins (Kreith and Goswami, 2007; Fisk, 2002; EPA_d, 2010).

Several national programs stress the effective implementation of environmental site design, energy efficiency, water efficiency, material/resource efficiency and indoor environmental quality. There are several green building programs that provide innovative techniques to minimize the environmental impact of residential construction projects by incorporating green building efficiency requirements.

National Green Building Programs

The green building movement originally began in the 1970's in response to the energy crisis. As the crisis devolved, builders and designers looked for ways to reduce the reliance of buildings and homes on fossil fuels and looked for alternative solutions. This movement regained mainstream attention in the 1990's after the 1992 Earth Summit in Rio de Janeiro. Since then green building programs have developed slowly but consistently. Today while there are several programs that require green building practices, only four of them have significant builder participation across the nation. These programs, NAHBgreen, LEED for Homes, EnergyStar, and WaterSense, use core green building principles to develop comprehensive programs that maximize products and services while minimizing a project's impact on the environment. As a result homes are more energy and resource efficient than they were 20 years ago and continue to be built with a smaller overall environmental footprint.

EPA WaterSense

The EPA WaterSense Program is a unique federal program that directly advocates for reductions in indoor and outdoor residential water use. The goal of the program is to decrease the indoor and outdoor non-agricultural water use through the promotion of more efficient products, equipment and programs (WaterSense, 2010) by at least 20 percent. In addition to promoting water efficient products and equipment, the EPA WaterSense program recently released a New Home Certification Program which not only promoted the use of water efficient products and equipment, but is also able to certify new homes that fulfill the required water use reduction products and techniques.

Energy Star

Energy Star, a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy, was created to encourage the development of energy efficient products and practices in 1992. Energy Star provides technical information, tools and a product certification program promoting energy efficiency for major appliances, office equipment, lighting, home electronics and residential and office buildings (DOE and EPA, 2011). The Energy Star home certification program requires all homes to be 15% more efficient than the 2004 International Residential Code (IRC). The IRC is a comprehensive residential code for one and two family dwellings of three stories or less. The IRC provides a prescriptive approach (i.e. a set of measures) and performance standards (EPA and DOE, 2011). The widespread use of the Energy Star program has assisted firms in reducing greenhouse gas contributions in the residential construction industry. For example, Ryan Homes, a residential construction firm building throughout Virginia voluntarily complies with the EnergyStar program, certifying every home they build as energy star compliant. Other smaller builders will comply with the EnergyStar requirements but stop short with completing the full certification process.

NAHB Green Building Standard

In 2008 the National Association of Home Builders (NAHB) developed the National Green Building Standard (NGBS) in conjunction with the International Code Council (ICC) which provides builders a certified guide that can be used when developing a green home. The Standard defines green building for single- and multifamily homes, residential remodeling projects, and site development projects while allowing for flexibility with regionally-appropriate best green practices (NAHBGreen, 2009). The NGBS is applicable to subdivisions, building sites, alternations, additions, renovations, mixed-use residential development, and residential portions of any building (Corn et al., 2010).

The standard has both mandatory compliance measures and voluntary measures both of which are contingent upon depending on the level of certification selected. Many of the mandatory measures in the Standard are consistent with the 2006 IECC building energy codes that have been adopted by several states across the nation. While the NGBS program addresses more than just energy efficiency in its certification process, incorporating energy efficient products that are also water efficient while simultaneously promoting environmental quality have been key to the program's success.

LEED for Homes

The US Green Building Council (USGBC) a fixture in the commercial sustainable development market, recently developed a new residential program as a LEED (Leadership in Energy and Environmental Design) for homes and a REGREEN program (USGBC, 2010) for redevelopment projects. Both programs use conservation strategies to improve performance, increase energy savings, water efficiency and carbon emission reductions, stewardship of resources, and improvements to indoor environmental quality (USGBC, 2010). While REGREEN provides guidelines for remodeling activities, LEED for homes program is designed to assess new single-family low to midrise multifamily housing of six stories or less (ASID, 2010; USGBC, 2010). Similarly to the NAHB Green Building Standard, the LEED for Homes program has gained in popularity with many because of its focus the design of the home, not just its focus on energy efficiency.

Green building principles and practices are found interwoven in many residential construction programs across the nation but there lacks a federal compliance baseline for green building practices and strategies. Despite the lack of federal oversight, green building programs have successfully advocated for the enhancement of environmental site design practices, energy efficient products and materials, water efficient products and materials, materials and resource efficiency practices and improved indoor environmental quality which are increasingly being adopted across the nation. These components and techniques are vital to the successful implementation of a green project and the success of the green building movement.

Chapter 6 | Literature Review

The search of available literature for this study identified extensive existing research addressing the institutional, uncertainty and stakeholder pressure theories. The comprehensive search revealed a robust literature set available that addresses, individually, the unique issues surrounding uncertainty, institutional theory and stakeholder theory. Literature discussing uncertainty, institutional and stakeholder theory has been available and refined over the past several years.

While a sizable body of literature exists separately for the three conceptual areas to be studied, there an insufficient amount of research evaluating the relationship between them. Existing research has failed to address this gap, resulting in little information addressing the relationship between the degree of institutionalization of green values when environmental and regulatory uncertainty is present. This research will extend what is currently known about institution theory and the rate of institutionalization by analyzing the impact uncertainty plays on the influence of internal and external stakeholder pressures.

Institutional theory

Institutional Theory analyzes the influential role pressure plays on adopting and institutionalizing proactive environmental values and behaviors. Institutional Theory has evolved as a manner in which firms address the influence external and internal forces have on firm practices and decision making processes (Delmas and Toffel, 2003) while identifying how and why items become institutionalized (e.g. values and practices) within institutions (Jennings and Zandberger, 1995). Pressure within institutions often comes from either decision makers or employees are responsible for driving environmental behavior and the adoption of environmental techniques because they are able to use a “top-down” approach. External pressure, on the other hand, can come from a variety of sources and often influence a firm’s long-term success in a community. Failure to address the concerns of entities external pressure can adversely impact a firm’s ability to survive and grow in a competitive market.

Researchers have studied institutions, institutional pressures and the process surrounding the adoption and institutionalization of environmental management practices for many years. Businesses must remain competitive; maintain a positive corporate image; and a high quality product all factor into a business’ success. Poor environmental performance has historically been viewed as exposing firms to greater risks of liabilities, penalties, higher future costs of compliance and poor environmental management practices all of which adversely impacts a firm's ability to be successful. In order to counter the backlash associated with poor environmental performance, many firms enact proactive rather than reactive environmental protection initiatives geared toward integrating-environmental considerations into production decisions (Khanna and Anton, 2002). Research on the institutionalization of environmental management practices has shown that such values and practices evolve out of a widespread, cumulative process that esults in the diffusion of new management practices and institutional behavior (Meyer and Scott, 1983; Scott and Meyer, 1994; Jennings and Zandberger, 1995). Values and behaviors that are institutionalized are done so to not only improve the firm's image within the community but to also gain legitimacy, resources, stability and enhanced competitive edge (Meyer and Rowan, 1977).

Institutional theory research analyzes what motivates firms to alter their environmental approach in order to better address the environmental impact of their activities. These studies found that perceived internal and external pressures have a strong role in explaining the adoption of environmental practices by firms (Henriques and Sadorsky, 1996; Hoffman, 2000; Khanna and Speir, 2007; Khanna et. al, 2007). Specifically, Henriques and Sadorsky (1997) found that customer pressure, stakeholder pressure, regulatory pressure and community pressures and lower sales-to-asset ratio estimates motivate firms to adopt environmental management plans. Similarly Hoffman (1997) found that increasing external environmental quality pressures among consumers, investors, lenders, competitor firms and communities have created a level of expectations that causes firms to view environmental protection as being central to the core objectives. Several studies analyzed the different internal and external pressures associated with environmental initiatives to determine whether environmental practices and practices differ significantly across firms with different motivations. These studies found that while firms face a variety of pressures that are influential to the adoption of proactive environmental practices, certain pressures including regulatory compliance, competitive advantage, stakeholder pressures, ethical concerns, and top management initiatives were the most influential motivators on firm environmental initiatives (Paulraj, 2009; Bansal and Roth, 2000; Dimaggio and Powell, 1983; Khanna and Anton, 2002).

Pressures exerted onto firms to modify existing pressures are categorized as one of three types: Coercive Pressure, Normative Pressure and Mimetic Pressure (DiMaggio and Powell, 1983; DiMaggio and Powell 1991; Scott, 1995; Lawrence, Winn and Jennings, 2001, Delmas and Toffel, 2003). *Coercive Pressure* has been defined as the threat or actual use of force by a powerful actor in order to gain compliance (DiMaggio and Powell, 1983). This form of pressure is associated with regulators. *Normative Pressure* has been defined as cultural or societal expectations that firms feel compelled to honor, often because they are rooted in professional affiliations. Institutional theory emphasizes the role of cultural and social pressures imposed on firms that influence firm practices and behavior (Scott, 1992). Finally, *Mimetic Pressure* has been defined as the perception of some value mimicking a behavior from other referent actors, often because they are rooted in professional affiliations. Firms have a tendency to mimic the practices that successful leading firms have adopted (Delmas and Toffel, 2003). D'Aunno et al. (2000) found that various stakeholder types are able to exert force that can successfully encourage strategic change that diverges from institutional norms. While this study will not specifically identify these pressure types in the manner in which Dimaggio and Powell (1991) originally described them, it will be evaluated conceptually within this research. This study will evaluate the pressures in a more generalized manner using stakeholder groups modeled after Buysse and Verbeke's 2003 research and Henriques and Sadorsky's 1996 research both of which focused on firm behavior as a result of pressure by three categories of stakeholders: primary internal, primary external and secondary.

While this research follows the process of defining stakeholders as seen in research by Buysse and Verbeke (2003) and Henriques and Sadorsky (1996), there have been several other critical research studies analyzing the impact of external and internal pressures on firm behavior and the institutionalization of proactive environmental techniques. Sharma (2000); Khanna and Anton (2002); Dacin, Goldstein and Scott (2002); and Paulraj (2009) analyzed the influence of pressure types on firm behaviors and the resulting firm evolution over time. The research focused not only on the initial adoption of behaviors but also the firm evolution within the institutionalization process as well. These studies showed that external pressures, particularly those pressures that impact the financial success of the firm, influence firms. The research on Institutional Theory is very robust but fails to evaluate the rate of institutionalization when uncertainty is a moderating factor on the effect internal and external pressures exert on firms. This gap in the literature will be addressed during the course of this research.

Uncertainty

Uncertainty is often associated with the level of certainty needed to reach a firm conclusion, is a constant area of concern for many. Uncertainty is the difficulty predicting the future due to incomplete knowledge (Beckman Haunschild and Phillips, 2004). As society seeks policy advice to deal with global environmental change, the issue of uncertainty in both the environmental and regulatory arenas is increasingly becoming a constant issue for businesses (Schneider and Kuntz-Duriseti, 2002).

Historically, uncertainty has been a core concept particularly in theories that seek to explain the type of relationship between organizations and their environments (Dill, 1958; Duncan, 1972; Lawrence and Lorsch, 1967; Thompson, 1967; Milliken, 1987). While misperceptions and the lack of information often results in uncertainty, more often the disagreement about factual, verifiable information causes uncertainty. Duncan (1972) and others stressed the importance of perceptions when studying uncertainty, as perceptions play a significant role in determining how managers react to their environment and potential environmental issues (Doty, Glick, and Huber, 1993; Huber and Daft, 1987; Ashill and Jobber, 2009). Businesses have been found to express high levels of uncertainty when they cannot forecast future threats, obstacles and impacts. As a result, this incomplete knowledge and the difficulty predicting future impacts to the industry and the manner in which firms operate (Beckman, Haunschild and Phillips, 2004).

Research has shown that many firms alter their performance practices directly in relation to uncertainty, not because of threat of unexpected change, but instead because the change is unpredictable, which adversely affects a firms ability to complete critical decision making (Lorenzi, Sims Jr., and Slocum Jr., 1981) and adopt new behaviors (Lindhquist, 2007). Uncertainty, and the ability to define and categorize different types of uncertainty, is important for stakeholder management, managerial decision making and is ability to influence firm behaviors (Carlton and Payne, 2004; Dill, 1958; Duncan, 1972; Lawrence and Lorsch, 1967; Thompson, 1967; Milliken, 1987). Firms are often faced with a variety of uncertainties that can adversely impact their business. This research will use two specific types (environmental and regulatory) to explain the modifications of relationships between organizations, stakeholders, behaviors and ultimately their environmental performance.

Perceived Environmental Uncertainty

Environmental uncertainty generally defined as "the absence of sufficient information about environmental events and activities and/or the inability to predict external changes and their impact on organizational decision alternatives" (Sawyerr, 2003). This type of uncertainty is a pervasive feature of climate change analysis and is a constant concern as firms strive to innovate and remain competitive. According to Duncan (1972), perceived environmental uncertainty is a result of (1) a lack of information concerning the environmental consequences associated with a particular organizational decision; (2) inability to accurately assign probabilities with regard to how environmental factors will affect the success or failure of a decision unit in performing its functions; and (3) a lack of information regarding the costs associated with an incorrect decision or action. When experiencing perceived environmental uncertainty, a firm alter how it invests, innovates and its competitor investment strategy. High levels of perceived environmental uncertainty make it difficult for a firm to anticipate what opportunities will be strategically attractive in the future.

Miliken (1987) defined environmental uncertainty as the perceived inability to predict (an organization's environment) accurately due to a lack of information or an inability of a firm to discriminate between relevant and irrelevant data. Other researchers have defined perceived environmental uncertainty as the perceived risk of the firm in the marketplace (Carrillo and Gaimon, 2004), which shapes how firms perceive drive, and environmental complexity (Miller and Friesen, 1983; Tan and Litschert, 1994; Martin-Tapia, Aragon-Correa, and Senise-Barrio, 2008; Sawyerr, 2003) thereby defining and redefining the relationship between organizations and their environments.

Perceived environmental uncertainty is often divided into as three distinct categories: state, effect and response uncertainty. *State uncertainty* is a perceptual uncertainty about the state of the environment. It relates directly to the unpredictable state of the world. State uncertainty occurs when managers do not feel confident that they understand what the major environmental trends are and therefore feel unable to accurately assigning probabilities to the likelihood that particular events or changes will occur (Milliken, 1987, 1990; Ashill and Jobber, 2009). Often they perceive that the environment or some component of the environment as unpredictable (Gerloff, Muir, and Bodensteiner, 1991, Miller, 1987).

Effect uncertainty is caused by the inability to predict the impact of environmental events and the subsequent changes to the organization (Milliken, 1987). Effect uncertainty is associated with a lack of understanding of cause-effect relationships, specifically addressing the inability to predict the nature of the effect of environmental change on the organization (i.e., a lack of understanding of cause-effect relationships) (Ashill and Jobber, 2009). Managers often have difficulty assessing the meaning and significance of environmental trends and events in terms of how they will affect the organization. The final type of uncertainty, *Response uncertainty,* is caused by a lack of information or knowledge regarding response options available and the inability to predict the likely consequences of a response choice (Milliken, 1987, 1990; Ashill and Jobber, 2009). This type of uncertainty becomes especially important in situations involving a need to take action in response to environmental issues.

Previous research on perceived environmental uncertainty not only analyzed the influence of uncertainty on firm relationships but also its influence on strategic processes, practices and organizational design (Beckman Haunschild and Phillips, 2004, Gerloff, Muir, and Bodensteiner, 1991, Miller, 1987). While this research will look at enviornmental uncertainty and its subcategories as one, perceived environmental uncertainty is important for stakeholder perceptions, firm behavior and managerial decision making (Carlton, 2004; Dill, 1958; Duncan, 1972; Lawrence and Lorsch, 1967; Thompson, 1967; Milliken, 1987). Studies are now under way analyzing the effect uncertainty about climate change impacts firm behavior.

Much of the uncertainty surrounds the validity of the science and the esoteric responsibility for mitigation and adaption among businesses. Trends in GHG emissions directly correlate to regional contributions but mitigation practices are contingent upon the pace of population growth, economic growth, the development and diffusion of technologies, and the demand for fossil fuels (CBO, 2005). With so many fluid variables, many businesses are unsure of their true impact and resist being overly conservative in their product development approach.

Environmental uncertainty associated with climate change is a persistent area of concern for the residential construction industry and while uncertainty can stem from a variety of sources, the manner in which the firm responds is unique and often internal to the firm (Beckman Haunschild and Phillips, 2004; Williamson, 1981; Gulati and Westphal 1999). Firms perceive high levels of uncertainty when facing uncertainty about the viability of future climate change mitigation technologies or about the changing expectations of stakeholders for green products and services that are, and possible changes in legislation to encourage climate change mitigation and adaptation practices (Rueda-Manzanares, Aragon-Correa, and Sharma, 2008).

Environmental Regulatory Uncertainty

Policymakers struggle with the need to make decisions that have far-reaching and often irreversible effects on both environment and society with sparse information (Schneider and Kuntz-Duriseti, 2002). Environmental regulatory uncertainty occurs when unregulated and previously unaddressed environmental issues capture the attention of policy makers. Conventionally, scientific discovery and consensus on environmental concerns precedes regulatory action. Climate change is one of the most prevalent environmental issues today. The continuous flow of scientific data has sounded the alarm for future adverse environmental and societal impacts if more is not done today to address GHG emissions. The relationship between climate change and uncertainty is complicated by the fact that the policy choices that will help to determine future growth in emissions are themselves a response to projects of future climate change (Quiggin, 2008). Because of this there is considerable uncertainty surrounding the regulatory implications of climate change research. Unlike most environmental policies where regulators establish significant risk of harm before imposing regulatory controls, regulators have supported and enacted regulations that have to potential to alleviate harm but have not yet proven to be effective because of the uncertainty of climate change.

As evidence and controversy over climate change increasingly mounts; local, state and federal government entities increasingly are modifying their environmental regulations to address estimated impacts on climate change. As Figure 8 illustrates, preventative or precautionary regulations are increasingly being adopted across the nation not only in cases where activities have been proven to cause harm, but also in cases of substantial uncertainty in the risk of harm. Because of the political uncertainty of climate change science, climate change policy is often packaged in its basic components which often includes not only GHG mitigation strategies on the federal level, but energy, water and resource efficiency as well. Policy makers have found that while there are often strong opposing responses to climate change, climate change mitigation policies are more likely to succeed if they are linked to or integrated with policies designed to address non-climatic stresses that impact not only communities, but more importantly individuals within a community.

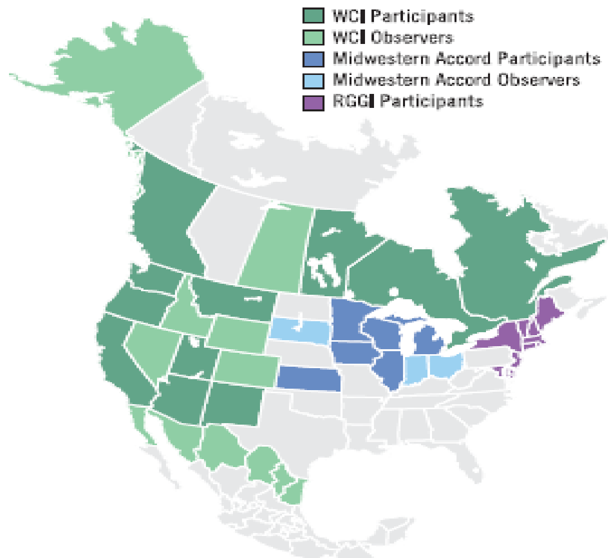

Figure 8: Current States Participating in Regional Climate Mitigation Programs (WRI, 2009)

State policy makers often play a key role in the climate change regulatory process because they often produce testable frameworks and policies that once adopted, is monitored by neighboring states and localities, and can be broadened and implemented across the country (WRI, 2009). For example, King County in Washington State recently adopted an impact fee program targeting the emissions associated with construction projects. As part of the permitting system, construction projects must quantify their emissions and depending upon the levels of proposed emissions, the project must conduct an Environmental Impact Statement (EIS) pursuant to the Washington's State Environmental Protection Act (SEPA) (King County, 2009). While unique in its approach to potential emissions, the program established in King County has been adopted not only in other counties in Washington State, but also in other states as well.

In the presence of environmental regulatory uncertainty specifically associated with climate change, many firms have begun to adopt corporate practices that were more environmentally friendly. Therefore it is believed that the higher the degree of uncertainty, the more likely a firm will be to adopt advanced green building practices.

Managerial Perceptions and Influence

Research has shown that organizational responses to environmental conditions are more determined by managerial perceptions of the strategic importance of the critical areas contained within different organizational functions than by organization – environmental interactions (Henriques and Sadorsky 1999; Gul and Chia, 1994; Gerloff, Muir, and Bodensteiner, 1991).   Organizations respond to environmental factors that they judge as having a higher degree of importance to firm survival. Managers are able to exert significant influence when uncertain about the impact of environmental issues on firm behavior. Researchers suggest that it is the perception of uncertainty, rather than the actual uncertainty present in the environment, that influences the decisions managers make in response to their respective organizations operating environment (Gul and Chia, 1994; Gerloff, Muir, and Bodensteiner, 1991).

Current uncertainty literature has effectively defined perceived environmental uncertainty and the influence of perceived environmental uncertainty on altering firm – stakeholder relationships. There is also a robust body of literature on environment regulatory uncertainty and its influence on firm decision making processes. There is a distinct gap, however, linking the relationship between the conceptualization of uncertainty and perceived environmental uncertainty its ability to moderate the rate of stakeholder influence on the institutionalization of green values.

Stakeholders

Freeman defined stakeholders as "any group or individual who can affect or is affected by the achievement of the organizations' objectives" (1984: 46), Savage, Nix, Whitehead and Blair defined stakeholders as groups or individuals who "have an interest in the actions of an organization and . . . the ability to influence it" (1991: 61). Stakeholders are able to exert their interest and influence in firm activities through direct pressure or by providing information (Henriques and Sadorksy, 1999). The influence of stakeholders on managerial behaviors has been studied extensively and a number of studies found that firms with differing level of environmental commitment vary in managerial perception of which stakeholders are important to the firm (Buysse and Verkeke, 2003; Carlton, 2004; Sharma, 2000; Sharma 2008; Henriques, and Sadorsky, 1999; Darnall et al., 2009). Studies have shown that firm managers evaluate stakeholders based on their perceptions and therefore serve as a critical interpreters of stakeholder influence (Donaldson and Preston, 1995; Fineman and Clark, 1996; Darnall, Henriques, and Sadorsky, 2009). Mitchell (1997) proposed that stakeholders who possess power, legitimacy, and urgency are more salient to firms. After assessing which stakeholders are salient, managers establish how much validity should be assigned to stakeholders and how firms should respond to stakeholder pressure (Donaldson and Preston, 1995; Mitchell et al., 1997). Balancing stakeholder interests often requires a process of assessing, weighing and addressing the competing claims of those who have a stake in the actions of the organization (Reynolds, Schultz, and Hekman, 2006).

Due to ability of stakeholders to exert pressure, stakeholders often drive change and encourage the adoption and institutionalization of alternative practices in a firm. The influence exerted by stakeholders varies and is often associated with firm perceived value. For example, stakeholders have used boycotts, demonstrations, lawsuits lobbying, litigation, policy research, coalition building and support for elected officials (Shepard, Betz, and O'Connell, 1997; Eesley and Lenox, 2006) in order to advance their agendas and encourage a different behavior from targeted firms. The publicity associated with these behaviors often drive firms to quickly address stakeholder concerns.

Previous research as exemplified in Table 1, has identified three main stakeholder groups; primary internal, primary external and secondary (Buysse and Verkeke, 2003) that are most influential on institutionalization of values and adoption of new firm environmental behaviors (Delmas and Toffel, 2004).

Table 1: Stakeholders Impacting Residential Construction Green Building Practices

Primary Internal Stakeholders	Primary External Stakeholders	Secondary Stakeholders
Management Employees	Competitors	Financial Institutions
NonManagement Employees	Home Buyers	Environmental Groups
	Trade Associations	Regulatory Entities
	Utility incentives	Shareholders
	Private incentives	Suppliers

The relevance of both primary and secondary stakeholders is contingent upon managerial perceptions and determination of salience. Perceived stakeholder salience is comprised of a reality shaped over time, rather than an objective reality. Stakeholders can gain or lose salience to firm managers when: (1) stakeholder attributes are variable, rather than constant; (2) stakeholder attributes subjective rather than objective; and (3) willful behaviors may or may not be present (Mitchell el al., 1997). While these behaviors can influence perceptions, other factors, such as manager's values, characteristics, and attitudes (Agle, Mitchell, and Sonnenfeld, 1999; Egri and Herman, 2000; Sharma, 2000) are also able to shape managerial perceptions. Managerial interpretations are critical because they ultimately determine the importance of stakeholders and, consequently, the environmental proactivity of firms. The determination of salience of both primary and secondary stakeholders will impact the level of influence exerted on the development of firm behavior and action strategy.

While these categories of stakeholders exert unique levels of influence on firms, studies have shown that under normal operating conditions Primary External Stakeholders exert significantly more influence than other stakeholder types (Buysse and Verbeke, 2003; Sharma and Henriques, 2005; Darnall et al., 2009). Figure 9 illustrates this varying influence.

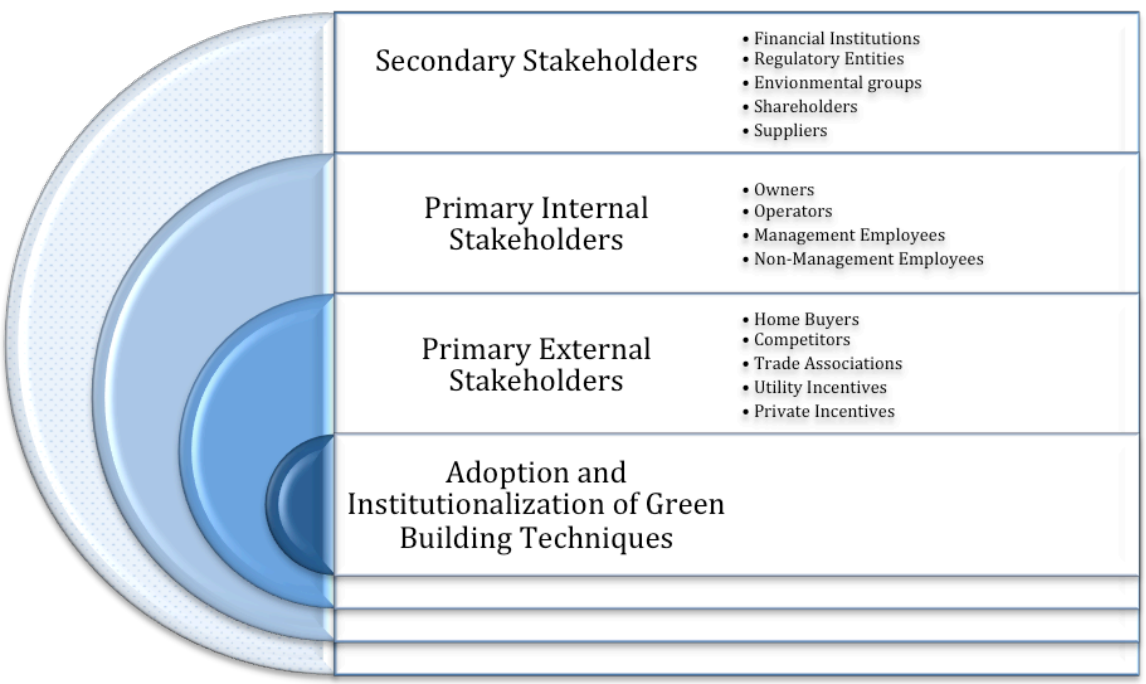

Figure 9: Internal and External Stakeholder Pressures on the Institutionalization of Green Building Practices in the Residential Construction Industry

Primary Internal Stakeholders

Primary Internal stakeholders are the most intimate of stakeholders and include management and non-management employees (Buysse and Verbeke, 2003) and are comprised of individuals with a significant investment in the success of the firm (Waddock and Graves, 1997; Freeman, 1984). These stakeholders are firm owners and employees and have varying degrees of intimate firm knowledge, a direct economic stake in the organization, are typically located within the organization and include management and non-management employees that are able to have direct influence in firm behavior impacting the success or failure of an adopted environmental strategy (Freeman, 1984; Darnall et al., 2009; Buzzelli, 1991). Delmas and Toffel (2004) found that internal pressures from both management and nonmanagement employees were important in determining the level of environmental protection behaviors adopted. However, management personnel are generally more knowledgeable about the business, and are more aware of the big picture than non-management personnel.

It is often the responsibility of managers to select activities and direct resources to obtain benefits for legitimate stakeholders (Donaldson and Preston, 1995). This responsibility means that management employees have the ability to exert influence over the adoption of green practices since they are often responsible for the indentification and acquisition of desirable land, the development of supplier commitments, the selection of products used, and interacting with financial institutions, government entities and the media. Non-management employees are responsible for the successful completion of projects. During the build process nonmanagement employees are often responsible for compliance with all applicable laws, advocating on behalf of the firm, ensuring proper installation of materials and products and marketing. Like management, nonmanagement employees also have intimate knowledge of the firm behavior and market trends and as a result can influence firm behavior.

Primary External Stakeholders

Primary external stakeholders have limited control of critical organizational resources and are not directly involved in firm decision making but are able to influence firm decisions but in certain instances these stakeholders may have the ability to guide a firm's performance direction (Mitchell et al., 1997); Sharma and Henriques, 2005; Darnall et al., 2009). Primary external stakeholders include homebuyers, competitors, regulatory entities, utilities and trade associations (Khanna and Speir, 2007; Freeman, 1984). These stakeholders have the ability to convince governments to standardize an environmental practices and so are able to inadvertently direct firm behavior (Henriques and Sadorsky, 1999) through financial incentives, compliance assistance and alternative compliance opportunities which are used to help offset the cost and information gap associated with the adoption of new techologies and practices (Alleng, Byrne and Zhou, 2001). Incentives provided by primary external stakeholders typically include: tax incentives, rebates, capital grants and green pricing. These incentive types are designed to defray the high up-front capital costs associated with green techology (Alleng, Byrne and Zhou, 2001). Under the traditional stakeholder-firm relationship, primary external stakeholders have the ability to heavily influence firm green building practices. The pressure exerted by these stakeholders can shape the direction residential construction firms take.

Secondary Stakeholders

Secondary stakeholders, like primary external stakeholders, are not directly engaged in a firm's economic activities, but are affected by the firm and are therefore able to exert influence (Savage et al., 1991; Mitchell, Agle and Wood, 1997). Studies have defined secondary stakeholders as societal stakeholders, non-governmental organiations, shareholders, suppliers and the media. (Henriques and Sadorsky, 1999; Klassen and McLaughlin, 1996; Waddock and Graves, 1997). While primary internal and external stakeholders are concerned about liabilities related to environmental risks associated with firm operations (Rueda-Manzanares, Aragon-Correa, and Sharma, 2008), secondary stakeholders concern themselves with ensuring the regulatory compliance of all projects in order to minimize the environmental and human health impacts associated with a project's progression.

Stakeholder Engagement

Integrating stakeholder concerns helps firms address the complexity of products that are developed from technologies or components that have the potential to cause significant environmental impacts. By giving a greater amount of attention to the environmental concerns of a wide variety of stakeholders, firms are able to develop a stakeholder integration strategy capable of adopting proactive practices where they can foresee negative environmental impacts and anticipate liabilities and risks as well as opportunities (Sharma, 2000). Policy makers have often argued that environmental regulation is instrumental to introducing better environmental management practices within firms, and that more stringent regulation is needed to further improve such practices. Many research studies have shown however that when crafting specific environmental practices, firms undoubtedly attach more importance to other stakeholders rather than government regulators (Neu, Warsame, and Pedwell, 1998; Rueda-Manzanares, Aragon-Correa, and Sharma, 2008). Managers drive firm innovation so managerial motivation to adopt advanced environmental practices must be combined with the ability to integrate the different stakeholder concerns about strategic environmental issues associated with the firm. Research has shown that managers who acknowledge the views of a wide range of stakeholders are more likely to develop proactive environmental practices than those firms that focus on a small stakeholder set such as customers and suppliers (Buysse and Verbeke, 2003; Henriques and Sadorsky, 1999).

Firms respond to stakeholder pressures in many ways. A 1999 Henriques and Sadorsky study found that firms generally respond to environmental and stakeholder pressure in found general ways and classified the different firm approaches to environmental issues as follows: reactive, defensive, accommodative, and proactive. A *Reactive* firm is a firm whose management provides no support or guidance for environmental issues. A *Defensive* firm is a firm whose management provides minimal involvement and employee training on environmental issues. These firms generally satisfy environmental regulations but only deal with environmental issues when necessary. An *Accommodative* firm is a firm with managerial involvement and support for basic employee training on environmental issues. These firms typically do minimal environmental monitoring and internal reporting but do not share such information externally. The final firm type, a *Proactive* firm has management that is not only supportive but maintains heavy involvement in environmental issues. This firm type maintains constant employee training, internal and external reporting and typically has environmental management plans to address unexpected environmental issues.

The literature available on Stakeholder Theory, like those of Institutional Theory and Uncertainty are robust when each area is studied individually, when analyzed to determine interrelationships, the literature is lacking. My proposed research will provide a link between these three areas and will be able to contribute to not only the institutional body of literature but also to the stakeholder and uncertainty body of literature as well.

Chapter 7 | Theoretical Framework

Institutional theory provides a process by which firms adopt and internalize new practices and behaviors based upon internal and external pressures. When in an environment operating with certainty, firms are able to systemmatically adopt values that have been diffused throughout the industry and legitimaized prior to institutionalization. This process is altered, however, in an uncertain environment. The rate of institutionalization will be excelerated due to internal and external pressures. The results of this project should demonstrate that when uncertainty is present, the traditional path of internal and external pressure is modified and will shift the type of stakeholder that is most influential on firm decision making processes. The theoretical framework will focus on the interchanging relationships of uncertainty, stakeholders, and institutionalization.

Institutional advancements are a necessary and often methodical process whereby organizations navigate their future direction and societal position through a series of firm decisions (Dacin, Goldstein, and Scott, 2002). Institutional theory is concerned with the influence of forces, both internal and external, on organizational decision-making. Also emphasized is the role social cultural pressures impose on organizations that not only influence organizational practices and structures (Scott, 1992) but how these pressures drive the manner in which values become institutionalized and the role of institutions in society (Scott, 1987). By instilling value, institutionalization encourages organizations to behave as stable, natural entities concerned with their own self-maintenance and prosperity.

The institutionalization of values and behaviors is a sequential process. Previous studies on institutional theory and the adoption of new environmental management practices and behaviors have used the "S-shaped institutionalization curve" (Figure 9) to exemplify the period of time in which innovation emerges and is diffused, followed by a period in which the innovation remains diffused throughout the organization (Lawrence, Winn, and Jennings, 2001).

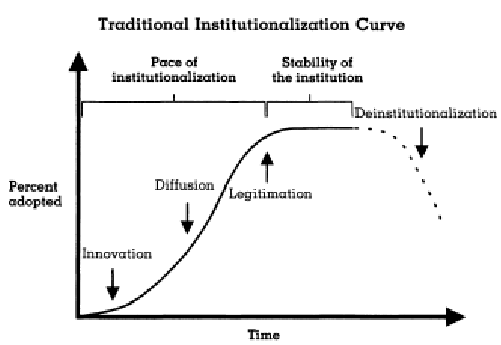

Figure 10: Traditional Institutionalization Curve (Lawrence, Winn, and Jennings, 2001)

The process of value institutionalization often varies depending on the motivational drivers of change. Organizations who conform and change to a new set of institutionalized values and behaviors do so because they are rewarded through increased legitimacy, resources, and survival capabilities (Meyer and Rowan, 1977). Henriques and Sadorsky (1996) found that stakeholder pressure (primarily customer, regulatory and community) and revenue seeking both motivate firms to adopt proactive environmental management plans when these firms operate under perceived certainty. D'Aunno et al. (2000) found that market forces, proximity to competitors, compliance with government regulations, and mimicry of observed competitor behavior will encourage strategic change and subsequent institutionalization of new values.

Proposed Theoretical Framework and Model

Firms are under continuous pressure to maintain a positive community image while remaining economically viable and maintaining a competative advantgage. The adoption of green building values, as illustrated in Figure 11, is assumed to be an intricite process by which residential firms have both internal and external pressures attempting to drive change. Internally, managers and employees must address will exert pressure based on personal beliefs on climate change, green building and the type of external stakeholder they find most influential. External pressures come from consumers, regulators, utilites, trade associations, financial institutions and non-governmental organizations and primary external stakeholders provide economic incentives to encourage green building technology adoption. Adoption and institutionalization of green buidling values will evaluate stakeholder pressures when the enviornmental effects of climate change and the regulatory measures taken to mitigate against the potential impacts of climate change are unknown to firms.

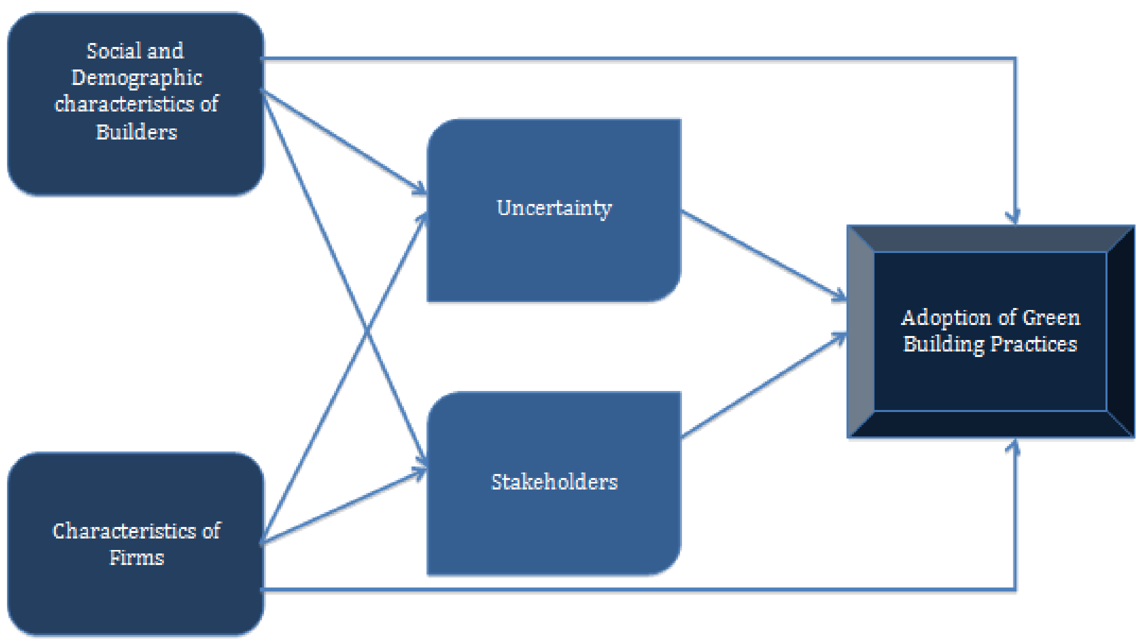

Figure 11: Conceptual Diagram for Hypothesized Causal Relationships

The Moderating Influence of Uncertainty on Stakeholder Pressure

Uncertainty, like stakeholder pressure, is able to modify firm behavior. Uncertainty however has the ability to not only modify firm behavior, but also firm – stakeholder relationships. Das and Teng found that risk perceptions are core to stakeholder interests because of the effect risk and perception of risk has on decision-making (2004). Geographic locations where future environmental conditions are associated with a greater degree of uncertainty drive managers to be more proactive, establish collaborative relationships with a wider range of stakeholders that can help them anticipate future trends, identify opportunities, facilitate experimentation based on innovative approaches and adopt more innovative practices than managers who work in less uncertain business contexts (Rueda-Manzanares, Aragon-Correa, and Sharma, 2008).

Firms have a higher degree of uncertainty about the validity of climate change, mostly because of the implications on their business (Cohen and Miller, 2011). The uncertainty of climate change is often associated with the likelihood that severe climate changes will occur, degree of climate change and the impact climate change beliefs held by policy makers will alter the existing regulatory framework. Increasingly federal, state and local governments are conducting research to address the impacts of industrial operations on GHG emissions and climate change. Perceived uncertainty in future climate changes and regulatory policy will have a moderating impact on how stakeholders are able to influence to adoption of advanced green building techniques.

Uncertainty can change both organizational inertia and how they do business. Internal and external presures can alter organizational structure and behavior, particularly when the outcome or consequences of change cannot be predicted (Hoffman and Henn, 2008). When environmental and regualtory uncertainty is present, uncertainty will moderate stakeholder influence by shifting influence over the decision making proces. When perceived uncertainty surrounding climate change is present, this study assumes that primary internal stakeholders will be the most influential in driving a firm to adopt and institutionalize green building practices.

Hypothesis 1: The adoption and institutionalization of green building practices will increase as the degree of environmental and regulatory uncertainty increases.

Perceived uncertainty surrounding climate change can influence the roll of stakeholders the adoption of green building practices by residential construction firms. Under normal conditions primary external stakeholders dictate the investments firms make in the marketplace with economic incentives and disincentives. While primary internal and secondary stakeholder groups also influence firm decision making, primary internal stakeholders will drive the residential home construction market when faced with uncertainty associated with climate change.

Hypothesis 2: Primary internal stakeholders will exert the most influence over the adoption of green building practices when uncertainty about climate change or environmental regulations is high.

Hypothesis 3: Primary external stakeholders will exert the most influence over the adoption of green building practices when uncertainty about climate change or environmental regulations is low.

Chapter 8 | Research Methodology

Research Design

In order to test the degree to which uncertainty affects stakeholder influences adopting of green building practices, this study surveyed a sample of residential construction firm managers regarding their beliefs, behaviors and backgrounds. The survey created was released in two stages. The first stage was used to pretest and finalize the survey and was done by sending out two pretests to two groups totaling approximately 75 participants who were asked to not only complete the survey but also provide feedback on the structure of the survey. Once the survey was finalized, the second stage was a distribution to 900 residential construction firm decision makers with affiliation to state home building associations across the nation.

The pretest participants reviewed and helped improve the survey while establishing a baseline for behavior of green firms. The first pretest was launched in October of 2010 for the members of the National Association of Homebuilders' (NAHB) green building committee. Twenty-Five members of the National

Association of Home Builder's (NAHB) green building committee were identified because of their work in this field. Seven members of NAHB's green building committee completed the survey at a 21% rate of response. Based on the suggestions for improvement, the survey was modified and in April of 2011 the second version of the survey was sent out to previous participants of the Partnership for Advancing Technology in Housing (PATH) for a final review.

PATH was a joint NAHB and HUD program that cataloged the best resources on advanced building technologies and practices to emerge from the decade-long public-private partnership, which ended in 2008 (PATH, 2008). Fifty participants were identified from the PATH program and of that 12 responded at a rate of 24%. An analysis of both pretest surveys results showed that respondents felt that customers, management and financial incentives were the top three factors influencing the adoption and institutionalization of green building practices. At the conclusion of the pretest session I modified the survey, condensing questions related to current green building practices, eliminated duplicative questions and further streamlined the survey by eliminating questions on products not commonly used in construction. The final survey was composed of questions addressing managerial decision making processes, climate change issues, green building practices, uncertainty and stakeholder influence.

All pretest participants used green building practices during construction. They used energy efficient, water efficient and resource efficient materials and techniques in their construction projects and have done so under managerial direction rather than in response to the consumer market or regulatory mandates. Many of the green building practices used by the pretest participants predated mainstream acceptance and demand for such building techniques.

The Survey Instrument

The survey was sent via Survey Monkey, a surveying website that provides surveying services with varying costs depending on the type and size of the survey to be sent. This site allows users to develop, collect and do basic analysis on collected survey responses. Participants were allowed to either respond directly on the site or submit a PDF version of their responses to me via email or fax. Prior to starting the survey participants were asked to complete an Informed Consent document, Appendix B, prior to initiating participation in the survey. Those completing the online survey were given the same language and asked for approval prior to participating in the survey. Appropriate contact information was provided on both the email seeking their participation and the actual survey in case the participants needed clarification on the survey. The survey questionnaire, reproduced in Appendix C, asked the participants a series of questions on their decision making processes, factors that influence firm decision making and the degree of impact, green building practices currently in use and enticements/prohibitions in use that affect adopting advanced green building practices.

Participants were provided well over sixteen weeks to complete the survey. During this time participants were reminded on a weekly basis via email until the end of the response window. Those respondents who refused to participate were thanked and removed from the email list. Respondents who did not answer the initial request were reminded to participate on a biweekly basis via email and were also contacted by phone seeking their participation. Those who responded were expected to read the directions and checked the box that appropriately corresponded to their beliefs and management practices. Upon completing the survey, Survey Monkey sent notification thanking them for their participation and updated their status to complete.

The survey questionnaire consisted of five major sections with approximately twenty-seven questions on a variety of subjects surrounding green building and climate change (Appendix C). The survey requested information on firm demographics, climate change beliefs, stakeholder involvement, green building products, firm values and firm behavior when presented with an uncertain operating environment. As illustrated in Figure 12, each major section generated a series of questions that will operationalize the five sections, make them measurable variables and will illustrate not only the relationship between the sections but also the possible effect of these variables on the adoption of green building.

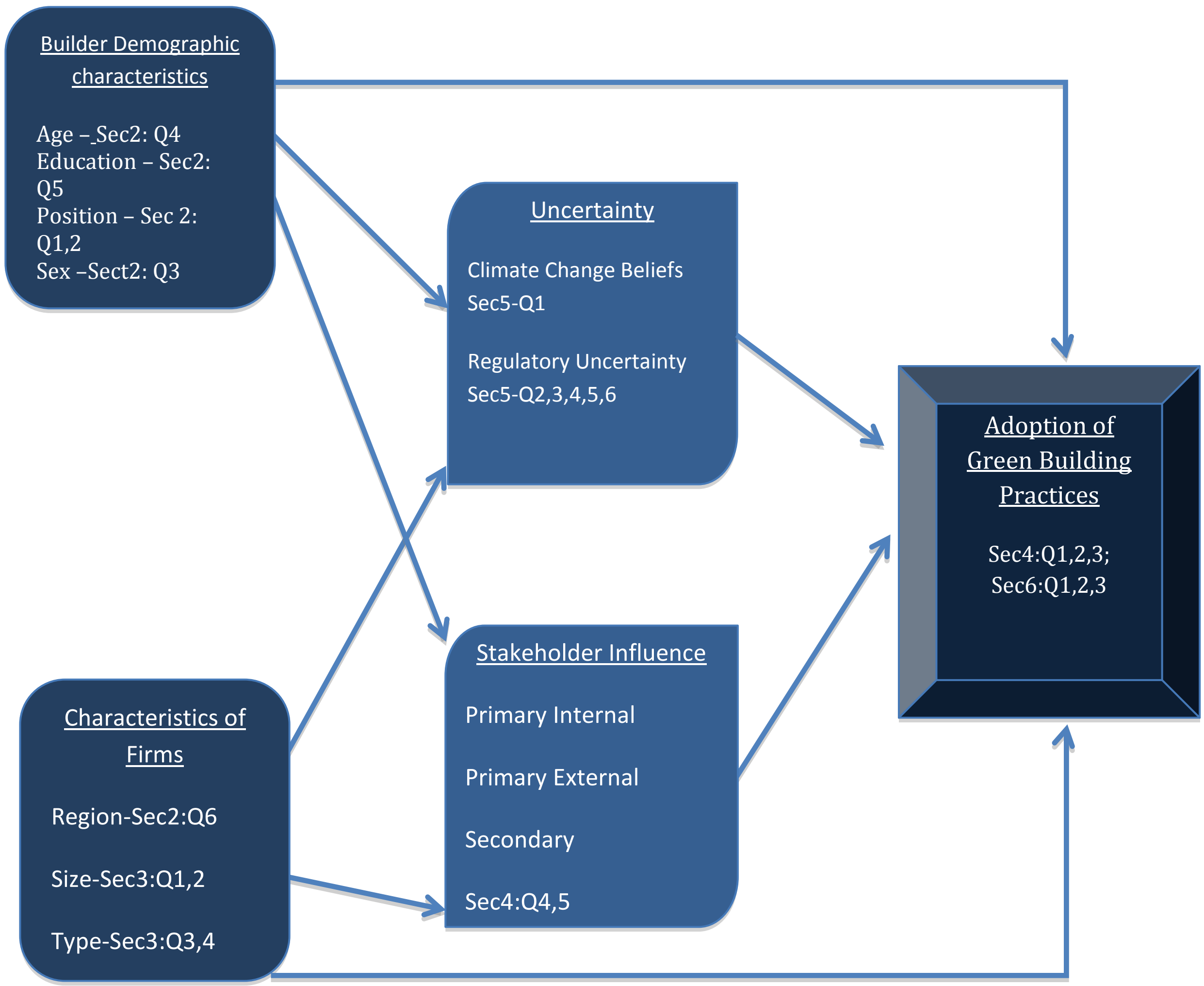

Figure 12: Path Analysis - Operationalization of Figure 10, the Conceptual Diagram

The builder and firm demographic survey sections addressed the respondents' basic background information of the respondent in addition to firm demographics such as firm size, geographic location, age and traditional building practices. This was useful for evaluating whether regional differences play a role in the rate of institutionalization. While builders construct homes in relatively the same manner, the codes and requirements associated with home construction vary across the nation. These questions created the exogenous variables used in statistical analysis. The "Uncertainty" section solicited the respondent's beliefs about the quality and institutionalization of green building and green building programs. Participants were also asked the current degree of participation in voluntary green building programs. This section also included beliefs about climate change, uncertainty and stakeholder requirements. The "Stakeholder" section contained questions on the type of stakeholder that is able to exert influence over firm decision-making. The variables associated with these questions were factor analyzed and were used as intermediate variables in the statistical analysis.

The final set of questions on green building values and practices were used to generate the dependent variable. This section asked about previous behaviors, current behaviors and the reason for any change in strategy. These questions also inquired about the types of green behaviors currently used by firms. Efforts were made to ensure the validity of the data by presenting subjects in a variety of forms to determine beliefs and assumptions and were grouped accordingly when analyzed as shown in Figure 12. Participants were also able to respond anonymously, to encourage honest responses to improve data quality. The goal was to encourage respondents to be completely honest in their responses in order to improve the quality of data collected.

The questions in the green building survey were presented in five formats. The first format used a dichotomous question format, which provided fixed-alternative questions allowing the participant to select one of the two provided answers. This was exemplified in several "yes-no" questions used throughout the survey. The second question format used a 3-point scale where the respondent was able to select multiple options. This was used to identify whether state and/or local governments currently had existing green building regulations. The third question format used the Likert scaling "agree-disagree" 1-5 point scale (Albaum, 1997). The Likert agreement scale was used to assess perceptions of upper management regarding the extent to which green building practices have been implemented and normalized into firm procedures and decision making.

The fourth question format used 4 point scaling. This was exemplified in the "Green Building Programs," "Climate Change and Firm Decision Making," and "Green Products and Product Quality" sections of the survey respondents were asked to complete a series of Likert scaled questions. These 4-point scales included the "Influence-no influence" 1-4 point scale and the "certain-uncertain" 1-4 point scale. The final question format used 5-point scaling. These responses included the "better than average" 1-5 point scale, and "always-never" 1-5 point scale. The

Likert-type ordered-response scale was used to assess perceptions of primary external and secondary stakeholder influences when presented with uncertainty.

In September of 2011 the participation solicitation email, Appendix A, and finalized survey, Appendix C, was emailed to 900 builders identified by their affiliations with state and local home building association websites. The final participant list was composed of upper level decision makers (managers, owners, etc) from residential construction firms and whose information was found on their website. All builders were members of state and local home building associations with affiliation with the National Association of Home Builders (NAHB) across the nine U.S. Census regions (Figure 13). A random (systematic) sampling method was used by generating a list of members in each region and select every fiftieth person. 100 participants per region were identified. Participants were both male and female of various ages. The selected participants represented firms of various types and sizes.

Of the 900 builders identified, 10% of the survey population was eliminated due to nonworking telephone numbers and/or nonworking email and website addresses. These firms were assumed to have gone out of business. An additional 25% opted not to participate. Of the 810 potential respondents, 146 individuals responded (an 18% response rate) to the survey in either written or oral form.

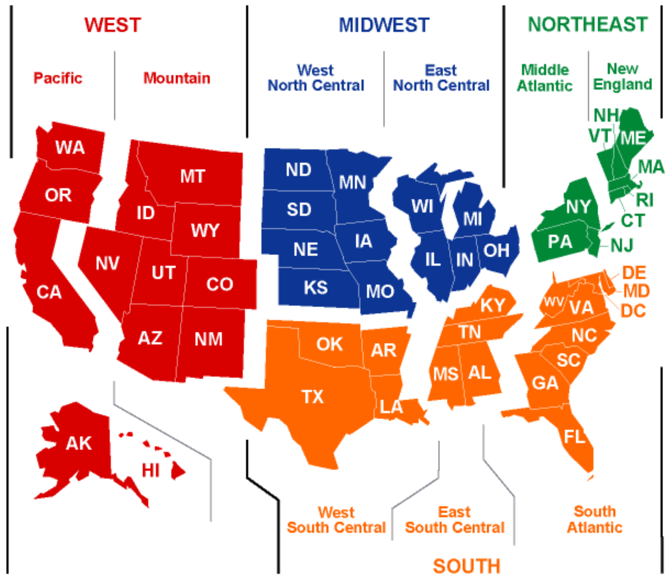

Figure 13: US Census Region Map (US Census, 2010)

Data Analysis

After closing the data collection window in February of 2012, the data were coded into numerical values on the Survey Monkey website then downloaded from the Survey Monkey website and uploaded into an excel spreadsheet. The variables were labeled and defined and then uploaded to STATA using STATA Data Analysis and Statistical software. Using the STATA program, the data were first analyzed using the factor analysis method to develop composite scales for the various attitude and behavioral measures shown in Figure 12. Once the factor analysis was complete and the final factor scales developed, basic descriptive statistics were computed and all variables were subjected to correlation analyses. The final step in the data analysis used multivariate regression analysis to better evaluate the influence the independent variables had on the adoption of green building practices.

Factor Analysis

Factor Analysis was the initial statistical techniques used because it allows the determination of broader constructs or "factor scales" composed of more detailed questions, thereby reducing the number of variables in the analysis. A total of six factor analyses were conducted on fifty-five variables, and these analyses yielded eight factor scales representing one dependent and seven independent variables.

Dependent Variable

The dependent variable "greenproduse" was generated from the "Green Products and Product Quality" section (Section 6) of the research survey. This section had fifteen questions asking frequency of use for water efficient, energy efficient and material/resource efficient products. The representative variables were factor analyzed to determine the existence of one or more factors. The results of the factor analysis identified two factors possible factors but only one factor was distinctive and had a high alpha reliability. This factor was defined by ten of the fourteen variables. The factor identified and used includes variables representing water reducing faucet fixtures, showerheads and toilets, prehung doors, increased insulation, insulated foundation, high efficiency HVAC systems, energy efficient lighting and energy efficient appliances. The four variables without significantly loading on this factor (use of grey water, use of tankless water heaters, use of fire suppressant technology and use of certified wood) all had extremely low response rates. These items represent green building products used by respondents therefore this factor was named "greenproduse." See Appendix D for the detailed factor analysis results.

The responses to these were initially coded so that 1 was all of the time and 5 was never; the codes were reversed so that 1 signifies "never" and 5 "all of the time." The alpha reliability of the rotated factor is very high at .92, which is more than sufficient.

Independent Variables

This study evaluated three main sets of independent variables, uncertainty of the regulatory environment, various types of stakeholder influence, and firm demographics based on background questions about the builder and their firms. The uncertainty variables were established through a series of questions that asked respondents to identify their views on green building, climate change and which regulatory factors influence their decisions on green building. Using a wide range of questions allowed respondents to give their opinions on a variety of scenarios that could be used to assess their belief and opinions about uncertainty, stakeholder influence, climate change and green building.

Demographics Variables

Demographic information was requested of the respondents to determine their background and exposure to both climate change and green building information. The questionnaire asked respondents about their age, sex, educational level and region(s) in which they operate. When asking for firm demographic information, the survey asked respondents to identify their job function and title, size of the firm and types of projects the firm is engaged in. Additional questions were asked about the number of projects completed annually and the average size of a completed project.

Views on Green Building Variable

The green building questions sought information on builder beliefs about green building. Section 4 "Views on Green Building Programs" of the questionnaire included questions on green building broken up into two categories: beliefs about green building products and views on green building. The section on the beliefs of green building asked respondents how they felt about the quality, availability and overall use of green building products. Questions on the views of green building asked about their participation in green building programs, the availability of green building products, voluntary versus mandatory implementation programs, the likelihood green building programs would gain in popularity and the impact green building has on the health of their business. While a majority of the survey questions were scaled started with the negative response at lowest number and ending with the positive response at the highest number, the factor analysis showed that the cost of green building variable "gb_cost," green building's effect on the longterm success of the firm "lngtrm," implementing green building mandates through building codes "bcmnd," and building green as a social responsibility "socresp" had to be reverse scored. This allowed for continuity among the responses. The resulting range for all of the variables in this section ranged from 1 "strongly disagree" to 5 "strongly agree" with 3 representing a "neutral" response. In total 11 variables were identified under the views of green building category.

The green building variables were factor analyzed (see detailed results in Appendix D) and one factor was established. This factor was defined by all but two of the variables tested (value of green building products and mandating green building in building codes). The alpha reliability is very high, at .81, which is more than sufficient. The factor scale created for the respondent's views on green building products was named 'gbviews.' This variable, while not found in the theoretical model shown in figure 12, was thought to be important for identifying builder beliefs about the quality and availability of green building practices, and as such it might be an important intervening variable.

Uncertainty - Climate Change Beliefs Variable

To determine the level of environmental uncertainty, section 5 “climate change and Firm Decision Making” of the questionnaire asked a series of 8 questions about climate change which included: seriousness of climate change, the threat of climate change, the future impact of climate change, where the most significant contributions of climate change are derived and whether or not respondents take into account climate change in their business decisions. Respondents were originally asked to respond on a 5-point Likert scale from 1 “strongly agree” to 5 “strongly disagree.” During the factor analysis this scale was reversed so the final 5-point scale ranged from 1 “strongly disagree” to 5 “strongly agree.”

The factor analysis (see detailed results in Appendix D) conducted on the 8 questions from the questionnaire and all 8 variables were highly correlated. As a result the factor analysis of the representative variables supported a single factor. The single factor had a high alpha reliability of .89, which was more than sufficient. As a result the variables were reduced to the single factor scale ‘ccbelief.’ The final scale has a score range from 1 to 5, where 5 signfies the strongest beliefs in the threats of climate change.

Uncertainty – Future Climate Change Regulations Variable

To determine the level of regulatory uncertainty the survey asked respondents a series of 8 questions about their level of certainty for the likelihood that their state and/or local government will implement new green building requirements addressing energy efficiency, water efficiency, resource efficiency and/or material efficiency requirements. The range on the scale for each question ranged from 1 "very certain" to 4 "very uncertain."

A factor analysis was completed on these questions about the uncertainty of future state and local green building requirements. The state and local certainty survey questions were factor analyzed and a single factor was identified with an alpha reliability of .93. The alpha reliability is very high and more than sufficient to justify the use of this factor. The state and local regulatory certainty variables were combined into the single factor "regcert." This factor scale ranges from 1 to 4, where 4 means certain. (See Appendix D for detailed results).

Existing Green Building Regulations Variable

In order to determine the types of existing green building regulations currently in existence across the country, the survey asked a series of 5 questions about existing green building regulations currently required by state and local governments. These questions addressed whether or not state and/or local governments had regulations requiring mitigation for greenhouse gas emissions and mandates for the use of energy efficiency, water efficiency, low impact development (LID) and low VOC product adoption. The original response had a scale: 1 "state," 2 "local," 3 "neither" and 4 "both." This scale was recoded and the new response ranged had a scale of: 0 "neither," 1 "either state or local" or 2 "both state and local." An analysis of the means indicated that while respondents have seen energy efficiency and water efficiency requirements either on the state or local level, as a combined factor with a mean of 2.99, respondents were not aware of state and/or local green building requirements that were applicable to their businesses.

The results of the factor analysis (Appendix D) identified one factor, which was representative of all variables. With an alpha reliability of .76, which is sufficient this factor was used. All factors were highly correlated and the single factor "certgbregs" was created. This factor scale was also not in the theoretical model, but it was nonetheless thought to be a potentially important intervening variable.

Stakeholder Influence Variables

The final set of independent variables addressed the types of stakeholders exerting influence on adopting and institutionalizing green business practices. To determine the respondent's views on stakeholder influence, section 4.4 of the survey asked a series of 11 questions addressing the influence of various stakeholders representing primary internal, primary external and secondary stakeholder groups. Respondents were asked to rate the level of stakeholder of influence on a 4-point scale ranging 1 "a lot of influence" to 4 "no influence." During the factor analysis this scale was reversed with the scale now ranging from 1 "no influence" to 4 "a lot of influence."

The primary internal stakeholders were hypothesized to represent employees and managers. The primary external stakeholders were hypothesized to be representative of private utilities incentives, trade associations, government incentives, and customers. Secondary stakeholders were hypothesized to represent financial institutions, environmental groups and regulatory agency groups.

A factor analysis (see Appendix D) on 11 stakeholder groups resulted in the identified of three factors where the original associations and groupings for the stakeholder groups did not hold true. The first factor was comprised of regulatory stakeholders and financial institutions, named "reginfluen," and it consisted of financial institutional influence, federal regulatory influence, state influence and local influence and environmental groups. The variables in this factor were most consistent with secondary stakeholders as previously defined. This factor had an alpha reliability of .69, which was sufficient.

The second factor consisted of trade associations and incentives from government agencies and private utility companies and was labeled "incentivinfl1."

The variables in this factor were most associated with the primary external stakeholders as previously defined. This factor had an alpha reliability of .68, which is sufficient.

The third factor included customers, employees and managerial influence and as such was labeled "cusemplinfl." The variables in this factor were most representative of primary internal stakeholders as previously defined. This factor also had an alpha reliability of .53, which is marginal.

Summary of Variables

Table 2 summarizes the 8 factors created as a result of the factor analysis completed on the twenty-seven variables generated from the survey. Analyzing the dependent variable "greenproduse" determined that all of the respondents said that they used green building products either "some of the time" (3), "most of the time" (4) or "all of the time" (5). Since these products were so commonly used respondents often scored between 3 and 5, the few instances of 1 and 2 were recoded to 3 and the name was changed to "greenprod3" to accurately reflect the responses. A high score on this variable means a greater use of green products (range 1 to 5). 133 respondents answered the questions surrounding green products used with a mean of 4.33 on a 5 point Likert scale with a standard deviation of $\pm$ .69, signifying heavy use of green building products.

There were two uncertainty variables generated from the data. The first uncertainty variable, "regcert," addresses the environmental regulatory uncertainty associated with future climate change mitigation and adaptation regulatory mandates. 132 respondents answered questions addressing regulatory uncertainty. The resulting responses had a mean of 2.43 with a standard deviation of $\pm$.72 indicating about half experienced a lot of uncertainty, while another have had expressed less uncertainty.

The second uncertainty variable, "ccbelief," addresses the uncertainty associated with the firm's interpretation of scientific findings and the adverse impacts of climatic changes and extreme weather events associated with climate change on the future health of their businesses. 135 respondents answered questions surrounding their views of climate change. The resulting responses had a mean 3.22 with standard deviation of $\pm$.83 indicating about half of the respondents are uncertain about climate change and future impacts and the other half is more certain.

146 respondents answered questions addressing regulatory certainty. This set of survey questions asked respondents about existing regulations in their state and local areas. The resulting variable "cergbregs" had a mean of 2.99 with a standard deviation of $\pm$2.70 points. With such a high standard deviation the data points must be spread over a large range of values. This means that while the representative values signified, on average, no existing green building requirements,

there were enough respondents with requirements on both the state and local level to influence the standard deviation.

139 respondents answered questions regarding their views on green building. The resulting variable "gbviews" had a mean of 2.71 and a standard deviation of ±.46 points signifying that firms agreed with the quality, availability and need for green building.

There were three variables created to address hypothesized stakeholder influence on firm decision making based on 139 respondents. The variable "reginfluen" had a mean of 1.89 on a 4 point scale with a standard deviation of ±.43 signifying that these stakeholders had less influence on a firm's decision to adopt green building practices. The variable "incentivinfl1" had a mean of 2.13 on a 4 point scale with a standard deviation of .53 signifying that, on average, stakeholders providing incentives had some influence on a firm's decision to adopt green building practices. The variable "cusempinfl" had a mean of 1.66 with a standard deviation of ± .39 signifying that these stakeholders had little to no influence on a firm's decision to adopt green building practices.

Table 2: Summary of Independent vs Dependent Variables

Variable	Var. Type	Variable Name	Obs (N)	Mean	Standard Deviation
Greenprod3 (1-5)	**DEP**	**Use of Green Products**	133	4.33	.69
Regcert (1-4)	**IND**	**Environmental Regulatory Uncertainty**	132	2.43	.72
Certgbregs (0-3)	**IND**	**Certainty of Green Building Regulations**	146	2.99	2.71
Reginfluen (1-4)	**IND**	**Influence of Secondary Stakeholders: Regulators, Financial Institutions, & Environmental Groups**	139	1.89	.43
Incentivinfl1 (1-4)	**IND**	**Influence of Primary External Stakeholders: Private Incentives, Utility Incentives, & Trade Associations**	139	2.12	.53
Cusempinfl (1-4)	**IND**	**Influence of Primary Internal Stakeholders: Customers, employees & managers**	139	1.67	.39
Gbviews (1-5)	**IND**	**Views on Green Building**	139	2.71	.46
Ccbelief (1-5)	**IND**	**Views on climate change**	135	3.22	.83

Multivariate Regression Analysis

After factor analyzing all of the variables, one new dependent variable and six new independent variables were created to represent the potential types of influence on firms adopting and institutionalizing green building practices (Table 2). In order to test the study hypotheses and the relationship posited in Figure 1, the technique of multiple regression analysis is required. In particular, regression analysis is required to determine how uncertainty moderates the role stakeholders play in influencing the adoption and institutionalization of green building practices. The analytic model for multivariate regression analysis in this study is presented below:

$$Y = b_0 + \Sigma b_i x_i + \Sigma b_j w_j + \Sigma b_k z_k + e$$

where y is the adoption of green building practices (greenprod3) and b_0 is the constant and the other b's are regression coefficients (either raw or standardized). The x_i variables represent the theoretical intermediate variables: regulatory certainty, current green building regulations, regulatory influence, incentive influence, customer and employee influence, green building views and climate change beliefs. The w_j represent several interaction terms implied by Hypotheses 2 and 3 involving the uncertainty and stakeholder variables; they will be explained in more detail when the regression results are presented in Chapter 9.

Finally, the z_k variables represent the exogenous variables, in this case the builder personal and business characteristics shown in Figure 1.

When running the regression models, several standard diagnostic procedures are also evaluated, including tests for multicollinearity and heteroskedasticity. Give the fairly straightforward variables used in this model and their distributions as shown in Table 2, there is no need to test for normality or outliers.

Chapter 9 | Results

The principle method for testing the 3 hypotheses formulated in Chapter 7 “Theoretical Framework” is the multivariate regression analysis. This technique analyzed the relationships between green product usage (the dependent variable) and ten endogenous and exogenous independent variables, according to the path model in Figure 12. Before conducting the regression analysis, some descriptive statistics and correlation analysis will be presented.

Descriptive Statistics

The study analyzed fourteen variables (Table 3), including five exogenous variables, seven intermediate variables and one dependent variable. The exogenous variables consist of the sex of the respondent “sex2”, respondents’ age “age6”, respondents’ education “educ”, average home size constructed “hsize”, and number of projects “n_project”. The seven intermediate variables consist of uncertainty about future green building mandates “regcert”, current green building mandates “certgbregs”, views on green building “gbviews”, views on climate change “ccbeliefs”, influence of primary external stakeholders providing incentives “incentivinfl1”, influence of secondary stakeholders consisting of regulators, financial institutions and nonprofit groups providing influence “reginfluen” and the influence of primary internal stakeholders’ influence on the decision to adopt green building practices “cusempinfl”. The dependent variable consists of the adoption of green building practices “greenprod3.”

Table 3: Summary Statistics							
Variable	**Var. Type**	**Variable Name**	**Obs**	**Mean**	**Std. Dev.**	**Min.**	**Max**
greenprod3	**DV**	**Use of Green Products**	133	4.3	0.69	3	5
regcert	**IND**	**Environmental Regulatory Uncertainty**	132	2.4	0.72	1	4
certgbregs	**IND**	**Certainty of Green Building Regulations**	146	3.0	2.70	0	10
gbviews	**IND**	**Views on Green Building**	139	2.7	0.46	1	4
ccbelief	**IND**	**Views on Climate Change**	135	3.2	0.84	1	5
incentivinfl1	**IND**	**Influence of Primary External Stakeholders: Private Incentives, Utility Incentives, & Trade Associations**	139	1.9	0.53	1	3
reginfluen	**IND**	**Influence of Secondary Stakeholders: Regulators, Financial Institutions, & Environmental Groups**	139	1.9	0.43	1	3
cusempinfl	**IND**	**Influence of Primary Internal Stakeholders: Customers, employees & managers**	139	1.7	0.38	1	3
custpaygbp	**IND**	**Customer like Paying for Green Products**	137	2.0	0.43	1	4
n_project	**IND**	**Number of Project Built Annually**	146	1.8	1.28	1	5
hsize	**IND**	**Average Size of Home Built**	137	3.2	1.10	1	5
educ	**IND**	**Highest Education of Respondents**	145	3.8	0.82	1	5
age6	**IND**	**Age of Respondents**	146	50.3	11.28	25	75
sex2	**IND**	**Sex of Respondents**	146	0.09	0.29	0	1

A vast majority (91percent) of respondents identified themselves as male small business owners that construct (67 percent) single-family homes (Figure 14). The mean age of the respondents “age6” was 50.3 years old with a standard deviation of ±.29 years. While not demonstrated in table 3, respondents were evenly distributed across all areas of the country (Appendix D) with a few building in multiple locations across the nation. Fifty-two percent of respondents have some belief in the seriousness of climate change, its current and future impacts, and factor potential climate change impacts into their business decisions. Fifty-eight percent of the respondents surveyed indicated that they have participated in at least one green building program. When asked about green building, respondents in felt that green products were readily available, better than average in quality, safety and lifespan, and justified the added costs of the green products.

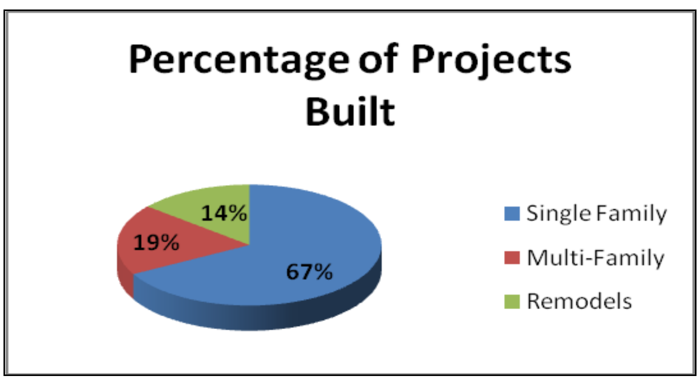

Figure 14: Percentage of Projects Built by Survey Respondents

When surveyed, fifty-nine percent of respondents were uncertain about whether state and local governments will implement new green building requirements but approximately seventy percent of respondents have seen energy and water efficiency requirements on both the state and local level. Approximately sixty percent of those who responded have not seen mandates in low impact development, volatile organic compounds or greenhouse gas mitigation requirements.

Due to the size of variable set, four variables (three intermediate and two exogenous variables) were analyzed independently to determine significance. The two intermediate variables, views on green building (gbviews) and existing green building regulations (certgbregs) are not part of the three hypotheses of the study and have therefore been analyzed separately to determine if they would contribute to the statistical analysis of variables.

Views on Green Building

The variable, "gbviews," was used to describe the respondents' beliefs about green building. This variable was created using the factor analysis method and encompasses questions on the quality, availability and cost of green products, the future of green building and the value on both the firm level and societal level. Since the variable was not part of the three identified hypotheses, it was analyzed separately from the other variables in the study. The correlation between gbviews and green product use is .24 and is not statistically significant at the .05 level (see Table 13).

Existing Green Building Regulations

The variable, “certgbregs,” was used to describe the current regulatory arena facing the residential construction industry. This variable was created using the factor analysis method and encompasses questions on current regulations addressing Greenhouse gas (GHG) mandates, energy efficiency, water efficiency, low impact development (LID) mandates and low volatile organic compound (VOC) mandates. While interesting, this variable was not part of the three identified hypotheses. The correlation between certgbregs is .04 and is not statistically significant.

Regional Variable

The variable, “region1,” was used to identify the region of the country where the respondent constructed or remodeled homes. As illustrated in Table 4, the respondents were evenly dispersed throughout the country. The cross tabulation analysis also reveals that respondents in each region had a mean between 4.07-4.2 illustrating that there were no significant regional differences in the use of green building products.

Table 4: Regional Cross Tabulation Analysis

Recode of Region (Censusregion)	Summary of adoption of Green Building Products		
	Mean	Std. Dev	Frequency
North East	4.10	.86	33
Midwest	4.21	.53	35
South	4.07	1.04	31
West	4.26	.84	32
Multiple locations	4.2	.28	2
Total	4.16	.82	133

Project Type

The second variable analyzed separately, the type of project constructed "projtype" was analyzed using both cross tabulation analysis and regression analysis. The cross tabulation analysis, Table 5, shows that sixty-five percent of the total respondents constructed single-family homes, twenty percent built multifamily homes and fifteen percent participated in remodel and renovation projects. Regardless of project type, respondents were likely to incorporate green building practices most of the type in their construction projects.

Table 5: Project Type Cross Tabulation Analysis

Project Type "Projtype"	Summary Statistics - Green Building Products Adoption		
	Mean	Std. Dev.	Freq.
Single Family	4.44	0.64	86
Multifamily	4.23	0.81	26
Remodel	4	0.65	20
Total	4.33	0.69	132

As illustrates in Table 6, the regression analysis of the project type variable illustrated the significance of remodel and renovation projects. While the effect of multifamily versus single-family projects was .21 lower and not significant, the effect of remodel and renovation projects versus single family projects was .44 lower and is significant at the P<.01 level. This variable is a good exogenous variable and will be used in the multivariate regression analysis.

Table 6: Project type Regression Analysis

greenprod3	Coef.
Projtype	
Multifamily	-0.21
Remodel	-0.44*
_cons	4.44
Number of Observations	132
R Squared	.05

* Significant at .01

The remaining variables were not individually tested and were instead used in the combined correlation analysis.

Correlation Analysis

Table 7 illustrates the correlation of the exogenous independent variables and endogenous independent variables to the dependent variable. The correlation analysis measures how associated these variables are to the dependent variable and to one another. This analysis omits any case with a missing value for any variable in the set.

When correlating the independent variables to the dependent variable, there were few strong correlations. The strongest correlation is between the primary external stakeholder incentive providers (incentivinfl1) variable and green product use (greenprod3) with a correlation of .37. The next strongest correlation between the number of projects built (n_project) annually and green product use and has a moderately strong negative correlation of -0.26. The weakest correlation observed was between regulatory uncertainty (regcert) and green product use at 0.20). The remaining correlations of other independent variables and green product use were extremely weak, indicating little to no correlation.

There were two correlations among the independent variables that were strong but not strong enough to require any further analysis. The strongest correlation was between regulatory influence, "reginfluen" which had a positive correlation with regulatory uncertainty, "regcert," at 0.27. Regulatory influence, "reginfluen," also had a negative correlation with incentive providers "incentivinfl1" at -0.22. The remaining correlations between independent variables were weak indicating little to no correlation.

Table 7: Correlation Analysis of Independent and Dependent Variables (131 Obs)

	greenp~3	regcert	ccbelief	cusemp~l	incent~1	reginf~n	custpa~p	n_proj~t	hsize	educ	age6	sex2
greenprod3	1.0000											
regcert	0.2016	1.0000										
ccbelief	0.1035	0.1807	1.0000									
cusempinfl	0.0319	-0.0030	0.1036	1.0000								
incentivin~1	0.3757	0.1850	0.0521	0.1393	1.0000							
reginfluen	-0.0710	0.2701	-0.0082	0.0699	-0.2206	1.0000						
custpaygbp	0.1511	0.0572	0.1548	0.1904	0.0190	0.1237	1.0000					
n_project	-0.2651	0.0545	-0.0490	0.1538	0.0291	-0.1176	-0.0922	1.0000				
hsize	0.1326	0.0048	0.0185	-0.0132	0.1173	0.1271	0.1152	-0.1952	1.0000			
educ	-0.0638	0.0281	0.0916	0.0453	0.0061	-0.0115	0.0211	0.0642	-0.0162	1.0000		
age6	0.1221	-0.0628	0.0936	-0.0741	0.1310	0.0092	0.1381	-0.1951	0.0164	-0.1075	1.0000	
sex2	0.1652	-0.0228	-0.0401	-0.0956	0.0648	-0.2160	0.0064	-0.0656	0.1055	-0.0792	-0.0138	1.0000

To further test the importance of variables, the pairwise correlation (pwcorr) analysis (Table 8) was conducted on the exogenous and intermediate variables. In this analysis, all cases are used for each pairwise correlation, and it also allows for a significance test. Using this method to look at the impact of the variables on the dependent variable “greenprod3,” it is clear that “incentivinfl1,” “n_project,” and “sex2” all have a significant correlation to the dependent variable.

In addition to the significant correlations between the independent and dependent variables, there were significant correlations found among the independent variables. Specifically, regulatory certainty was observed to be significantly correlated to both” incentivinfl1” and “reginfluen” at the .05 level. Primary internal stakeholder variable, “cusempinfl,” was found to be significantly correlated to both “custpaygb” and “n_project” at the .05 level. The variable “incentivinfl1” was significantly correlated at the .05 level with the “reginfluen” variable and the “n_project” variable was found to be significantly correlated with both hsize and age6.

Table 8: Pairwise Correlation of Dependent and Independent Variables

	greenp~3	regcert	ccbelief	cusemp~l	incent~1	reginf~n	custpa~p	n_proj~t	hsize	educ	age6	sex2
greenprod3	1.0000											
regcert	0.1653	1.0000										
ccbelief	0.1119	0.1682	1.0000									
cusempinfl	0.0475	0.0114	0.1355	1.0000								
incentivin~1	0.3569*	0.1813*	0.0623	0.1251	1.0000							
reginfluen	-0.0514	-0.2870*	-0.0039	0.0948	-0.2309*	1.0000						
custpaygbp	0.1400	0.0566	0.1426	0.1886*	0.0365	0.1405	1.0000					
n_project	-0.2537*	0.0724	-0.0138	0.1729*	0.0691	-0.1645	-0.1053	1.0000				
hsize	0.1370	-0.0055	0.0492	-0.0076	0.1432	0.1217	0.1030	-0.1875*	1.0000			
educ	-0.0699	0.0293	0.0614	0.0154	-0.0177	-0.0649	-0.0178	0.0671	-0.0382	1.0000		
age6	0.0887	-0.0750	0.0983	-0.0795	0.1203	0.0407	0.1289	-0.1735*	0.0417	-0.0584	1.0000	
sex2	0.1723*	-0.0217	-0.0495	-0.1033	0.0612	-0.2218*	-0.0055	-0.0605	0.0943	-0.0464	-0.0183	1.0000

*Significant at .05

Multivariate Regression Analysis

In order to evaluate the hypotheses of this study, three regression models are tested, each of which is implied by the study hypotheses and the path model in Figure 12. The first two models, Model 1 and Model 2, are shown in Table 9. Model 1 analyzes the effects of intermediate variables without the presence of interaction effects and background (exogenous) variables. The result of this analysis show that of the fiver intermediate variables tested, only the primary external stakeholder "incentivinfl1" variable had a statistically significant effect on the adoption of green building practices. Since the uncertainty variables "regcert" and "ccbelief" did not have significant effects on the adoption of green building practices, model 1 fails to support the first hypothesis "*adoption and institutionalization of green building practices will increase as the degree of environmental and regulatory uncertainty increases*." Adopting green building practices occurred independently of the presence of uncertainty.

Model 2 for this analysis analyzed the interaction between the stakeholder variables and the uncertainty variables to determine the presence of a significant relationship between uncertainty and the various stakeholder groups. Hypothesis 2 hypothesized that "Primary Internal Stakeholders "cusempinfl" will exert the most influence over the adoption of green building practices when uncertainty about climate change or environmental regulations is high." This implies an interaction between "cusempinfl" and both "regcert" and "ccbelief," and interaction terms were derived by multiplying "cusempinfl" by" regcert" and "ccbelief," respectively. Hypothesis 3 hypothesized that "Primary external stakeholders "incentivinfl1" will exert the most influence over the adoption of green building practices when uncertainty about climate change or environmental regulations is low." This implies an interaction between incentivinfl1 and both "regcert" and "ccbelief," and interaction terms were derived by multiplying incentivinfl1 by "regcert" and "ccbelief," respectively.

Model 2 is broken down into four submodels, each submodel testing one of the interaction terms. The results are also shown in Table 9. As indicated by the footnote, none of the interaction models were valid due to multicollinearity, although with the exception of incentivinfl1, none of the other main effects or any of the interaction effects involving the stakeholder variables and the uncertainty variables were statistically significant. The results for Model 2 fail support either Hypothesis 2 or Hypothesis 3.

Note that the primary external stakeholder variable, "incentivinfl1," was statically significant in all of the submodels at both the p=.05 and p=.001 levels. It appears, then, that in these data, the influence from primary external stakeholders – in this case trade associations, government incentives, and private utility companies

– is the main determinant of green building product usage among the intermediate variables shown in Figure 12.

Table 9: Model 1 & 2 –Multivariate Regression Analysis of Variables

	Var. Type	Model 1	Model 2a[a]	Model 2b[a]	Model 2c[a]	Model 2d[a]
greenprod3 (DEP)		**Coef.**	**Coef.**	**Coef.**	**Coef.**	**Coef.**
regcert	**INV**	.073	.043	.108	.656	.100
ccbelief	**INV**	.004	.049	-.046	.049	.269
cusempinfl	**INV**	-.063	-.145	-.235	-.042	-.046
incentivinfl1	**INV**	.445**	.454**	.452**	1.186*	.845**
reginfluen	**INV**	.085	.124	.119	.056	.096
Cusempinfl*regcert	**INV**	-	.039	-	-	-
Custempinfl*ccbelief	**INV**	-	-	.058	-	-
Incentivinfl1*regcert	**INV**	-	-	-	-.305	-
Incentivinfl1*ccbelief	**INV**	-	-	-	-	-.119
R-squared			.15	.15	.18	.15
Number of Observations			131	131	131	131

[a] The coefficients for this model are not valid due to multicollinearity.
* Significant at .05
** Significant at .001

Model 3 includes all of the intermediate variables and adds the exogenous variables to test (1) whether they alter the effects of the primary theoretical variables and (2) whether they offer any independent effects on green product usage. Note that Model 3 also includes beta or path coefficients, which allow one to evaluate standardized effects. Model 3 is shown in Table 10.[1]

First, the coefficient for primary external stakeholders variable (incentivinfl1) actually increases somewhat, to .50, still significant at the .001 level. This means, holding everything else constant, incentives are associated with an increase of about half a point on the greenprod3 scale. In terms of standardized effects, this also means that for a one standard deviation increase in incentives, green product use increases by .4 sd's. This is a very strong effect. None of the other theoretical variables are statistically significant.

Second, two of the exogenous variables have a statistically significant negative effect on green product usage. The number of projects (n_projects) is found to be statistically significant at the p=.001 level. Holding everything else constant, each additional project is associated with a decrease of .14-points on the greenprod3 scale. This is somewhat surprising that green product usage is associated with a smaller number of projects.

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[1] The final test conducted on Model 1 and Model 3 was the Cook-Weisberg test for heteroskedasticity. Heteroskedasticity measures whether constant variances for different observations for standard deviations of a variable is present. A lack of heteroskedasticity signifies no bias in our standard errors. The test of Model 1 resulted in a Chi Square of 0.76, which does not indicate the presence of heteroskedasticity. The test of Model 3 resulted in a Chi Square of 1.84, which also does not indicate the presence of heteroskedasticity.

Table 10: Model 3 - Exogenous and Intermediate Variable Regression Analysis

Model 3: Exogenous and Intermediate Variable Regression Analysis			
greenprod3	**DEP**	**Coef.**	**Beta**
regcert	**INV**	.133	.142
ccbelief	**INV**	.003	.005
cusempinfl	**INV**	.035	.020
incentivinfl1	**INV**	.506**	.395
reginfluen	**INV**	.046	.029
custpaygbp	**INV**	.039	.078
n_project	**INV**	-.140**	-.253
hsize	**INV**	-.013	-.020
projtype	**INV**		
Multifamily		-.203	-.121
Remodel		-.364*	-.175
R-squared		.29	
Number of Observations		124	

* Significant at .05
** Significant at .001

The final significant variable, the remodel and renovation project type is found to be statistically significant at the p<.016 level. Holding everything else constant, builders who specialize in remodel and renovation projects are less likely to use green products than builders specializing in single-family units. There is no significant association for builders specializing in multifamily versus single family with respect to green products use.

The remaining exogenous independent variables were found to be not statistically significant in this model. There was one variable that was close to being significant. The regulatory uncertainty variable "regcert" had a coefficient of .133 and a beta of .142. While not statistically significant at the standard .05 level, regulatory uncertainty "regcert" did have a $p = .1$ which signifies a 1 in 10 chance of being significant. The lower significance level here may be the result of the small sample size, and the modest beta of .14 would be statistically significant if the sample size had been 200 or more.

This model "fit" is measured by the multiple correlation coefficient (R^2). The R^2 represents the percent of the total variation that can be explained by the regression model. The R^2 will fall between zero and one with a higher value indicating a stronger relationship among the variables. The model has generated an R^2 of .29, which indicates that approximately 29% of the variance in the greenprod3 scale is explained by the variables in this model.

The results of the statistical analyses failed to support the major hypotheses of this study. The first hypothesis sought to determine the relationship between the rate of green building adoption and environmental and regulatory uncertainty. It was hypothesized that the rate of adoption and institutionalization of green building practices will increase as the degree of environmental and regulatory uncertainty increases. The statistical analyses conducted did not support this hypothesis.

Instead the analysis indicated that the rate of adoption and institutionalization of green building practices occurred independently of uncertainty. Since uncertainty did fail to moderate the relationships between stakeholders and residential construction firms, the remaining two hypotheses were subsequently not supported.

The second and third hypotheses also failed to be supported because each assumed stakeholder influence was dependent on the rate of uncertainty. The second hypothesis assumed primary internal stakeholders would exert the most influence over adopting of green building practices when environmental and regulatory uncertainty is high. Primary internal stakeholders were not found to exert the most influence over the adopting and institutionalizing of green building practices. Instead primary external stakeholders, specifically those providing incentives for adopting green building practices, exert the most influence over a firm's decision to adopt and institutionalize green building practices. This influence, however, did not validate hypothesis 3 because the influence occurred independently of the presence of uncertainty.

Chapter 10 | Discussion and Conclusions

This study evaluated the factors building firms to adopt and institutionalize of proactive environmental management techniques is vital to develop successful climate change mitigation practices. Greenhouse gas emissions in the United States continue to contribute to adverse climatic conditions and global warming. The residential sector contributes significantly to the total U.S. emissions but in the last two decades this sector has begun to take the steps necessary to slow its emissions. Green building has long been promoted as the saving grace for the residential construction industry. Green building allows builders to continue constructing homes but requires more efficient products, better home placement, limited land grading and an overall smaller environmental footprint.

The drivers encouraging adopting and institutionalizing of green building practices in the residential industry have been historically associated with consumer demand. In the wake of an economic recession and an unprecedented housing bust, many builders struggling to stay in business are focusing on different factors that will drive innovation in green building. This study identified and analyzed several factors whose influences have the ability to drive the adopting and institutionalizing green building practices.

900 residential builders were selected from across the country. Respondents were primarily small family owned firms who participated in other types of construction projects in addition to new home construction. Given the economy and the current state of the residential construction industry, many builders are taking on a variety of projects to stay in business and keep as many employed as possible. Of the 900 selected participants, 10% no longer had current contact information available, 25% opted not to participate. Of the 810 potential respondents, 146 of the remaining population responded to my request for participation, which is 18% response rate.

Using the factor analysis, multiple regression analysis and tests for multicollinearity and heterskedacisity to analyze the data received, primary external stakeholders consisting of government, private and utility incentives were shown to exert the most influence on the adoption of green product use independent of environmental or regulatory uncertainty, which failed to exert a significant influence. While a majority of responding firms believed in climate change and felt that adopting green building practices was necessary to their business strategy, neither of these views were significant nor exerted more influence than incentive programs.

There has been a heavy public and private push over the past few years to adopt green building practices, assisted by federal, state and local and private funding opportunities. A majority of existing incentive programs are geared toward new home construction and not toward remodel, redevelopment or renovation projects. Therefore lucrative green building incentives geared toward new construction projects may make may make firms less likely to use green products when doing remodels.

Hypothesis one "*The adoption and institutionalization of green building practices will increase as the degree of environmental and regulatory uncertainty increases,"* assumed a directional relationship between the adopting of green building practices and uncertainty.   The statistical analysis revealed that environmental uncertainty "ccbelief" did not exert a significant influence over the adoption of green building techniques. While regulatory uncertainty "regcert" did not exert a statistically significant influence over the adoption of green building practices, it did exert modest influence which was significant at the p= .1 level, a result possibly due to the small sample size of this study. A higher response rate and a larger sample size might have resulted in a statistically significant effect of regulatory uncertainty. Overall however, the finding that incentives exerted the most influence over adopting and institutionalizing green building products independent of environmental and regulatory uncertainty failed to support Hypothesis 1 of this study.

Previous academic research on the institutionalization of values identified that internal and external pressures have a significant influence on a firm's decision to adopt and institutionalize new practices. Given the state of the economy, climate change science and the dramatic increase in rule making addressing climate change and green building, the premise of this research was to further test this theory on the residential construction industry. Hypothesis 2 and Hypothesis 3 assumed that the traditional linear path of stakeholder influence on residential construction firms would be moderated by the environmental and regulatory uncertainty associated with climate change, which would subsequently alter the type of stakeholder significantly influencing firm adoption of green building practices when faced with such uncertainty.

Specifically Hypothesis 2 predicted that *"primary internal stakeholders will exert the most influence over the adoption of green building practices when uncertainty about climate change or environmental regulations is high,* and Hypothesis 3 predicted that "*Primary external stakeholders will exert the most influence over the adoption of green building practices when uncertainty about climate change or environmental regulations is low."* The results of the study failed to confirm Hypothesis 2 and Hypothesis 3 and instead showed that when presented with financial incentives, builders were significantly influenced and were most likely to adopt green building practices. The interaction variables presented in Model 2 (Table 9) were developed to analyze Hypothesis 2 and Hypothesis 3 but all had a high degree of multicollinearity when analyzed. The presence of multicollinearity invalidated the Model thereby failing to support Hypothesis 2 and Hypothesis 3.

Model 3 illustrated the results of the multivariate regression used to analyze the influence of all remaining exogenous and intermediate variables on the adoption of green building practices. The results of this regression also failed to confirm the moderating influence of uncertainty on stakeholders' abilities to influence firm behavior and adopting and institutionalizing green building practices. Analyzing the influence of the exogenous and intermediate variables on adopting green product practices, primary external stakeholders "incentivinfl1," number of projects "n_project," and remodel and renovation projects "projtype" were found to exert significant influence. The remaining variables, including uncertainty failed to exert significant influence over the adoption of green building practices. Primary external stakeholders consisting of government grant agencies, private utility companies and trade associations, are able to exert a significant influence (at a $p<.000$ level) on adopting green building practices. The study found that increasing the number of incentive programs will significantly increase the rate of adoption.

The remaining significant variables, the number of projects "n_project" and remodel and renovation projects "projtype," were both found to exert a negative relationship with the green product use variable. The analysis showed that an increase in the number of annual projects was shown to result in a decrease in the adoption of green building practices. This finding was surprising but can be attributed to the size of the firm and the availability of capital to invest in advanced green building techniques. Small firms building more homes may have less capital to spend on green features that are not incentivized unless the homeowner is willing to pay for them. Finally the analysis also showed that builders who specialize in remodel and renovation projects were less likely to use green products than builders specializing in single-family units. This finding can be attributed a lack of capital and a lack of comprehensive remodeling incentive programs targeting the remodel and renovation industry to assist in offsetting the cost of adoption.

The results of this study, while understandable, were not anticipated. In a challenged economy, government and private utility incentives are very influential because of their ability to provide funding that allows builders to offset the costs associated with green building. It is unknown whether this influence will result in the institutionalization of green building practices. Clearly builders will adopt the practices and behaviors necessary to obtain funding but it is unclear whether these adopted behaviors and practices will continue if incentive programs cease. Many of the incentive programs that have been put in place to encourage green residential development are beginning to expire and/or run out of funding. With this influential resource diminishing and the economy not back to its pre-2006 boom production levels, it will be interesting to see if the green building trend will continue if voluntary programs are not adopted as mandatory regulatory programs on the federal, state and/or local level.

To prepare for the shift from incentivized green development on the federal level, the federal government has begun to mandate developing of more efficient products and the development of more efficient federal buildings. The recent changes to federal standards for household appliances and furnaces, all now require more development and production of efficient products. Many states are requiring more efficient home construction standards in their building codes. This shift may be in preparation to prevent backsliding because of the eventual loss of incentivized funding assistance. It is also possible federal, state and local governments will continue to shift from encouraging voluntary participation in green development and construction to a mandated compliance program to increase home efficiency and offset GHG emissions. It is unclear how builders will proceed in the future, in the absence of such mandates and with increased programmatic shifts to further adopting green building. The assumption is that more builders will initially adopt and institutionalize green building practices because of incentive programs but the behavior will continue because of the inevitable government mandates.

Residential construction contributes significantly to the total U.S. GHG emissions. Over the past two decades however, voluntary programs, firm buy-in, consumer demand, and regulatory mandates have improved the quality and efficiency of new homes built. A majority of today's residential GHG emissions are associated with the existing pre-1990 housing stock. Without incentivizing remodel and renovations projects, the remodeling sector will continue to remodel homes without utilizing advanced green building techniques. In order to address GHG emissions in the residential sector, incentive programs will have to be created, as it was for the new construction sector, to encourage the adoption of green building techniques. Without these incentive programs encouraging green home renovations, the GHG emissions contribution of the residential sector cannot be effectively addressed.

Sources of Error

This study evaluated participants' responses to determine impacts of uncertainty on stakeholder's ability to influence on the adoption of green building practices. Possible sources of error can be associated with the type of respondents participating and the type of businesses they were a part of. A vast majority of the respondents were either owners or chief executive officers for the small businesses. Respondent type was controlled and limited to firm decision makers but the intrinsic nature of the respondents cannot be controlled. It is a possibility that respondents are more likely to incorporate green building practices than non-respondents. Those who use green building practices may have found more value from the research study than those that do not build green thereby skewing the response rate. Rather than seek the participation of decision makers within a firm, seeking the participation of project managers or foremen may have provided a greater perspective.

Another source of error could come from the sizes of the firms who responded. Since a majority of respondents were small businesses they may have less capital to invest in alternative practices and are therefore more dependent on incentive programs than larger firms. Due to the limited responses of middle to large residential firms who responded, this could not be addressed in the study.

The most important potential source of error was the low response rate for the survey. It is difficult to effectively determine what factors influence the adoption and institutionalization of green building products and practices practices with only a twenty-five percent response rate. A more reliable determination should have a larger population tested and a larger response rate.

Recommendations for Future Research

There are few studies researching the residential construction industry and the factors that shape their building practices. The traditional view of the construction industry is that builders construct homes that buyers want. This study demonstrates that incentives have a strong influence in steering builders towards improving their building practices. Future research on this sector should look further into how the industry is shaped and influenced and what type of incentive programs most influence firms to adopt green building practices.

Appendix A: Participation Solicitation Email

Original email:

Dear Participant,

My name is Larissa Mark, and I am a doctoral student at George Mason University. My dissertation is studying the factors that influence the adoption of green building practices by builders throughout the country.

I would very much appreciate your participation in a short survey. You can complete the survey by going to a special link, [url]. This survey will take you less than 15 minutes to complete (promise!!).

Thank you in advance for your participation! If you have any questions please do not hesitate to contact me at (202) 266-8157 or (804) 869-6718.

Thanks Again!

Larissa Mark
Environmental Policy and Social Science Doctoral Program
George Mason University, 2012

Reminder email:

Good afternoon!

My name is Larissa Mark and I am a doctoral student at George Mason University. I emailed you approximately two weeks ago seeking your participation in my graduate study.

To date I have gotten back a few responses and the information I have been able to collect from it has been extremely helpful! If you have not yet been able to participate in the survey, please do so. I would love to gather your input on the state of the residential construction industry and the factors that influence the adoption of green building practices.

If you have any questions please do not hesitate to contact me. My phone number is 804-869-6718. The survey can be found on the Survey Monkey website. The URL is: https://www.surveymonkey.com/s/GreenBuildingDoctoralSurvey_BaselinePretest.

Thanks again!
Larissa Mark
Environmental Policy and Social Science Doctoral Program
George Mason University, 2011

Appendix B: Informed Consent Document

Determining the Moderating Influence of Uncertainty on the Adoption of Green Building Practices in the Residential Construction Industry.

INTRODUCTION

The Department of Environmental Science and Public Policy at George Mason University supports the practice of protection for human subjects participating in research. The following information is provided for you to decide whether you wish to participate in the present study. You may refuse to sign this form and not participate in this study. You should be aware that even if you agree to participate, you are free to withdraw at any time. If you do withdraw from this study, it will not affect your relationship with this unit, the services it may provide to you, or George Mason University.

PURPOSE OF THE STUDY

The purpose of this project is to determine the perception of stakeholder influence on residential construction firms on the adoption and institutionalization of green building values when faced with perceived environmental uncertainty. Human participants will complete a survey on their business practices and beliefs regarding climate change, stakeholder involvement and the adoption of green building practices.

PROCEDURES

Attached is the survey for you to complete. The survey has less than 20 questions and should take you no more than 15 minutes to complete. Please check off all answers that are applicable to you, your firm and your business practices. Once complete please return the survey to the surveyor or email it to (804) 869-6718.

RISKS

Completion of this survey is strictly voluntary and there are no risks associated with its completion.

BENEFITS

While there are no direct benefits to the participants, this research has the potential to benefit the manner in which NAHB directs educational Green Building efforts. It will also benefit the population at large as they seek to educate themselves on the decisions made when attempting to adopt and institutionalize new behaviors and values.

PARTICIPANT CONFIDENTIALITY

Your name will not be associated in any publication or presentation with the information collected about you or with the research findings from this study. Instead, the researcher(s) will use a study number or a pseudonym rather than your name. Your identifiable information will not be shared unless you give written permission.

Permission granted on this date to use and disclose your information remains in effect indefinitely. By signing this form you give permission for the use and disclosure of your information for purposes of this study in the future.

REFUSAL TO SIGN CONSENT AND AUTHORIZATION

You are not required to sign this Consent and Authorization form and you may refuse to do so. However, if you refuse to sign, you cannot participate in this study.

PARTICIPATION

Your participation is voluntary, and you may withdraw from the study at any time and for any reason.

PARTICIPANT CERTIFICATION:

I have read this Consent and Authorization form. I have had the opportunity to ask, and I have received answers to, any questions I had regarding the study. This research is being conducted by Larissa A. Mark of the Environmental Science and Public Policy Department at George Mason University. She may be reached at 804-869-6718 for questions or to report a research-related problem. You may contact the George Mason University Office of Research Subject Protections at 703-993-4121 if you have questions or comments regarding your rights as a participant in the research.

I agree to take part in this study as a research participant. By my signature I affirm that I am at least 18 years old and that I have received a copy of this Consent and Authorization form.

______________________________ ____________________

Type/Print Participant's Name Date

____

Participant's Signature

Researcher Contact Information

Larissa Mark
Principal Investigator
EVPP Graduate Student.
George Mason University
3101 Naylor Road SE #102
Washington, DC 20020
804-869-6718

S.L. Beach, Ph.D
Faculty Supervisor
Geography and Geoinformation Science
4400 University Drive
George Mason University
MSN 6C3
Fairfax, VA 22030
(703) 993-1213

Appendix C: Respondent Survey

Informed Consent Document

Determining the Moderating Influence of Uncertainty on the Adoption of Green Building Practices in the Residential Construction Industry.

RESEARCH PROCEDURES

This research is being conducted to determine the perception of stakeholder influence on residential construction firms on the adoption and institutionalization of green building values when faced with perceived environmental uncertainty. Participants will complete a survey on their business practices and beliefs regarding climate change, stakeholder involvement and the adoption of green building practices. Surveys will be available via email and Survey Monkey. Participants can either complete the online survey or submit the survey via email or fax. The PDF version of the survey will be an editable document. If you agree to participate, you will be asked to complete the survey from your email or by following the link to the electronic survey on the Survey Monkey website.

RISKS

There are no foreseeable risks for participating in this research.

BENEFITS

There are no benefits to you as a participant other than to further research in the manner in which the Construction Industry directs educational Green Building efforts. This study can assist in a firm's decision to adopt additional green building practices and strategies. This research can also benefit firms as they seek to educate themselves on the proactive environmental protection strategies when attempting to adopt and institutionalize new behaviors and values.

CONFIDENTIALITY

The data in this study will be confidential. All responses will be submitted anonymously. Any names and other identifiers will not be placed on surveys or other research data. All data will instead by coded for analysis. This means that rather than placing your identifying information in the survey data, code will be placed on the survey and other collected data. This code will focus on the state and U.S. Census region in which you reside. Only I will have access to the coding information and the link to your identifying information. This information will not be shared. While it is understood that no computer transmission can be perfectly secure, reasonable efforts will be made to protect the confidentiality of your transmission.

PARTICIPATION
Your participation is voluntary, and you may withdraw from the study at any time and for any reason. This survey should take less than 15 minutes to complete and should be taken by a decision maker within the firm. If you decide not to participate or if you withdraw from the study, there is no penalty or loss of benefits to which you are otherwise entitled. There are no costs to you or any other party. This research has been reviewed according to George Mason University procedures governing your participation in this research.

CONTACT
This research is being conducted Larissa A. Mark at George Mason University. She may be reached at 804-869-6718 for questions or to report a research-related problem. Or please contact Dr. Sheryl Beach at George Mason University. She may be reached at (703) 993-1213 for questions or to report a research-related problem. You may contact the George Mason University Office of Research Subject Protections at 703-993-4121 if you have questions or comments regarding your rights as a participant in the research.

This research has been reviewed according to George Mason University procedures governing your participation in this research.

CONSENT
I have read this form and agree to participate in this study. The George Mason University Human Subjects Review Board has waived the requirement for a signature on this consent form. However, if you wish to sign a consent form, please contact Larissa Mark at 804-869-6718 or via email at lmark@gmu.edu.

Researcher Contact Information

Larissa Mark
Principal Investigator
EVPP Graduate Student.
George Mason University
3101 Naylor Road SE #102
Washington, DC 20020
(804) 869-6718

S.L. Beach, Ph.D
Faculty Supervisor
Geography and Geoinformation Science
4400 University Drive
George Mason University
MSN 6C3
Fairfax, VA 22030
(703) 993-1213

2. General Information

Please select the options that best describes you.

1. What is your job function within the residential construction industry?

- [ ] Current Builder
- [ ] Previous Builder
- [ ] Custom Home Builder
- [ ] Remodeler
- [ ] Architect
- [ ] Environmental Analyst
- [ ] Manager
- [ ] Quality Assurance Manager
- [ ] Engineer
- [ ] Chief Executive Officer
- [ ] Supervisor
- [ ] Project Manager
- [ ] Supplier
- [ ] Other

2. What is your job title?

3. Are you Male or Female?

- ○ Male
- ○ Female

4. Please identify your age

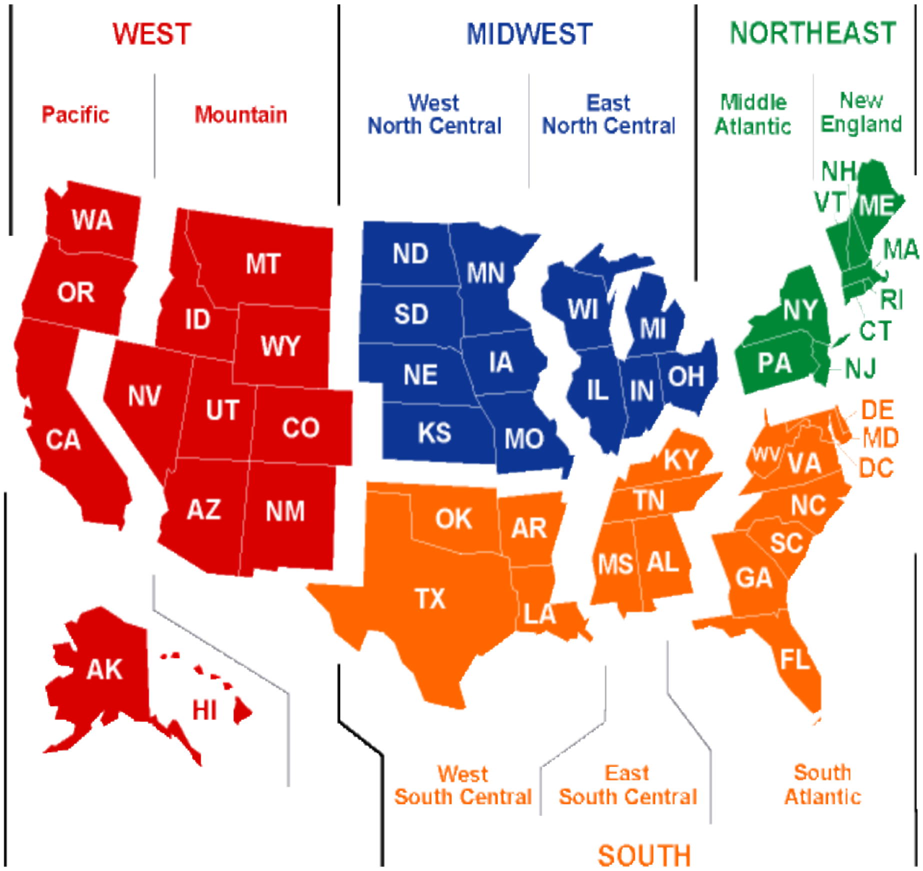
- ○ 20-30
- ○ 31-40
- ○ 41-50
- ○ 51-60
- ○ 61-70
- ○ 70+

5. What is the highest level of education you have completed?

- ○ Grades 6-8
- ○ High school
- ○ Less than 4 years of college
- ○ College Degree
- ○ Advanced College Degree

finalized survey

U.S. Census Regional Map



6. What region or regions of the country do you build homes? (select all that apply)

- ☐ New England (NorthEast)
- ☐ East South Central
- ☐ West North Central (Midwest)
- ☐ Middle Atlantic (NorthEast)
- ☐ West South Central
- ☐ Mountain (West)
- ☐ South Atlantic
- ☐ East North Central (Midwest)
- ☐ Pacific (West)

finalized survey

3. General Project Information

1. Are you Classified as a:

- ◯ Small business (Employing less than 100 employees)
- ◯ Medium-Sized Business (Employing Greater than 100 but less than 500 employees)
- ◯ High Production Business (Employing Greater than 500 employees)

2. How many projects are you involved with annually?

- ◯ 0-10
- ◯ 11-20
- ◯ 21-30
- ◯ 31-40
- ◯ 41+

3. What type of construction projects do you engage in?

- ◯ Single Family
- ◯ Multifamily
- ◯ Modular
- ◯ High production Single Family
- ◯ Remodels and Renovations
- ◯ All of the Above
- ◯ None of the Above

4. What is the average size of the homes built?

- ◯ Less than 1000 sq ft
- ◯ 1001 - 2000 sq ft
- ◯ 2001 - 3000 sq ft
- ◯ 3000 – 4001 sq ft
- ◯ 5000+ sq ft

4. Views on Green Building Programs

1. Please check which of the following most closely represents your beliefs: Overall, green building products are:

	Better Than Average	Average	Below Average	Worse than Average	N/A
On average, the safety of green products are:	○	○	○	○	○
On average, the lifespan of green products are:	○	○	○	○	○
On average, the quality of green products are:	○	○	○	○	○

2. Mark the response that best describes your views on Green Building.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Green building is a fad which will soon pass	○	○	○	○	○
Because of energy savings, Green building is cost effective for home and business owners	○	○	○	○	○
Green design is important to my company and the long term success of my company.	○	○	○	○	○
Green products are not readily available	○	○	○	○	○
Green products are expensive	○	○	○	○	○
Implementing green building strategies are easier when it is mandated through building codes.	○	○	○	○	○
Green building does not provide enough savings to justify the extra costs	○	○	○	○	○
Green building is a social responsibility	○	○	○	○	○

3. I have participated in voluntary programs green building programs/certifications.

	Yes	No
I have participated in voluntary programs green building programs/certifications	○	○
I have participated in from 1 to 5 green building programs/certifications	○	○
I have participated in more than 5 green building programs/certifications	○	○

4. Mark the response that describes how much influence the following have on your firm's decisions to adopt green building techniques

	A Lot of Influence	Some Influence	Neutral	No Influence
Customers	◯	◯	◯	◯
Employees (non management)	◯	◯	◯	◯
Employees (management)	◯	◯	◯	◯
Financial Institutions	◯	◯	◯	◯
Regulations (local, state, federal)	◯	◯	◯	◯
Environmental advocacy organizations	◯	◯	◯	◯
Trade Associations	◯	◯	◯	◯
Government Incentives	◯	◯	◯	◯
Private or Utility Incentives	◯	◯	◯	◯

5. Buyers are willing to pay additionally for green features

◯ Always

◯ Most of the Time

◯ Some of the Time

◯ Never

finalized survey

5. Climate Change and Firm Decision Making

1. Please check which of the following most closely represents your beliefs:

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The seriousness of climate change is exaggerated.	◯	◯	◯	◯	◯
Climate Change is impacting the weather across the nation and across the globe.	◯	◯	◯	◯	◯
Climate Change will not pose a serious threat to me and my way of life in my lifetime	◯	◯	◯	◯	◯
Climate change will impact future generations	◯	◯	◯	◯	◯
Humans and human activities do not contribute to climate change.	◯	◯	◯	◯	◯
Greenhouse gases from burning fossil fuels (coal, oil, gas etc) does contribute to changes in climate.	◯	◯	◯	◯	◯
I take into consideration the impacts of climate change in my business practices	◯	◯	◯	◯	◯
Energy efficiency programs assist in reducing the impacts of climate change	◯	◯	◯	◯	◯

2. Check if your state or local jurisdiction mandates or supports voluntary investment in any of the following:

	State	Local	Neither
Green House Gas (GHG) mitigation requirements in building codes	☐	☐	☐
Use of energy efficient products and materials (i.e. windows, insulation, appliances etc)	☐	☐	☐
Use of water efficient products and materials (i.e. showerheads, faucets, water efficient appliances etc)	☐	☐	☐
Use of low impact development techniques (i.e. bioswales, rain gardens, rain barrels, storm water reclamation systems etc)	☐	☐	☐
Use of low volatile organic compound (VOC) containing paints and other materials	☐	☐	☐

3. How certain are you that your STATE government will implement new green building requirements (which can include energy efficiency, water efficiency, resource efficiency and/or material efficiency requirements) in residential building codes in the near future?

- ◯ Very certain
- ◯ Certain
- ◯ Uncertain
- ◯ Very uncertain

4. Does the potential STATE implementation of green building requirements influence your businesses decisions?

- ◯ Yes
- ◯ No

5. How certain are you that your LOCAL government will implement new green building requirements (which can include energy efficiency, water efficiency, resource efficiency and/or material efficiency requirements) in residential building codes in the near future?

- ◯ Very certain
- ◯ Certain
- ◯ Uncertain
- ◯ Very uncertain

6. Does the potential LOCAL implementation of green building requirements influence your businesses decisions?

- ◯ Yes
- ◯ No

6. Green Products and Product Quality

1. Which of the following strategies do you employ or provide during the construction of new residential buildings?

Water Efficiency

	Always	Most of the time	Some of the time	Never	Not Applicable
Water-Reducing Plumbing Fixtures	○	○	○	○	○
Low Flow Sinks and Showerheads	○	○	○	○	○
High Efficiency Toilets	○	○	○	○	○
Tankless Water Heaters	○	○	○	○	○
Capture gray water for irrigation	○	○	○	○	○

2. Which of the following strategies do you employ or provide during the construction of new residential buildings?

Energy Efficiency

	Always	Most of the time	Some of the time	Never	Not Applicable
Increased insulation	○	○	○	○	○
Factory built components including trusses and prehung doors	○	○	○	○	○
Well insulated foundations	○	○	○	○	○
High efficiency HVAC	○	○	○	○	○
Energy efficient lighting	○	○	○	○	○

3. Which of the following strategies do you employ or provide during the construction of new residential buildings?

Materials and Resource Efficiency

	Always	Most of the time	Some of the time	Never	Not Applicable
Energy efficient windows	○	○	○	○	○
Fire suppression systems contains no HCFCs or halons	○	○	○	○	○
Energy efficient appliances	○	○	○	○	○
Use of Certified Wood	○	○	○	○	○

7. Additional Feedback

1. Would you like a copy of the results of this survey? If so please enter your email address.

Email Address:

2. Please share any additional comments.

Appendix D: Factor Analysis of Data

Dependent Variable Analysis

Green Products Used

1. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
h2oredfixt	133	1.834586	1.09531	1	5
lowflowss	133	1.917293	1.108132	1	5
etoilet	133	1.796992	1.11979	1	5
tankless	131	3.045802	1.058755	1	5
gwcapt	133	3.962406	.7528332	1	5
insul	133	1.759398	1.074148	1	5
prehundoo	133	1.93985	1.092394	1	5
insfound	133	2.180451	1.301716	1	5
hehvac	132	1.825758	1.13579	1	5
eelight	133	2.007519	1.040806	1	5
eewind	132	1.378788	.8869736	1	5
firesup	131	3.70229	1.187723	1	5
eeappl	133	1.75188	.9723917	1	5
certwood	133	2.87218	1.15741	1	5

2. Correlation

	h2ored~t	lowflo~s	etoilet	tankless	gwcapt	insul	prehun~o	insfound	hehvac	eelight	eewind	firesup	eeappl
h2oredfixt	1.0000												
lowflowss	0.9196	1.0000											
etoilet	0.7921	0.8391	1.0000										
tankless	0.2564	0.1892	0.2028	1.0000									
gwcapt	0.1902	0.1264	0.0727	0.2848	1.0000								
insul	0.3982	0.3868	0.4331	0.3111	0.1880	1.0000							
prehundoo	0.3642	0.4062	0.4159	0.2557	0.0728	0.5236	1.0000						
insfound	0.3218	0.3768	0.4327	0.2132	0.1207	0.5927	0.4615	1.0000					
hehvac	0.4548	0.4191	0.4255	0.4366	0.2178	0.6538	0.5560	0.4686	1.0000				
eelight	0.4575	0.4507	0.4373	0.3834	0.2013	0.6506	0.3911	0.5592	0.5678	1.0000			
eewind	0.4651	0.4186	0.4751	0.3798	0.1996	0.6919	0.5943	0.4874	0.6321	0.6299	1.0000		
firesup	0.1383	0.1071	0.1171	0.0908	0.2845	0.1951	0.1050	0.0791	0.2857	0.2680	0.2280	1.0000	
eeappl	0.5375	0.5169	0.4869	0.3635	0.1659	0.6478	0.4783	0.5699	0.6057	0.7019	0.7143	0.2341	1.0000
certwood	0.2163	0.2373	0.2876	0.1271	0.2488	0.3917	0.2052	0.2671	0.3698	0.2891	0.4288	0.2158	0.3710

	certwood
certwood	1.0000

3. Factor Analysis

```
Factor analysis/correlation                        Number of obs    =       127
    Method: principal factors                      Retained factors =         7
    Rotation: (unrotated)                          Number of params =        77
```

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	5.93434	4.64203	0.7703	0.7703
Factor2	1.29230	0.75113	0.1677	0.9380
Factor3	0.54118	0.28536	0.0702	1.0083
Factor4	0.25581	0.03013	0.0332	1.0415
Factor5	0.22568	0.13078	0.0293	1.0708
Factor6	0.09490	0.04211	0.0123	1.0831
Factor7	0.05279	0.06212	0.0069	1.0899
Factor8	-0.00933	0.00306	-0.0012	1.0887
Factor9	-0.01239	0.02501	-0.0016	1.0871
Factor10	-0.03739	0.02539	-0.0049	1.0823
Factor11	-0.06279	0.07153	-0.0081	1.0741
Factor12	-0.13432	0.04409	-0.0174	1.0567
Factor13	-0.17840	0.07981	-0.0232	1.0335
Factor14	-0.25821	.	-0.0335	1.0000

LR test: independent vs. saturated: chi2(91) = 1074.46 Prob>chi2 = 0.0000

Factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Uniqueness
h2oredfixt	0.7452	-0.5613	0.1479	-0.0886	-0.0254	-0.0569	0.0023	0.0960
lowflowss	0.7403	-0.6140	0.0276	0.0158	-0.0082	0.0267	0.0281	0.0724
etoilet	0.7245	-0.4722	-0.0596	0.0913	0.0578	0.0522	-0.0431	0.2323
tankless	0.4216	0.1791	0.1776	-0.3232	-0.0373	0.0448	-0.0853	0.6435
gwcapt	0.2567	0.1426	0.4396	-0.0098	0.0120	0.1107	-0.0364	0.7067
insul	0.7667	0.2786	-0.1246	0.0764	0.0011	0.0481	-0.0039	0.3109
prehundoo	0.6215	0.1009	-0.2424	-0.1189	0.2422	0.0234	0.0609	0.4677
insfound	0.6351	0.1474	-0.2538	0.0917	-0.1224	0.1667	-0.0128	0.4591
hehvac	0.7499	0.2235	0.0516	-0.1140	0.1354	0.0379	0.0713	0.3473
eelight	0.7516	0.1912	0.0067	-0.0078	-0.2710	-0.0154	0.0426	0.3229
eewind	0.8001	0.2433	-0.0471	0.0010	0.1146	-0.1575	-0.0634	0.2564
firesup	0.2654	0.1564	0.3384	0.1280	0.0218	-0.0201	0.1374	0.7544
eeappl	0.8110	0.1457	-0.0478	0.0250	-0.1581	-0.1282	-0.0067	0.2767
certwood	0.4352	0.1544	0.1724	0.2763	0.1266	-0.0026	-0.0883	0.6568

4. Alpha Reliability

```
. alpha h2oredfixt lowflowss etoilet insul prehundoo insfound hehvac eelight eewind eeappl, std

Test scale = mean(standardized items)

Average interitem correlation:      0.5302
Number of items in the scale:           10
Scale reliability coefficient:      0.9186
```

5. Recode and Redefinition of Green Product use

```
. recode greenproduse (1/3.49 = 3 "some of time") (3.5/4.49 = 4 "most of time") (4.5/5 = 5 "all of time"),  gen (greenprod3)
(110 differences between greenproduse and greenprod3)

. label variable greenprod3 "RECODE - adoption of green building products (rounded)"

. tab greenprod3
```

RECODE - adoption of green building products (rounded)	Freq.	Percent	Cum.
some of time	17	12.78	12.78
most of time	55	41.35	54.14
all of time	61	45.86	100.00
Total	133	100.00	

Independent Variable Analyses

a. Views on Green Building

1. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
gbp_safe	131	1.725191	.5122114	1	3
gbp_lfspn	124	1.919355	.6061578	1	4
gbp_qual	131	1.877863	.6204577	1	4
gb_fad	138	3.536232	1.11499	1	5
gb_cost	137	2.70073	1.073511	1	5
lngtrm	138	2.57971	1.052016	1	5
gbp_aval	137	3.277372	.9213954	1	5
gbp_expen	133	2.082707	.816915	1	5
gbs_bcmnd	135	3.17037	1.290266	1	5
gb_save	137	2.773723	1.143991	1	5
gb_socresp	136	2.492647	1.074942	1	5

2. Correlation

	gbp_safe	gbp_lf~n	gbp_qual	gb_fad	gb_cost	lngtrm	gbp_aval	gbp_ex~n	gbs_bc~d	gb_save	gb_soc~p
gbp_safe	1.0000										
gbp_lfspn	0.5326	1.0000									
gbp_qual	0.4842	0.7823	1.0000								
gb_fad	-0.3974	-0.1700	-0.2185	1.0000							
gb_cost	0.3615	0.3253	0.3165	-0.3178	1.0000						
lngtrm	0.3766	0.2110	0.1989	-0.4955	0.5418	1.0000					
gbp_aval	-0.1668	-0.1180	-0.1091	0.1792	-0.0031	-0.0833	1.0000				
gbp_expen	-0.0223	-0.0569	-0.1478	0.2117	-0.3971	-0.3142	0.2681	1.0000			
gbs_bcmnd	0.1053	0.2160	0.1183	-0.1271	0.0900	0.2442	-0.0916	-0.0914	1.0000		
gb_save	-0.3000	-0.2765	-0.3275	0.4250	-0.5610	-0.5488	0.1231	0.4521	0.0307	1.0000	
gb_socresp	0.3420	0.3125	0.2792	-0.4576	0.2855	0.5531	-0.1663	-0.1446	0.3424	-0.3498	1.0000

3. Factor Analysis

Factor analysis/correlation				Number of obs = 114
Method: principal-component factors				Retained factors = 4
Rotation: (unrotated)				Number of params = 38
Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	3.95041	2.40931	0.3591	0.3591
Factor2	1.5411	0.34014	0.1401	0.4992
Factor3	1.20096	0.12604	0.1092	0.6084
Factor4	1.07492	0.16174	0.0977	0.7061
Factor5	0.91318	0.35064	0.083	0.7891
Factor6	0.56254	0.05125	0.0511	0.8403
Factor7	0.51129	0.12905	0.0465	0.8868
Factor8	0.38224	0.02351	0.0347	0.9215
Factor9	0.35873	0.04984	0.0326	0.9541
Factor10	0.30889	0.11317	0.0281	0.9822
Factor11	0.19572	.	0.0178	1
LR test: independent vs. saturated: chi2(55) = 445.44 Prob>chi2 = 0.0000				

Factor loadings (pattern matrix) and unique variances					
Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
gbp_safe	0.6595	0.3807	-0.0267	0.0693	0.4146
gbp_lfspn	0.6294	0.6583	-0.1343	-0.0917	0.1441
gbp_qual	0.6312	0.5856	-0.2501	-0.1326	0.1785
gb_fad	-0.6357	0.2263	-0.1994	-0.1091	0.493
gb_cost	0.69	-0.2197	-0.3213	0.1928	0.3353
lngtrm	0.7402	-0.3424	0.1588	0.2686	0.2375
gbp_aval	-0.2622	0.0789	-0.2089	0.8442	0.1687
gbp_expen	-0.4403	0.5184	0.226	0.4348	0.2973
gbs_bcmnd	0.2958	0.1102	0.7188	-0.0296	0.3828
gb_save	-0.7104	0.3375	0.3422	-0.0348	0.2632
gb_socresp	0.6619	-0.0455	0.4722	0.138	0.3179

4. Alpha Reliability

```
Test scale = mean(standardized items)
Reversed items:  gb_fad gbp_expen gb_save

Average interitem correlation:      0.3270
Number of items in the scale:            9
Scale reliability coefficient:      0.8139
```

b. <u>Stakeholders Influencing Firm Decisions</u>

1. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
custinfl	139	1.546763	.6726868	1	3
emplinfl	139	2.561151	.5787932	1	3
manginfl	137	1.992701	.7717089	1	3
finstinfl	138	2.673913	.5815038	1	3
reginfl	139	1.964029	.7264174	1	3
envorginfl	138	2.637681	.5659696	1	3
trdasocinfl	139	2.323741	.6045219	1	3
govinctinfl	139	2.035971	.7061846	1	3
privincinfl	138	2.021739	.7195639	1	3
stproginfl	131	1.419847	.4954283	1	2
llproginfl	132	1.439394	.498204	1	2

2. Correlation

	custinfl	emplinfl	manginfl	finsti~l	reginfl	envorg~l	trdaso~l	govinc~l	privin~l	stprog~l	llprog~l
custinfl	1.0000										
emplinfl	0.2064	1.0000									
manginfl	0.1621	0.4117	1.0000								
finstinfl	0.1843	0.1286	0.0060	1.0000							
reginfl	0.2728	0.1499	0.1456	0.3276	1.0000						
envorginfl	0.0025	0.1400	0.1007	0.2550	0.1179	1.0000					
trdasocinfl	0.0005	0.3020	0.0119	0.0811	0.2818	0.4077	1.0000				
govinctinfl	0.1639	0.2691	0.0588	0.0915	0.2563	0.0794	0.2778	1.0000			
privincinfl	0.1761	0.3403	-0.0007	0.2482	0.3390	0.1220	0.3184	0.7491	1.0000		
stproginfl	0.1208	0.0093	-0.1782	0.1880	0.3652	0.1577	0.1720	0.0586	0.0759	1.0000	
llproginfl	-0.0114	0.0215	-0.1147	0.1688	0.2979	0.1678	0.1627	-0.0579	0.0080	0.7236	1.0000

3. Factor Analysis

```
Factor analysis/correlation                        Number of obs    =      125
    Method: principal-component factors            Retained factors =        4
    Rotation: (unrotated)                          Number of params =       38
```

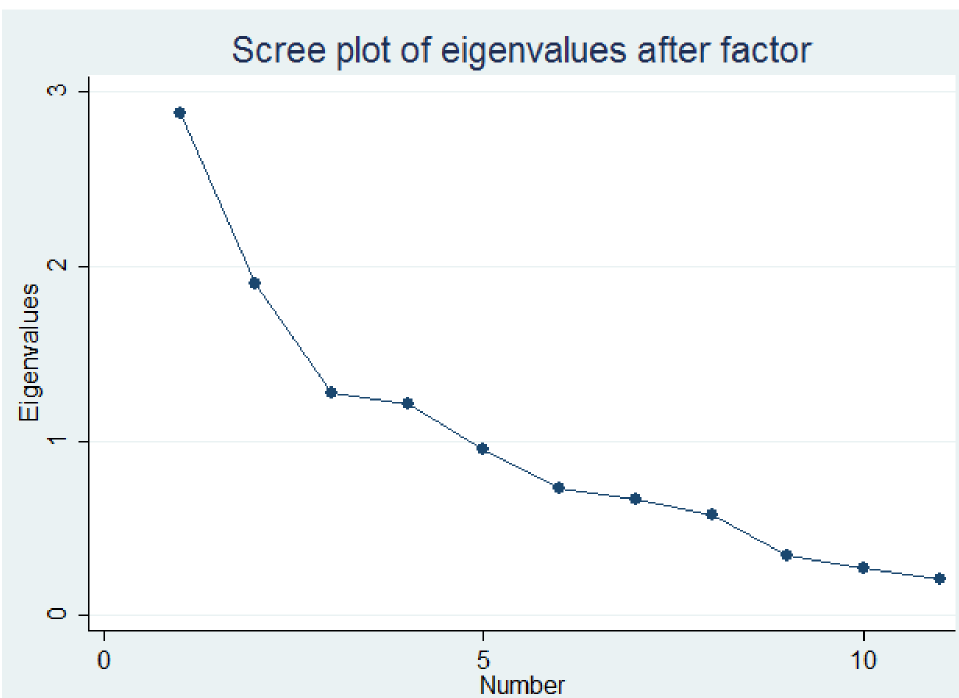
Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	2.88008	0.98046	0.2618	0.2618
Factor2	1.89962	0.62656	0.1727	0.4345
Factor3	1.27305	0.05977	0.1157	0.5502
Factor4	1.21329	0.25835	0.1103	0.6605
Factor5	0.95494	0.23213	0.0868	0.7474
Factor6	0.72281	0.05633	0.0657	0.8131
Factor7	0.66648	0.08795	0.0606	0.8737
Factor8	0.57853	0.23846	0.0526	0.9263
Factor9	0.34006	0.07391	0.0309	0.9572
Factor10	0.26616	0.06117	0.0242	0.9814
Factor11	0.20499	.	0.0186	1.0000

LR test: independent vs. saturated: chi2(55) = 382.78 Prob>chi2 = 0.0000

Factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
custinfl	0.3631	-0.1614	0.3122	-0.5733	0.4159
emplinfl	0.5111	-0.4236	0.3580	0.1367	0.4125
manginfl	0.1725	-0.4521	0.7057	0.0419	0.2661
finstinfl	0.4773	0.1450	0.1530	-0.1633	0.7011
reginfl	0.6705	0.1596	0.1135	-0.2844	0.4313
envorginfl	0.4285	0.1206	0.1894	0.6315	0.3672
trdasocinfl	0.5848	-0.0150	-0.1078	0.5644	0.3277
govinctinfl	0.6116	-0.4266	-0.4926	-0.1038	0.1906
privincinfl	0.7018	-0.3671	-0.4625	-0.1053	0.1476
stproginfl	0.4779	0.7300	0.0057	-0.1321	0.2212
llproginfl	0.3991	0.7608	0.0950	-0.0011	0.2529

i. Scree Plot



ii. Rotate Factor 2

```
. rotate, f(2)

Factor analysis/correlation                        Number of obs    =       125
    Method: principal-component factors            Retained factors =         4
    Rotation: orthogonal varimax (Kaiser off)      Number of params =        38
```

Factor	Variance	Difference	Proportion	Cumulative
Factor1	2.61238	0.44506	0.2375	0.2375
Factor2	2.16731	0.89426	0.1970	0.4345
Factor3	1.27305	0.05977	0.1157	0.5502
Factor4	1.21329	.	0.1103	0.6605

LR test: independent vs. saturated: chi2(55) = 382.78 Prob>chi2 = 0.0000

Rotated factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
custinfl	0.3939	0.0521	0.3122	-0.5733	0.4159
emplinfl	0.6571	-0.0941	0.3580	0.1367	0.4125
manginfl	0.3833	-0.2953	0.7057	0.0419	0.2661
finstinfl	0.3312	0.3730	0.1530	-0.1633	0.7011
reginfl	0.4883	0.4864	0.1135	-0.2844	0.4313
envorginfl	0.3023	0.3268	0.1894	0.6315	0.3672
trdasocinfl	0.5064	0.2928	-0.1078	0.5644	0.3277
govinctinfl	0.7443	-0.0441	-0.4926	-0.1038	0.1906
privincinfl	0.7902	0.0537	-0.4625	-0.1053	0.1476
stproginfl	0.0260	0.8722	0.0057	-0.1321	0.2212
llproginfl	-0.0572	0.8572	0.0950	-0.0011	0.2529

Factor rotation matrix

	Factor1	Factor2	Factor3	Factor4
Factor1	0.8526	0.5225	0.0000	0.0000
Factor2	-0.5225	0.8526	0.0000	0.0000
Factor3	0.0000	0.0000	1.0000	0.0000
Factor4	0.0000	0.0000	0.0000	1.0000

iii. Rotate Factor 3

```
. rotate, f(3)

Factor analysis/correlation                        Number of obs    =      125
    Method: principal-component factors            Retained factors =        4
    Rotation: orthogonal varimax (Kaiser off)      Number of params =       38
```

Factor	Variance	Difference	Proportion	Cumulative
Factor1	2.21421	0.01135	0.2013	0.2013
Factor2	2.20286	0.56717	0.2003	0.4016
Factor3	1.63568	0.42240	0.1487	0.5502
Factor4	1.21329	.	0.1103	0.6605

LR test: independent vs. saturated: chi2(55) = 382.78 Prob>chi2 = 0.0000

Rotated factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
custinfl	0.1219	0.1515	0.4665	-0.5733	0.4159
emplinfl	0.0023	0.3409	0.6728	0.1367	0.4125
manginfl	-0.1686	-0.0845	0.8346	0.0419	0.2661
finstinfl	0.4129	0.1948	0.2526	-0.1633	0.7011
reginfl	0.5307	0.3490	0.2907	-0.2844	0.4313
envorginfl	0.3701	0.1496	0.2733	0.6315	0.3672
trdasocinfl	0.3105	0.4847	0.1497	0.5644	0.3277
govinctinfl	-0.0579	0.8916	0.0195	-0.1038	0.1906
privincinfl	0.0462	0.9144	0.0548	-0.1053	0.1476
stproginfl	0.8644	0.0340	-0.1137	-0.1321	0.2212
llproginfl	0.8559	-0.0853	-0.0850	-0.0011	0.2529

Factor rotation matrix

	Factor1	Factor2	Factor3	Factor4
Factor1	0.5768	0.7147	0.3956	0.0000
Factor2	0.8055	-0.4169	-0.4211	0.0000
Factor3	0.1361	-0.5616	0.8162	0.0000
Factor4	0.0000	0.0000	0.0000	1.0000

4. Alpha Reliability

```
Test scale = mean(standardized items)

Average interitem correlation:      0.1685
Number of items in the scale:           11
Scale reliability coefficient:      0.6903

. alpha finstinfl reginfl stproginfl llproginfl, std

Test scale = mean(standardized items)

Average interitem correlation:      0.3547
Number of items in the scale:            4
Scale reliability coefficient:      0.6874


. alpha govinctinfl privincinfl, std

Test scale = mean(standardized items)

Average interitem correlation:      0.7427
Number of items in the scale:            2
Scale reliability coefficient:      0.8524

. alpha  trdasocinfl custinfl  emplinfl manginfl, std

Test scale = mean(standardized items)

Average interitem correlation:      0.1858
Number of items in the scale:            4
Scale reliability coefficient:      0.4772
```

c. Beliefs in Climate Change

1. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ccexag	135	2.725926	1.277998	1	5
ccimpact	135	2.681481	1.182281	1	5
ccnothreat	135	2.762963	1.153886	1	5
ccftimpact	135	2.385185	1.085764	1	5
hmnccimp	134	3.462687	1.11488	1	5
ghgcccontri	135	2.57037	1.033331	1	5
myimpact	135	2.911111	1.047147	1	5
enereffimpc	135	2.622222	1.042862	1	5

2. Correlation

	ccexag	ccimpact	ccnoth~t	ccftim~t	hmnccimp	ghgccc~i	myimpact	eneref~c
ccexag	1.0000							
ccimpact	-0.5658	1.0000						
ccnothreat	0.6012	-0.3595	1.0000					
ccftimpact	-0.6922	0.6830	-0.4210	1.0000				
hmnccimp	0.6456	-0.4527	0.5922	-0.6446	1.0000			
ghgcccontri	-0.5355	0.5436	-0.2848	0.6291	-0.5801	1.0000		
myimpact	-0.2741	0.2999	-0.3466	0.4130	-0.3147	0.3823	1.0000	
enereffimpc	-0.5750	0.4753	-0.4385	0.6094	-0.6120	0.5645	0.4797	1.0000

3. Factor Analysis

```
Factor analysis/correlation                        Number of obs    =      134
    Method: principal-component factors            Retained factors =        1
    Rotation: (unrotated)                           Number of params =        8
```

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	4.56563	3.72352	0.5707	0.5707
Factor2	0.84211	0.01994	0.1053	0.6760
Factor3	0.82217	0.27300	0.1028	0.7787
Factor4	0.54917	0.15579	0.0686	0.8474
Factor5	0.39338	0.07304	0.0492	0.8966
Factor6	0.32034	0.01098	0.0400	0.9366
Factor7	0.30935	0.11150	0.0387	0.9753
Factor8	0.19786	.	0.0247	1.0000

LR test: independent vs. saturated: chi2(28) = 562.88 Prob>chi2 = 0.0000

Factor loadings (pattern matrix) and unique variances

Variable	Factor1	Uniqueness
ccexag	-0.8263	0.3173
ccimpact	0.7333	0.4622
ccnothreat	-0.6616	0.5623
ccftimpact	0.8592	0.2618
hmnccimp	-0.8157	0.3346
ghgcccontri	0.7575	0.4263
myimpact	0.5489	0.6987
enereffimpc	0.7930	0.3711

4. Alpha Reliability

```
Test scale = mean(standardized items)
Reversed items:  ccexag ccnothreat hmnccimp

Average interitem correlation:      0.4996
Number of items in the scale:            8
Scale reliability coefficient:      0.8887
```

d. Certainty of State and Local Green Building Codes

1. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
steeprog	132	2.242424	.9738662	1	4
stweprog	131	2.40458	.942816	1	4
streprog	131	2.717557	.8064624	1	4
stmeprog	131	2.862595	.7821406	1	4
lleeprog	131	2.374046	.9473516	1	4
llweprog	129	2.410853	.9487854	1	4
llreprog	130	2.738462	.8586437	1	4
llmeprog	127	2.826772	.8460411	1	4

2. Correlation

	steeprog	stweprog	streprog	stmeprog	lleeprog	llweprog	llreprog	llmeprog
steeprog	1.0000							
stweprog	0.7045	1.0000						
streprog	0.6482	0.6567	1.0000					
stmeprog	0.5671	0.5872	0.8583	1.0000				
lleeprog	0.5886	0.5426	0.4890	0.4705	1.0000			
llweprog	0.4801	0.6993	0.5426	0.5082	0.8084	1.0000		
llreprog	0.4071	0.6110	0.7478	0.7060	0.6508	0.7491	1.0000	
llmeprog	0.3323	0.4713	0.6139	0.7188	0.6460	0.6509	0.8531	1.0000

3. Factor Analysis

```
Factor analysis/correlation                        Number of obs    =      124
    Method: principal-component factors            Retained factors =        1
    Rotation: (unrotated)                           Number of params =        8
```

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	5.34361	4.42880	0.6680	0.6680
Factor2	0.91481	0.08890	0.1144	0.7823
Factor3	0.82591	0.43349	0.1032	0.8855
Factor4	0.39242	0.18856	0.0491	0.9346
Factor5	0.20387	0.03711	0.0255	0.9601
Factor6	0.16676	0.07718	0.0208	0.9809
Factor7	0.08958	0.02653	0.0112	0.9921
Factor8	0.06305	.	0.0079	1.0000

LR test: independent vs. saturated: chi2(28) = 975.79 Prob>chi2 = 0.0000

Factor loadings (pattern matrix) and unique variances

Variable	Factor1	Uniqueness
steeprog	0.7111	0.4943
stweprog	0.8031	0.3550
streprog	0.8531	0.2722
stmeprog	0.8323	0.3073
lleeprog	0.7921	0.3725
llweprog	0.8342	0.3042
llreprog	0.8847	0.2174
llmeprog	0.8164	0.3335

4. Alpha Reliability

```
Test scale = mean(standardized items)

Average interitem correlation:      0.6165
Number of items in the scale:            8
Scale reliability coefficient:      0.9279
```

e. **Current State and Local Requirements**

1. Recode of variables

recode bcghg (3=0) (1 2 = 1) (4=2), gen (ghgbldcde)
recode eepreq (3=0) (1 2 = 1) (4=2), gen (eemand)
recode wepreq (3=0) (1 2 = 1) (4=2), gen (h2omand)
recode lidreg (3=0) (1 2 = 1) (4=2), gen (lidmand)
recode vocreq (3=0) (1 2 = 1) (4=2), gen (lowvocmand)

2. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ghgbldcde	124	.2741935	.5750745	0	2
eemand	123	1.138211	.7716833	0	2
h2omand	119	1.10084	.7745415	0	2
lidmand	123	.5691057	.7690882	0	2
lowvocmand	126	.4920635	.7456115	0	2

3. Correlation

	ghgbld~e	eemand	h2omand	lidmand	lowvoc~d
ghgbldcde	1.0000				
eemand	0.2804	1.0000			
h2omand	0.3141	0.7079	1.0000		
lidmand	0.2943	0.3273	0.3939	1.0000	
lowvocmand	0.2760	0.3242	0.3140	0.4977	1.0000

4. Factor Analysis

```
Factor analysis/correlation                        Number of obs    =      112
    Method: principal factors                      Retained factors =        2
    Rotation: (unrotated)                          Number of params =        9
```

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	1.92130	1.60100	1.0611	1.0611
Factor2	0.32030	0.37264	0.1769	1.2380
Factor3	-0.05235	0.09876	-0.0289	1.2091
Factor4	-0.15111	0.07645	-0.0835	1.1257
Factor5	-0.22756	.	-0.1257	1.0000

LR test: independent vs. saturated: chi2(10) = 148.55 Prob>chi2 = 0.0000

Factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Uniqueness
ghgbldcde	0.4306	0.1060	0.8033
eemand	0.7274	-0.2697	0.3981
h2omand	0.7584	-0.2423	0.3661
lidmand	0.5827	0.2900	0.5764
lowvocmand	0.5403	0.3059	0.6145

5. Alpha Reliability

```
. alpha ghgbldcde eemand h2omand lidmand lowvocmand

Test scale = mean(unstandardized items)

Average interitem covariance:     .2055113
Number of items in the scale:            5
Scale reliability coefficient:      0.7577
```

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Curriculum Vitae

Larissa Mark graduated from Manchester High School in Chesterfield, Virginia in 1995. She received her Bachelor of Science in Biology with a minor in Secondary Education from the College of William and Mary in 1999. While employed as a teacher in Richmond Public Schools for five years, she received her Master's in Environmental Studies from Virginia Commonwealth University, which she completed in 2004. Following graduation Larissa Mark worked as an environmental policy consultant for Science Applications International Corporation (SAIC), Tetra Tech Inc. and finally the National Association of Home Builders (NAHB) where she is currently employed.