Non-State Market-Driven (NSMD) Green Building Systems: An assessment of the diffusion mechanisms promoting NSMD green building certifications

1. Introduction

Buildings are responsible for 32% of total global final energy use, 19% of all global GHG emissions, and approximately one-third of black carbon emission. In order to work towards the Paris agreement's goal of curbing planetary GHG emissions and keeping a temperature raise at well below 2°C, the building sector represents one of the most affordable and effective alternative to reduce emissions.

With the final goal of promoting the widespread of green building practices, this paper will assess the diffusion mechanisms that are driving the uptake of non-state market-driven (NSMD) green building systems and policies.

First, this paper will provide background and context information on the importance of green buildings for the reduction of GHG emissions and the environmental impacts of the construction industry. Second, it will review the history of NSMD green buildings standards and certification systems, considering the most influential certifications in the international market. Third, it will present three mechanisms of institutional diffusion, which will serve as the lenses from where the paper will analyze the different processes of isomorphism of NSMD green building certifications.

The main body of this paper is a literature review from scholars around the world that have conducted research on the diffusion of green building practices. The main findings from the review are then compiled in three tables to better understand and catalog to which diffusion mechanism each strategy belongs to, and whether it comes from a developed or developing country (or both). The next step is an assessment of all the information compiled in the tables, where the data is translated into a graphic that visualizes the diffusion mechanism spectrum and where each strategy is located. Finally, the results and trends observed in the graphic are identified and the main conclusions about the diffusion mechanisms are provided.

2. Background and Context

Current concerns about climate change and global GHG emission-reduction led to the historic Paris Agreement, which aims to keep the global temperature increase "well below 2°C." With the international community searching for strategies to address this challenge, special attention should be paid to the building sector, as it the one that can reduce global GHG emissions at the lowest cost and with immediate application (IPCC 2007), while at the same time addressing the triple bottom line (economic, environment, society).

In regards to complying with the Intended Nationally Determined Contributions (INDCs) established under the Paris Agreements, buildings can serve as a readily availabe option to cut emissions, providing not only highly cost-effective energy saving opportunities, but also other co-benefits such as energy security, improved employment and poverty alleviation. Out of the 164 INDCs proposed, only 82 contain actions on the building sector, and one third of them do not indicate specific actions on how to acomplish the targets (UNFCCC 2017), which is a clear indicator of the unexploited potential of this sector to curve emissions.

According to the latest report from the Intergovernmental Panel on Climate Change (IPCC), buildings are responsible for 32% of total global final energy use, 19% of all global GHG emissions, and approximately one-third of black carbon emissions (Lucon O. 2014). Such contributions to global warming reflect the immediate urgency in addressing sustainable constructions worldwide, considering that today's new buildings are tomorrow's existing stock, which have an important lock-in risk resulting from its long lifespan and retrofits.

When searching for specific strategies to reduce GHG emissions within the building sector, standards and labels are among the most environmentally effective tools, many of them stemming from NSMD green building certifications. Such market mechanisms, however, cannot drive the transition towards lower carbon buildings on its own. External policy intervention are needed to fix market failures and to provide financial assistance to businesses in facing higher first costs. As a result, both public and private initiatives combined can act as impactful tools in reducing the emissions of the building sector.

Thanks to the processes of green building difussion, initiatives as the ones mentioned before can retrofit and widespread among private certifications and public agencies at the national and international level. This paper will provide an overview of the main causes of green building policies diffusion in an attempt to inform policy makers, NGOs and the business sectors on the most effective ways to promote the widespread of sustainable construction policies.

3. History of NSMD green building certification systems.

3.1 Green Building movement history – The U.S. case

Sustainable constructions practices, such as passive solar design or the utilization of local and renewable materials can be traced back to ancient times. Nonetheless, the encompassing of those strategies under the common umbrella of the green building movement has a much more recent history. The specifics of this phenomenon are different in every country and hard to generalize. Therefore, and for the purpose of this paper, we will focus on the case of the US to explain the evolution of the green building movement, referring both to particular national milestones and international events that influenced and contributed to its development.

In order to understand the origins of this movement, we first need to understand that the concept of "green building" has many definitions. Generally speaking, and according to the World Green Building Council (WGBC), a "green building is a building that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on our climate and natural environment" (WGBC). Other authors have a more prescriptive focus on the topic and assert that a green building is a "construction project that is either certified under any recognized global green rating system or built to qualify for certification" (McGraw-Hill 2013).

The green building movement in the US, as explained by Erten et al., can be divided into four milestones involving major environmental and building policy initiatives (Korkmaz, Erten et al. 2009). The first of them is the publication of the New York Times bestseller book named "Silent Spring" by Rachel Carson in 1962, which raised the public awareness about the unrestricted use of pesticides by the industry and further led to the celebration of the first Earth Day in 1970, putting environmental concerns on the front page of newspapers. Two years later, the first Earth Summit took place in Stockholm, Sweden, and it is considered to be the first occasion in which sustainable development was recognised as an international concern.

The second milestone is the oil embargo from the Organization of Petroleum Exporting Countries (OPEC) on the US in 1972. Even though it only lasted for six months, it created an environmental crisis related to energy security that lead the government to seek for alternative sources of energy and to promote measures to reduce the use of oil.

In 1987, the United Nations (UN) established the Brundtland Commission to unite countries to pursue sustainable development together, leading to the creation of "Our Common Future—also known as the "Brundtland Report"—which coined and defined for the first time the

meaning of the term “Sustainable Development,” expressed as the “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” This international event represented the third milestone in the development of the green building movement in the US.

Finally, the last milestone was the creation of the United States Green Building Council (USGBC) in 1993. As a means to address a shift in paradigm of the architecture, engineering, and construction (AEC) industry to incorporate social, cultural and environmental concerns in their processes, the USGBC developed a set of guidelines to measure and recognize “sustainable” buildings. These guidelines gave birth to the Leadership in Energy and Environmental Design (LEED) certification, launched in 2000, and nowadays considered the most widespread and internationally accepted green building certification in the world.

3.2 Green Building Certification history

Green building certifications have a relative short history, with their first example being the "Building Research Establishment Environmental Assessment Method” (BREEAM), created by the Building Research Establishment (BRE) in the UK in 1990 (BREEAM 2014). In its earliest version, the certification assessed only new office buildings with guidelines covered in a 20-pages book, until 1998, when it was revamped to start incorporating broader aspects of sustainability, including weightings between different environmental issues, annual updates, and variations for other building types. BREEAM’s creator, BRE, was a government-funded research laboratory operating as an Executive Agency of its parent Department until its privatization in 1997, when it was owned by the “Foundation for the Built Environment”—later renamed to “The BRE Trust”—which is currently a registered charity with the mission to support research on the built environment for the public benefit (BRE 2018).

After BREEAM was introduced to the market, other countries began to create their own green building certifications. Among them we can mention CASBEE in Japan, Green Globes in Canada, Green Mark in Singapore, LEED in the US, etc. New green building certifications are created both by private and independent organizations, as well as by governmental departments. In addition, new certifications tend to proliferate first in developed countries, followed by emerging economies, and finally adopted by developing countries.

Out of the many differences that exist between the different certification systems, a first overall classification can distinguish two major groups: On the one hand, those certifications

that assess the potential environmental performance of new or refurbished buildings—based on their proposed design—and on the other hand, those certifications that assess actual performance or operations. Private organizations favor the design-based approach in most of the cases, while certifications created by governments usually follow a performance-based system.

Chronology of NSMD Green Building Certifications

Year	NSDM Green Building Certification - Organization	Location
1990	BREEAM (Building Research Establishment Environmental Assessment Method) -	U.K
1996	HK-BEAM	Hong Kong
1996	HQE	France
2000	LEED (Leadership in Energy and Environmental Design)	U.S.
2000	NABERS	Australia
2000	GB Tool	International
2002	Green Star	Australia
2002	Green Globe	Canada
2005	LEED (Leadership in Energy and Environmental Design)	India
2005	Green Mark	Singapore

Table 1: Source (Zahari 2014)

3.3 Relevance of the World Green Building Council in promoting diffusion of green building NSMD certifications

The World Green Building Council (WGBC) is a global environmental governance entity that acts as an umbrella organization encompassing all the Green Building Councils (GBC) worldwide, which are further grouped in five regional green building councils (RGBC) corresponding to their geographic location. Green Building Councils are, to a greatest extent, the main promoters of green building practices in the countries where they operate, making of the WGBC one of the most influential organizations in contributing to the diffusion of sustainable construction practices.

More specifically, Green Building Councils are independent, non-profit organizations made up of businesses and organizations working in the building and construction industry. As members of the WGBC, they work to advance green building in their own countries, as well as uniting with other GBCs to achieve environmental, economic and social goals on a larger, global scale (WGBC 2018). The composition of GBCs includes not only representatives from the

industry, but also experts from academia, non-profits and governments to ensure a multi-disciplinary approach to the decisions that they make.

There are currently 73 GBCs around the world with varying degrees of development. The WGBC divides its members into three membership levels, ranging from the most advanced category known as “Established”—fully developed and delivering change on a national level—to “Emerging”—an organization open to membership and with a strong foundation—to the least developed category “Prospective”—an organization in its early stages. Emerging and Prospective members are expected to upgrade their status within 24 months to support a steady progress in the promotion of green building practices at the national level.

The way in which the WGBC helps its members and contributes towards the widespread of sustainable construction practices is two folded. On the one hand, it promotes the exchange of knowledge between its members and facilitates workshops and activities to address specific issues of a certification system, incentivizing the creation of new initiatives within existing GBCs. On the other hand, it provides a governance framework that guides the establishment of new GBCs and provides assistance with the first steps of their operations. The goal behind this framework is to provide a comparable and consistent institutional standard among all its members, while at the same time guaranteeing maximum freedom of action at the national level.

GBCs work on the production of a vast array of tools and resources that promote sustainable construction practices. Among their most successful creation we can mention the development of national green building certifications that are tailored to the local context, such as the “Green Star South Africa” in South Africa, the “Green Building Evaluation System” in China, “Referencial CASA Colombia” in Colombia, “BERDE” in the Philippines, etc. Ranking as the most widely used certification in the world is the LEED system, created by the United States Green Building Council (USGBC). Later in this paper we will discuss the influence that this certification in particular has had in the drafting and diffusion of new and existing green building rating systems.

In addition to the creation of certifications, GBCs are also responsible for the creation of a diverse set of solutions to incentivize growth in the green building market sector. Strategies include financial incentives (e.g. creating partnerships with banks to provide green bonds), government advocacy (e.g. lobbying governmental agencies to promote environmental regulations on efficiency, conservation and social inclusion), and educational endeavors (e.g. teaching technical courses on construction, water and energy efficiency).

4. Diffusion mechanisms

Diffusion refers to "the spread of a phenomenon over space and through time" (Gregory 1994). For the purpose of this paper, diffusion mechanisms of green building policies and certifications are assessed from a number of academic publications focused on the spread of NSMD certifications in several countries. Based on the literature from DiMaggio and Powell (1983), the review will distinguish between three different diffusion mechanisms:

- ***Coercive isomorphism***: It stems from political influence in a top-down approach. The pressure comes from other authorities from same or similar markets, and it is related to the relative authority level of each actor. I.e. the implementation of a mandatory governmental policy requiring new public buildings to be certified under a certain green building label.
- ***Mimetic isomorphism***: Resulting from standard responses to uncertainty. It is horizontally distributed among similar organizations or associations from other markets. In its most simple stage, it refers to companies "copying" others on certain practices.
- ***Normative isomorphism****:* It is associated with professionalization. It stems from a bottom-up approach, where pressures come from similar organizations or associations from other markets that influence behaviors upwards and can lead to changes in public policies and regulations.

Over the course of this paper, the terms "diffusion" and "isomorphism" are used interchangeably.

5. Literature review

In order to better understand the different diffusion mechanisms taking place in the world of green building policies, this paper contains a review and assessment of 16 academic papers, including researches, studies and reports on this topic.

Given the variety of methods utilized for carrying the researches, and the diverse perspectives taken into the subject, the findings from the authors are divided into three main categories depending on the country—or countries—where the study was based, and whether that country is considered in a developed or developing economic stage. This classification is also based on the assumption that the diffusion mechanisms from wealthier, more developed nations will be different from those in less affluent countries and regions of the world.

5.1 Diffusion Mechanisms of Green Buildings in Developed Countries

Over the last decade, there has been a growing number of scholars focusing their studies on the implications of green building policies diffusion, with a high concentration of publications originated in the U.S. after the creation of the LEED system.

Johansson (Johansson 2012) studies the spatial diffusion of green building technologies, focusing specifically on the LEED certification diffusion in the United States. The author finds that the expansion of green building practices had three major phases: A first stage of innovation during 2000-2004, with the government acting as the main catalyzer; an early adopter stage from 2005 to 2008, with the private for-profit sector taking the lead; and a third one, where he recognizes that policies and tax incentives had a major role in supporting innovation adoption across all geographies. Relating these stages to the diffusion mechanisms, it can be argued that for the first innovation stage, *coercive* mechanisms rendered the most successful, as the government required public buildings to be LEED certified. For the second stage, however, with the uptake of the private sector as the major green building promoting actor, *normative* and *mimetic* mechanisms seem to be more relevant in a scenario were the innovation of green buildings is more widely known.

The analysis of Kontokosta (Kontokosta 2011) also adds to the literature on spatial and temporal diffusion mechanisms of green building policies in U.S. cities, finding evidence that regulatory, economic, and climate variables are clear predictors of green building policy adoption.

According to the author, it is unlikely that *coercive* isomorphism is driving green building policy diffusion in the cities from the study, based on the evidence that green building policies implemented at the state level did not affect local policy adoption. Nonetheless, *normative* and *mimetic* methods may be better at explaining the first steps in green building policy development. The results of this research consider the mayor trends occurred in the whole 2000-2010 period in the United States, and are thus consistent with the findings from Johansson (Johansson 2012), where he identified that the private sector was driving the green building diffusion in the post 2005 period.

Kontokosta argues that the earliest adopter cities may have done so to remain competitive, in terms of job creation, infrastructure investment, and environmental impact, with other earlier adopters—responding to *normative* isomorphism. Similarly, it is also possible that other cities may have been driven to enact policies emulating the lead of other larger cities without necessarily competing with them—*mimetic* isomorphism.

Simcoe and Toffel (Simcoe and Toffel 2014) study how government green procurement policies diffuse into the private-market sector and stimulates the construction of green buildings. They analyze how new green building procurement policies influence the wide spread of LEED certified buildings and LEED Accredited Professionals in California, focusing on the diffusion generated within local and neighboring cities—those bordering a city that has adopted a green building policy. The authors find that local government green building procurement rules produce spillover effects, promoting private-sector adoption of the LEED standard and stimulating local suppliers to invest in green building expertise.

Continuing with the spatial diffusion literature, the paper from Tiwari et al. (Qiu, Tiwari et al. 2015) analyzes the spatial isomorphism of green building certifications of four states, NY, AZ, CO, and FL. What they find is that there is a strong spatial correlation in the diffusion of green building certificates, estimating that "if the distance weighted share of green buildings of other neighborhoods increases by 10%, the share of green buildings in a neighborhood will increase by 5～10％." The paper also shows that buildings occupied by owners and areas where economic activity is high (more business establishments) are more likely to obtain green certificates, and thus suggest that in order to leverage green building penetration, policy makers and marketers should consider these factors as main targets for their decisions.

The research from Yin et al. (Qiu, Yin et al. 2016) builds on previous literature on peer effects, which shows that the influence that a peer group of similar social status and characteristics tend to have on each other's decisions is an important factor in the diffusion of new technologies or programs (Leary and Roberts 2014). Yin et al. found empiric evidence that peer effects have statistically significant positive impacts on the diffusion of green building certificates. Analyzing two states in the U.S. (NY and AZ), they arrived to two main conclusions: "an additional approved LEED certificate within a zip code will increase the probability of a commercial building in the same zip code to apply for a LEED certificate by 3–4 percentage points", and "an additional approved Energy Star certificate within a zip code will increase the probability of a commercial building in the same zip code to apply for an Energy Star certificate by 1–2 percentage points."

Some of the suggestions brought by the authors include establishing early adopters of green certificates or green building demonstration projects and creating platforms and networking events for interactions among building managers or corporate environmental staffs. These findings are relevant as they can be associated with other studies on peer effects and thus better inform policymakers and marketers on diffusion strategies for green building certificates. Following Leary and Roberts' findings as an example, these strategies can be more effective if

targeted to smaller firms with less experienced CEOs and financial constraints, which are proven to be the most influenced by peers.

Shifting the research focus to Australia, Mitchell (Mitchell 2009) analyzes the two nationally developed green building certifications currently available in the Australian market, Green Star and NABERS. The main difference between the two systems is that Green Star is a design-based certification created by a non-profit private organization (Green Building Council Australia), as opposed to NABERS, which is a performance-based certification created by the government.

When discussing different drivers in the diffusion of green building policies, Mitchell points out a dynamic that is currently taking place in Australia. Following the criteria of Larsson (Larsson 2004) and Hes (Hes 2007), the author mentions that rating tools with a narrow focus and more objective measurements are more likely to become part of regulatory systems than the broader, more aspirational rating tools. Such observation seems to fit the trend occurring in Australia, where NABERS is the preferred option for governmental agencies. This is reflected in the number of public regulations that require new and existing constructions to comply with NABERS' specification. As an example, the Australian Government requires 4.5 star NABERS Energy rating for new buildings and major refurbishments, and all new leases must include a requirement for annual NABERS Energy ratings.

In addition, the paper mentions a similar process that is taking place in Japan, where the government is providing preferential planning and development approvals for buildings with high CASBEE ratings (Japanese green building certification), as well as subsidies and preferential interest rates (Murakami, Levine et al. 2009). These types of policies carried on by the government speak to the *normative* and *coercive* nature of the diffusion mechanisms that appears to be taking place in Australia and Japan, where the governments are actively using their influence and authority to promote green building practices, either by setting mandatory rules (Australia), or by providing incentives to voluntary adoptions from third parties (Japan).

The author also discusses the possibility of convergence between the two Australian green building systems, as well as the harmonization of other international green building systems. This idea stems from the concerns that having several systems cause confusion among building owners and tenants. Mitchell suggests that establishing common units and metrics could be a first step in this endeavor, assisting in making comparisons between buildings in different countries and making it easier to share best practices between tools. Such harmonization could be related to a *mimetic* isomorphism process, which would better communicate the different

strategies implemented by various systems and promote a faster diffusion of green building practices and policies.

5.2 Diffusion Mechanisms of Green Buildings in Developing Countries

With a focus on the trends ocurring in developing countries, Citra et al. (Sinem, Citra et al. 2016) carry an analysis of the spatial and temporal diffusion of green building policies in Turkey and Indonesia. The authors first define green building policies and certifications as architecture, engineering and construction (AEC) innovations, and proceed to compare them with previous literature on the "diffusiom of innovations." Based on the five categories established by Rogers (Rogers 2003)—i.e. innovators, early adopters, early majority, late majority and laggards—the research identifies three main sectors—governmental institutions, environmental groups and large business houses—and assign them to their corresponding category.

The results show that both countries (Turkey and Indonesia) have approximately ten times as many innovators and twice as many early adopters as theory would predict. Due to the small proportions of late adopters and laggards in these two countries, the authors conclude that useful green building innovations could be quickly incorporated.

It is worth mentioning that the two countries have followed different paths in the promotion of green buildings. The Green Building Council Indonesia, for example, launched the Greenship certification for New Buildings version 1.0 in 2010 as an assessment tool for green buildings tailored to the national climate and priorities. The Turkish government, on the other hand, doesn't have any national certification system and has signed several agreements with three different international green building certification systems to support the application of sustainable construction in the country.

Erten et al. (Korkmaz, Erten et al. 2009), in their review of green building movement timelines in developed and developing countries, identified the pathways that supported the rise of green building policies in Turkey and India. Comparing the case of India with the history of the U.S., where they argue that governmental policies were based on the public pressure through the environmental movements, major policy decisions by the Indian government happened in response to international events such as the OPEC oil embargo, the Brundtland Commission or the Second Earth Summit. Thus, the Indian green building movement can be mainly associated with a top-down approach, where government initiatives promoted sustainability in the society, and these were actively adopted and supported by the corporate sector, describing a clear *coercive* diffusion mechanism.

In Turkey, international investors and non-profits are importing an environmentally conscious ethos to some high-profile developments, resulting in external pressure on the government to further encourage environmentally responsible development. This trend can be associated with a *normative* diffusion mechanism, where higher and voluntary standards push the local market to raise the bar and move beyond business-as-usual practices and become more sustainable.

With a focus on the green building drivers in South Africa, Windapo (Windapo 2014) studies whether these are economic or ecologically motivated. According to the results, the main drivers of green buildings are financial rather than environmental, indicating rising energy costs and the attendant need to reduce building operating cost one of the most influential factors. In addition, the data suggests that the availability of an appropriate rating tool, i.e., the Green Star SA rating system and the competitive advantage and building codes are also primary drivers of green buildings in South Africa. Similar results have been observed in Malaysia, where Zahari (Zahari 2014) identifies that reduced operational costs and marketing benefits are the main drivers in their national green building market.

Thanks to the findings of the paper, the author concludes that in order to promote a faster diffusion of green buildings, it is necessary to create financial incentives—such as benefits due to reduced operating costs and higher rental income or government regulations to support green building constructions—in order to provide a stronger uptake of sustainable construction practices in the country.

A study by Zhang et al. (Teng, Zhang et al. 2016) reviewed the main barriers for the development of green building certification in China. Understanding the incremental cost of a green technology as the ratio between the beneficial environmental performance brought over the incremental cost of the green technology, they found that high-incremental-cost and the immature green technologies are the two major barriers for a widespread diffusion of green building policies. In order to overcome such barriers, the authors suggest that promoting the maturity level and industrialization of applied technologies, as well as having a stronger governmental policy guidance and support through incentives to enhance the incremental cost efficiency could leverage a faster growth in the construction of green buildings in China.

5.3 Diffusion Mechanisms of Green Buildings: International Agencies findings

Unlike the previous literature reviewed in this paper, the following reports were created by international agencies focused on global and regional trends, as opposed to the country-specific research of the above mentioned authors.

The Fifth Assessment Report from the Intergovernmental Panel on Climate Change (Lucon O. 2014), carried a worldwide research on the implications that the building sector has in terms of contribution towards climate change. Among their results, many similarities can be observed with the findings from the country-specific analysis already assessed in this literature review.

According to the report, building codes and appliance standards with strong energy efficiency requirements that are well enforced, tightened over time, and made appropriate to local climate and other conditions have been among the most environmentally and cost-effective, in addition to Clean Development Mechanisms and Joint Implementation (CDM JI), and financing tools (grants and subsidies). The report also says that in developed countries, evidence indicates that behaviors informed by awareness of energy and climate issues can reduce demand by up to 20 % in the short term and 50 % of present levels by 2050. In small developing countries, the evidence shows that utility demand side management (DSM) may be the most viable option to implement and finance energy efficiency programs

Despite the different market mechanisms that are currently helping with the diffusion of green building practices, the report arrives to the conclusion that such forces will not achieve necessary transformation towards low carbon buildings without external policy intervention to correct market failures and to encourage new business and financial models that overcome the first-investment cost hurdle, which is one of the key barriers.

Building on the insights provided by the IPCC, the latest World Green Building Council (WGBC) report (Laski 2017) presents an alternative strategy for the future of green buildings, stemming from the completion of their goals and counting with the private sector as the main driving force. The WGBC has established two very ambitious goals: having all new buildings to be net zero by 2030 and having every building to be net zero by 2050 to achieve the Paris Agreement's goal of curving global temperature increase below 2 degrees, and ideally below 1.5.

In order to accomplish these targets, the report suggest a pathway that would start with the voluntary action by businesses recognizing the market leadership opportunities. Such businesses will be the ones to certify under net zero certification and verification programs. The next step would be to have an active and interested role from all levels of government at the

outset, including a willingness to lead by example by requiring public buildings to be net zero carbon and through the creation of incentive programs and policy to support the transition to net zero carbon buildings. Finally, the report mentions the importance of market development, training and recognition opportunities offered by GBCs and other NGO subject-matter experts, including licensing and trade associations.

Following the logic of the three steps, the report implies a succession in the diffusion mechanisms that will lead to the accomplishment of the goals, relying first on *mimetic* and mostly *normative* mechanisms fostered by businesses, followed by an uptake from the governments—*coercive isomorphism*—and finalizing with the market considering green building practices (net zero buildings) as the norm—normative mechanisms.

The final piece of literature analyzed for this paper is the World Green Building Trends 2016, (Analytics 2016), a report that contains survey data from 69 countries assessing the main trends and challenges that are driving the diffusion of green buildings worldwide. As shown by the results, even though each country and region has its own particular circumstances, there are several indicators that are consistent across the globe. For example, client demand is consistently an important driver for green globally. This demonstrates how critical it is to create greater public awareness of the benefits of green and the importance of establishing the business benefits of green building, since these are factors that drive clients to make investments in green.

Market demands is also important but has been steadily declining compared with the last three studies (the first one done in 2008, and the second one in 2012). The biggest growth since the 2012 study has been among those reporting that environmental regulations are important triggers for green. When asking about the challenges, the report finds that the top one is higher perceived first costs, but the percentage who consider this a top challenge has shrunk by 26 percentage points since 2012. This drop may suggest a global trend toward greater experience with green building techniques and wider availability of green building products and service providers, which may be reducing the premium for building green.

In terms of economic development, the report finds that the main challenges for developing countries are the lack of public awareness and lack of political support and incentives. On the other hand, the perception that green is for high-end projects only is more common in developed countries.

6. Literature review assessment

Based on the literature review, the different drivers, challenges, trends, findings and strategies are compiled, summarized and processed in the following tables (Tables 2, 3 and 4) to show the interaction between the three main diffusion mechanisms assessed and the information gathered from the different scholars. Given that in most of the cases, the literature did not provide a direct classification of the mechanisms operating behind their findings, this report has allocated them to their most closely related diffusion mechanism for a better understanding of the dynamics involved in their diffusion.

The overall assessment of the literature is divided in three sections. The first one includes a summary of all the strategies and findings from the review, organized into three tables, each one corresponding to a different diffusion mechanism. The second section further processes the information gathered in the tables and locates the different strategies into a pyramid-like graphic, where the relative diffusion mechanism influence from each strategy can be better visualized and distinguished between developed and developing countries. Finally, the last section assesses the trends found in the pyramid.

6.1 Diffusion Mechanisms: Summary

The following tables summarize the Diffusion Processes and Strategies obtained from the literature reviewed. The column headed with a "#" on the left side of the tables represents the reference number of each strategy, which is used in the following section for a graphic visualization of the different strategies and their corresponding location in the diffusion mechanism spectrum.

Diffusion Processes and Strategies - Coercive Isomorphism

#	Country	Effect - Finding	Strategy	S.
1	International	• Governments often try to design policies that will "influence the behavior of other socio-economic actors by setting the example, and by sending clear signals to the market-place • Green building practices had a first stage of innovation during 2000-2004, with the government acting as the main catalyzer • Government initiatives in India promoted sustainability in the society, and these were actively adopted and supported by the corporate sector. External policy intervention is needed to correct market failures and to encourage new business and financial models that overcome the first-investment cost hurdle, which is one of the key barriers to the	• Cities requiring public constructions to be green builing certified; to comply with certain environmental standards; to provide formal administrative benefits for green building proposals; alterations on buidling code	*[1] [2] [3] [4] [5] [6] [7]*
2	International	• Rising costs of energy and the need to reduce building operating costs is an important driver of green buildings	• Remove or reduce subsidies to energy	*[5] [6] [8] [9]*
3	Small developing countries	• Utility demand side management (DSM) may be the most viable option to implement and finance energy efficiency programs	• Implement utility DSM programs	*[7]*
4	Australia	• The Australian Government alone represents approximately 13% of the commercial office market. • Rating tools with a narrow focus and more objective measurements are more likely to become part of regulatory systems than the broader, more aspirational rating tools	• The Australian Government requires a 4.5 star NABERS Energy rating for new buildings and major refurbishments, and all new leases must include a requirement for annual NABERS Energy ratings	*[10] [11] [12]*
5	U.S.	• Cities with more restrictive land use regulations are significantly more likely to adopt a mandatory green building policy	• Increase the stringency of land use regulations	*[2]*
6	U.S.	• Cities with democratic or independent mayors are more likely to institute a mandatory green building program	• Craft mandatory or voluntary policies according to the political inclination of the mayor	*[2]*

Sources: [1] Simcoe and Toffel, 2014; [2] Kontokosta, 2011; [3] Choi, 2010; [4] Johansson, 2012; [5] Korkmaz, Erten et al. 2009; [6] Windapo, 2014; [7] Lucon O., 2014; [8] Sinem, Citra et al., 2016; [9] Zahari, 2014; [10] Mitchell, 2009; [11] Hes, 2007; [12] Larsson, 2004; [12] Qiu, Tiwari et al., 2015; [13] Qiu, Yin et al. 2016; [14] Analytics, 2016; [15] Murakami, Levine et al., 2009

Table 2: Coercive Isomorphism

Diffusion Processes and Strategies - Mimetic Isomorphism

#	Country	Effect - Finding	Strategy	S.
7	Developed countries	• Behaviors informed by awareness of energy and climate issues can reduce demand by up to 20 % in the short term and 50 % of present levels by 2050	• Raise awareness on energy and climate related behaviors	*[7]*
8	Australia	• Having several systems cause confusion among building owners and tenants	• Harmonization of different systems by using similar metrics and units that are easily comparable between each other	*[10]*
9	U.S.	• The adoption of green building procurement policies stimulates private-sector developers in neighboring cities to adopt LEED at a greater rate, even when those neighbor cities do not have their own green building policies. It also promotes the growth in green building input markets (more	• Adoption of green building procurement policies	*[1]*
10	U.S.	• Buildings occupied by owners are more likely to obtain green certificates	• Design of policies to address the split incentive problem	*[7] [12]*
11	U.S.	• Strong spatial correlation in the diffusion of green building certificates: if the distance weighted share of green buildings of other neighborhoods increases by 10 %, the share of green buildings in a neighborhood will increase by 5 ~ 10 %.	• Based on the cluster effect, target buildings that are more likely to adopt green certificates via incentives or marketing campaigns. • Target building management firms or owners that own multiple buildings in the	*[12]*
12	U.S.	• Peer effects have statistically significant and positive impacts on the diffusion of green building certificates.	• Establish early adopters of green certificates or green building demonstration projects • Create platforms and networking events for interactions among building managers or	*[13]*
13	U.S.	• Open communication channels between cities and stakeholders can facilitate learning, which will serve to refine green building policy interventions over time	• Foster continued communication between cities regarding green building policies	*[2]*
14	U.S.	• The climate zone of the city is not a significant variable in policy adoption and diffusion, except for the most temperate climate environments where heating and cooling demands are relatively low, making	• Focus first efforts and resources in more extreme climatic zones	*[2]*

Sources: [1] Simcoe and Toffel, 2014; [2] Kontokosta, 2011; [3] Choi, 2010; [4] Johansson, 2012; [5] Korkmaz, Erten et al. 2009; [6] Windapo, 2014; [7] Lucon O., 2014; [8] Sinem, Citra et al., 2016; [9] Zahari, 2014; [10] Mitchell, 2009; [11] Hes, 2007; [12] Larsson, 2004; [12] Qiu, Tiwari et al., 2015; [13] Qiu, Yin et al. 2016; [14] Analytics, 2016; [15] Murakami, Levine et al., 2009

Table 3: Mimetic Isomorphism

Diffusion Processes and Strategies - Normative Isomorphism

#	Country	Effect - Finding	Strategy	S.
15	International	• The formation of green building councils helps to increase awareness in both developed and developing countries	• Creation and support of national Green Buidling Councils	*[5]*
16	International, strongly in developing countries	• The availability of an appropriate rating tool is a primary driver of green buildings	• Support the creation, availability and access to local green buidling certificiation systems	*[5] [6] [7] [8] [14]*
17	Turkey - South Africa	• International investors and non-profits are importing an environmentally conscious ethos to some high-profile developments	• Further encourage governmental environmentally responsible development.	*[5] [14]*
18	U.S. - Turkey - Indonesia	• Cities that provide a platform for innovation, measured as the number of patents issued per capita, are more likely to adopt green building policies • Due to the small proportions of late adopters and laggards in Turkey and Indonesia, useful green building innovations could be quickly incorporated	• Create an urban environment where innovation can occur and thrive	*[2] [8]*
19	Japan*	• The final energy consumption in Japan has substantially decreased about approximately 37% over the last 30 years (from 2009), and the government aimed to further improve its efficiency by at least 30% by 2030	• The government is providing preferential planning and development approvals, subsidies and preferential interest rates for buildings with high CASBEE ratings	*[15]*
20	U.S.	• The adoption of green building procurement policies produces spillover effects that stimulate both private-sector adoption of the LEED standard and investments in green building expertise by	• Adoption of green building procurement policies	*[1]*
21	U.S.	• Peers getting green can impose a new norm in a neighborhood and, thus, buildings feel the pressure to conform	• Create platforms and networking events for interactions among building managers or corporate environmental staffs.	*[13]*
22	U.S.	• The density of environmental non-profit organizations is not a significant variable in driving the diffusion on green building policies	• If available, focus the resources in a small number of NGOs instead of spreading them too thin among many organizations	*[2]*
23	U.S.*	• Cities with higher per capita emissions are more likely to adopt a green building policy	• Quantify and disclose city level carbon's footprints. A city's carbon emissions can be used to benchmark performance against other cities and to create a mechanism for higher levels of government to incentivize or penalize cities based on their relative impact	*[2] [7]*
24	U.S.*	• A sustainability plan is a significant predicator of green building policy adoption	• Cities should develop a sustainability or climate action plan to guide green building policy decision-making	*[2]*

*Strategies are not mandatory

Sources: [1] Simcoe and Toffel, 2014; [2] Kontokosta, 2011; [3] Choi, 2010; [4] Johansson, 2012; [5] Korkmaz, Erten et al. 2009; [6] Windapo, 2014; [7] Lucon O., 2014; [8] Sinem, Citra et al., 2016; [9] Zahari, 2014; [10] Mitchell, 2009; [11] Hes, 2007; [12] Larsson, 2004; [12] Qiu, Tiwari et al., 2015; [13] Qiu, Yin et al. 2016; [14] Analytics, 2016; [15] Murakami, Levine et al., 2009

Table 4: Normative Isomorphism

6.2 Diffusion Mechanisms: Strategies & spectrum

Based on the notion that a single strategy promoting green building policies is not exclusive to any particular diffusion mechanism, but rather is plausible to be subjected to several mechanisms simultaneously and be influenced by them in different degrees, this study recognizes that strategies operate in a "spectrum" of diffusion mechanisms. To this end, and to better visualize such influences, a pyramid-like graph was created to represent the relative degree to which each strategy is related to each diffusion mechanism. Each of the corners of the triangle represents a case where the influence is closer to 100% of the mechanism in that location, whereas the dashed lines represents the locations where the influence is more equally shared between two or the three mechanisms (the latter being closer to the central axis).

Utilizing the information compiled in tables 2, 3 and 4, Fig. 1 locates all the strategies into the spectrum space to represent their respective influence level and location in the triangle. In order to extract more information out of this graphic, the different strategies are visually cataloged with three different symbols, representing whether the strategy comes from the analysis of a developed or developing country, or if it is implemented in both scenarios—referred to as "internationally."

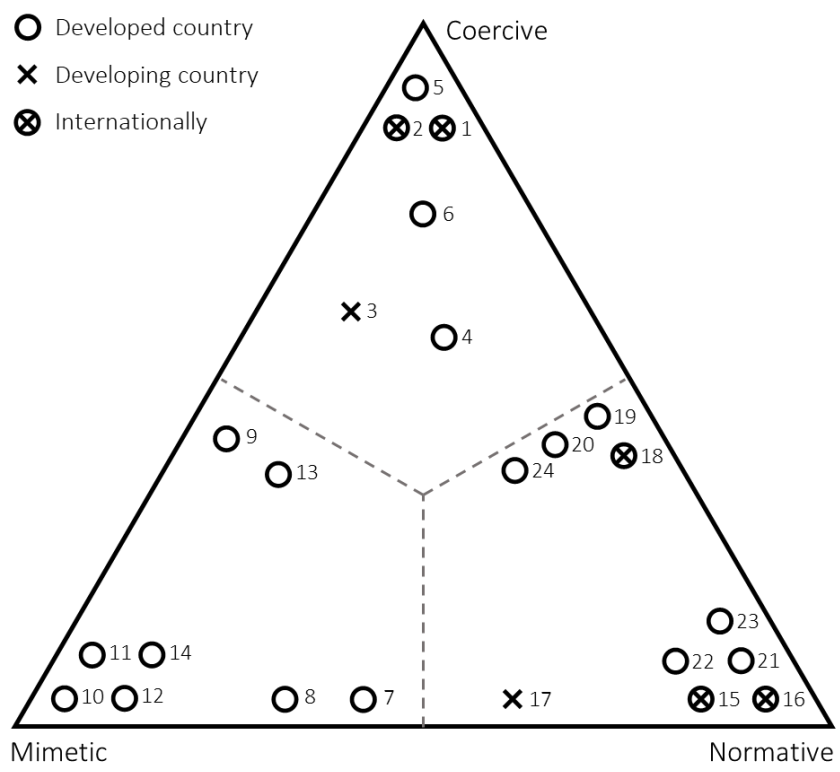

Fig. 1: Diffusion Mechanism Spectrum

6.3 Diffusion Mechanisms: Strategies & spectrum assessment

Using the outcomes from Fig. 1, five main trends have been identified based on the visual distribution of the different strategies into the diffusion mechanism spectrum. The first trend (Fig. 2-A), shows that mimetic mechanisms are taking place only in developed countries. The reason of this could be related to the fact that in more advanced markets there is a widespread awareness of the importance of implementing green building practices and green buildings are more prominent and visible in the cities. Thus, the public is more inclined to follow green building practices by default, as they consider this a benign practice worth the effort, even when they may not have any formal requirements nor competition pressures to do so.

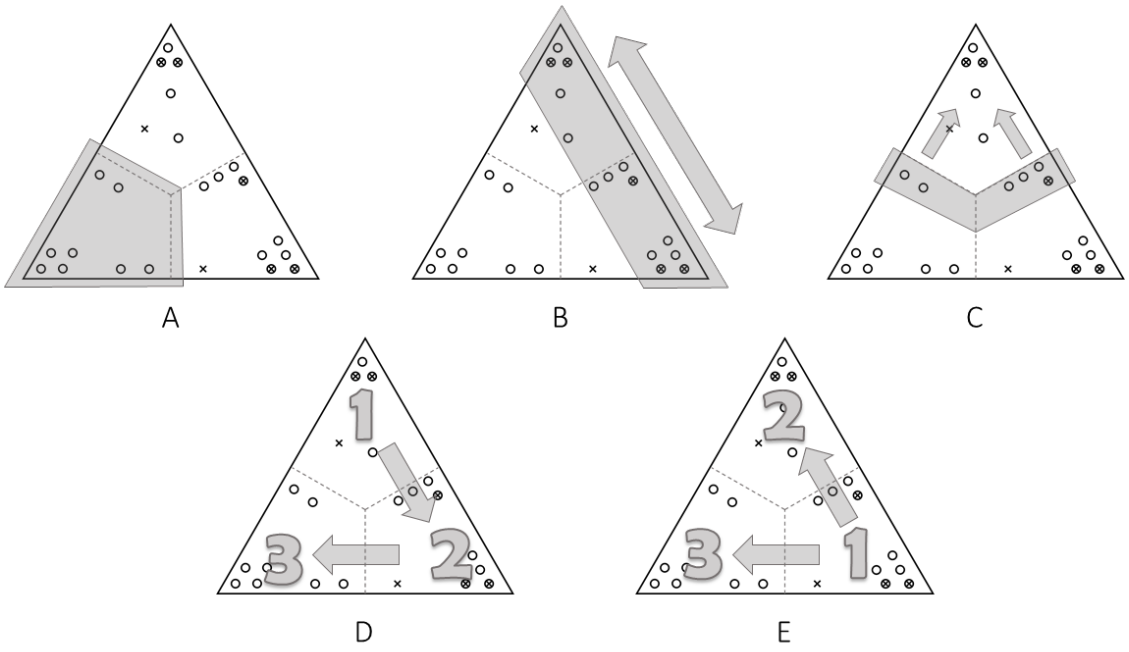

Fig. 2: Diffusion Mechanism Spectrum - Trends

The second trend identified (Fig. 2-B) is that coercive and normative mechanisms seem to be the most relevant across the board, with strategies that vary in their level of influence from each corresponding mechanism. This is due mainly to the nature of certain normative strategies, where they depend heavily on the set of norms, standards and regulations, but the fact that they are voluntary instead of mandatory refrains them from being considered within the coercive classification (although they are very similar in nature).

The third trend observed in the graph (Fig. 2-C) is associated to the relative importance that coercive mechanisms have in the overall promotion of green building practices. This conclusion is triggered by the number of strategies that are strongly influenced by coercive processes, which is shown in the proximity of mimetic and normative strategies to the normative space (closer to dashed line).

Analyzing the spatial distribution of strategies and comparing it with the findings from the literature review, there seems to be a positive correlation between the amount of strategies and their composition (from developed or developing countries) with the stages of evolution of diffusion mechanisms described for developed countries. As mentioned by the scholars, the early stages of green building policies in the U.S. were driven by the government—coercive

isomorphism, then followed by an uptake from the private sector, establishing green building practices as a norm—normative isomorphism—and finally, mimetic processes taking place once there is an abundance of green building projects certified in the cities (Fig. 2-D). This also relates with the finding that governments, especially in developing countries, play a decisive role in motivating the uptake of sustainable construction practices by giving the example, setting regulations and standards, and providing incentives.

Finally, Fig. 2-E shows the case described in the WGBC's report, where they expect the businesses to lead the change towards net zero buildings. According to the number of strategies in the normative category, and based on the evidence from the literature, the pathways described by the WGBC could likely follow their predictions in developed countries. Nations with a more widespread awareness of green building practices and with the right number of innovators and early adopters could initiate the transition towards net zero building practices, fostering normative channels of diffusion until there is an uptake from the government to enact public policies to require or incentivize such practices, and later be mimicked by peers.

7. Conclusions

The literature reviewed for this paper shows clear evidence of the different diffusion mechanisms and the strategies that are influencing the spread of NSMD green building certifications and sustainable construction practices. Thanks to the scholar's research, we now have a better idea of what factors and processes are affecting the diffusion of building green across the globe. Such processes have important temporal and spatial components, they develop in stages depending on the national level of awareness in green buildings, they vary mostly between developed and developing countries, with a few exceptions that are common to every location.

Drawing on the findings from this paper, it can be argued that mimetic mechanisms of diffusion take place only in developed countries; normative and coercive mechanisms seem to be much more effective in driving green building innovations, with coercive channels having an important influence over the other mechanisms. Coercive isomorphism has shown to have a key role in driving and supporting the uptake of green building policies, specially in developing countries where the lack of awareness and the high perceived first costs detract the public from such practices. In developed countries, on the other hand, normative mechanisms are the main driver of green buildings, which is supported by the presence of innovator and early adopter

businesses. However, it is important to mention that market forces alone cannot drive the necessary change to shift current construction practices towards low carbon buildings without governmental intervention to correct market failures and support the public in early stages of development.

This paper will contribute to a body of work that seeks to better understand what the drivers of diffusion in the realm of green building certification systems and green building policies are. Further research on this topic could include a quantitative analysis of the impact that each diffusion mechanism and strategy is having at the country level based on empiric data. Such a research presents a number of difficulties due to the complexity of the green building industry and the myriad of factors involved in the diffusion processes. Only one of the reviewed papers incorporated empiric data, while the remaining literature based their analysis on surveys. This fact represents the potential for more investigations that are available in the green building sector.

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