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Green buildings cost premium: A review of empirical evidence

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ABSTRACT

Evidence indicates that green buildings can outperform conventional (non-green) buildings in many performance areas. Nevertheless, the perceived higher upfront cost by building owners and investors is frequently cited as a hurdle to a widespread adoption of green buildings. In this study, an extensive literature survey was conducted to aggregate the green cost premiums which were reported as results of published empirical studies that investigated the cost premium associated with the green building. Results and methodologies of 17 empirical studies were tabulated and comparatively analyzed to find a conclusive answer whether the green building costs more or less than its conventional counterpart. Yet, consensus is not reached, and a significant gap exists in the quantified cost premium range. More than 90% of the reported green cost premiums through empirical investigations fall within a range from −0.4% to 21%. Two studies found that green buildings cost less than their conventional counterparts. Surprisingly, among the 17 reviewed empirical studies, only six publications were classified as academic publications, of which four research articles published in peer-reviewed journals, one conference paper, and one book. The size of the literature which addresses the issue of green buildings cost premium does not reflect the significance of the problem.

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1. Introduction

Being the largest contributor to pollution and greenhouse gas emissions, the construction sector has gained momentum in sustainable development and plays a significant role in sustainability achievement [1–3]. The Construction sector occupies the first place as the largest contributor to pollution and greenhouse gas emissions [3]. According to the United Nations Environmental Program [3], one third of the total energy end use is consumed in buildings, it is also responsible for one third of the global resources consumption including 12% of all fresh water usage, as well as it produces around 40% of the total solid waste volume. Based on these estimates, in response to the concept of sustainable development triggered in the United Nations Global Assembly on March 20, 1987 through the report of Brundtland Commission [4], known as Our Common Future, in the early nineties, green buildings were introduced as a high potential solution to reduce gas emissions and to improve the economic,

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health, and environmental performance of the built environment [2,5].

While there is consensus about several benefits associated with the green building, its initial construction cost in comparison to a conventional counterpart is still debated. Several market surveys concluded that green building practitioners believe that the construction cost of the green building is significantly higher than that of its conventional counterpart [6,7]. However, still there is not much empirical evidence that supports this general perception formed in the mindset of building owners and investors; the issue of green cost premium is still debated and three different opinions can be found in the literature. The first opinion suggests that there is no significant variation between the cost of green buildings and conventional buildings [8–10]. Advocates of this view empirically argue that green buildings cost premium is insignificant and even green buildings can be achieved with little or no added cost [11–13]. The second opinion says that the green building tends to cost more than its conventional (non-green) counterpart [14–16]. A third opinion suggests that the green building may cost less than a conventional building [17,18].

The purpose of this research is to survey the existing body of literature in order to aggregate the findings of the empirical investigations which address the controversial issue of green cost premium, and to comparatively analyze the evidences in order to find an answer whether the green building costs more or less than its conventional counterpart.

2. Background information

2.1. The concept of green buildings

The terms green buildings, high performance buildings, sustainable buildings, sustainable construction, high performance construction, or green construction are used interchangeably [2,12,19,20]. Intrinsically, sustainable construction should take into account the environmental aspects through the whole life cycle of a facility, including material acquisition, installation, operation, disposal, and recycling. However, the green building definition varies and there are numerous definitions for the green building [21,22]. Yudelson [23] defines the green building as: "A high-performance property that considers and reduces its impact on the environment and human health". According to Yudelson [23], the green building is designed to use less energy and water as well as to reduce the life cycle environmental impact of the used material. Likewise, Kibert [2] suggests that the term green building describes the characteristics of the building which complies with the principles and practices of sustainable construction; he defines the green building as: "Healthy facilities designed and built in resource-efficient manner, using ecologically based principles". Green buildings or sustainable buildings, according to the International Energy Agency [24], are characterized by increased energy and water efficiency, reduced material and natural resource consumption, in addition to improved health and environment.

Aforementioned definitions imply similar characteristics of the green building; there is a consensus among the definitions that the green building is a healthy facility that has less negative impacts on the environment through using fewer natural resources. However, none of the definitions indicate life cycle thinking as a fundamental approach in assessing the performance of the green building. Life cycle thinking, which is also known as life cycle perspective [25], has recently gained considerable attention to account for the three pillars of sustainable development which are: environmental, economic, and social aspects [26–28]. In its principle, life cycle thinking means taking account of a product's impact on the three pillars of sustainability throughout its entire life cycle [25,29]. The term *product* is defined as any good or service [29,30].

In the light of discussed characteristics of the green building, and considering the life cycle approach, the green building can be defined as an eco-friendly economic facility that uses less natural resource to build and operate. It positively impacts productivity, health, and welfare of human being throughout its entire life cycle. This definition inherently adheres to the concept of sustainable development which balances the three pillars of sustainability [26,27,31]. The added keywords to the definition which are: economic and life cycle, are backed up by a growing body of evidence as discussed in the subsequent Section 2.2.

The green building can reduce the carbon emissions up to zero levels through utilizing renewable energy systems to meet the requirements of its occupants [32]. Renewable energy systems in the green building can be either passive or active systems [3,33], while passive energy systems refer to improvements of building envelope elements to minimize the total energy demand [34], the active systems utilize newer technology and more efficient electrical devices and appliances to reduce energy demand, and to produce energy from renewable energy sources such as solar, wind, geothermal (heat from the earth) [24,34]. Passive solar design has a potential to eliminate 50–75% of cooling and heating energy demand in buildings [35].

Energy efficiency and renewable energy sources utilization are key features of the green building [2,32,35,36]. Reducing energy demand through proper building orientation, more efficiently insulated and glazed building envelope, passive solar design approaches, in addition to more efficient electrical appliances and devices are major design strategies to meet the concept of the green building [5,24,35]. Reducing energy demand allows on-site energy production through renewable energy sources to cover a higher percentage of the total building energy demand [5], or completely cover the energy demand using renewable energy sources [32,35].

Typically, the environmental performance of green buildings is assessed and rated using building environmental assessment methods, in which standard definition and performance for green buildings against sustainable development requirements are defined [2,23,37,38]. The main purpose of the green rating tools is to assess the sustainable design of a building in terms of compliance to sustainability requirements with various levels of assessment [38]. However, there is a plethora of green building standards and rating tools which vary from country to country based on need and climate requirements [39]. Internationally, almost 60 countries in the world [2] have developed their own rating systems to evaluate and promote the green building. Being the leading examples of green rating tools, the British Research Establishment Environmental Assessment Method (BREEAM) and the American Leadership in Energy and Environmental Buildings (LEED) are the first and most internationally recognized environmental assessment methods for green buildings [39,40].

Launched in 1990, the British Research Establishment Environmental Assessment Method (BREEAM) is an assessment and rating tool for sustainably designed buildings in which a standard definition and performance for the green building against sustainable development requirements are proposed [2]. In BREEAM, buildings are rated (or labeled) and certified based on a scale of Good, Very Good, Excellent, and Outstanding [41]. Later in 2002, the U.S. Green Building council developed the Leadership in Energy and Environmental Buildings (LEED), it is also a rating system for green buildings with multilevel certification. Based on credit points achievement against sustainability requirements, buildings according to LEED are rated as: Certified, Silver, Gold, or Platinum, the sustainability requirements are increased for each level of certification [40]. Developed by the Green Building Council of Australia in 2003, Green Star is another internationally recognized