Not All Green Buildings Are Made Equal: Green Building Construction Cost Premium

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This study aims to investigate the cost surcharges of green buildings. In this study, the green construction cost surcharge (GCCS) is defined as the additional capital costs associated with sustainable building features and practices. More specifically, this study intends to (1) identify the green cost surcharge difference on a global scale, (2) identify the green cost surcharge differences across building types, and (3) gain a basic understanding of the causes of cost differences. A literature survey on green building surcharge costs was performed, resulting in a total of more than 1,300 cases from 11 countries. The cases included both residential and non-residential units. The results show that there is a regional difference among green cost surcharges; however, the median and mean green cost surcharges are 7%. Furthermore, there is a cost difference among building types, with school buildings having the highest cost surcharge. Varied cost estimation and collection methods also lead to different green cost surcharge results; the differences between industry findings and academic research are very apparent. Lastly, eleven cost variables are identified as well.

1.0 INTRODUCTION

The construction industry is making the transition to greener technology and sustainable building practices; however, the progress has been slow (Chegut et al. 2019). The 2019 Green Building Adoption Index shows only 13.8% of all commercial office buildings in the United States as being green certified (CBRE 2019), and the adoption rate for multifamily green buildings is merely 3.3% (units) (CBRE 2019). Globally, environmentally certified buildings represent just 5.4% of the commercial office stock (CRI 2020). The Dodge Data & Analytics World Green Building Trends report (2018) indicated that green building activities are increasing. However, there is a major gap between projects that are considered to be “green” by project teams and those projects actually seeking green certification (DDA 2018).

In spite of the large evidence of life cycle cost benefits (Ries et al. 2006; Dwaikat and Ali 2018; Shen and Cong 2012) and environmental benefits (Zou et al. 2017) provided through sustainable buildings, key building stakeholders, such as contractors and developers, are still somewhat skeptical about the financial feasibility and benefits that green buildings can deliver (Hwang et al. 2017). The higher first cost has been rated as the number one barrier to building green during the last decades, and despite the recent years’ cost drop, 49% of industry experts and professionals still think green building is expensive (DDA 2018). Meanwhile, there are also researchers who argue that the cost surcharge of green buildings is insignificant based on empirical data, and they claim the large marginal life cycle cost benefits provided by a green building can outweigh the insignificant first cost (Langdon 2004; Matthiessen and Morris 2004), which is also called capital cost (Shrestha and Pushpala 2012), and investment cost (Rehm and Ade 2013). It is therefore critical for the building construction industry to examine the green building costs, particularly the additional costs that green buildings require in comparison to conventional buildings. To this extent, this study aims to survey the existing body of literature to aggregate the findings of empirical evidence that address the green building cost surcharge, and to comparatively analyze the differences across building types and regions to gain an understanding of the variables influencing the green building cost surcharge.

2.0 METHOD

A literature survey and content analysis on green building costs were performed, resulting in more than 1,800 buildings from 11 countries. The survey included office, residential, school, higher education, and other commercial buildings. An attempt was made to find the normal range of green building cost surcharges for different building types, as well as to find the regional differences, and identify the influential factors for those construction cost surcharges. Other literature review papers were exempted from the analysis if they did not provide new empirical evidence on green cost surcharges. Similarly, green building studies only focusing on the economic benefits of building green were also exempted since they did not provide evidence of the construction costs.

A total of 36 studies were identified that provided empirical data; 5 studies only included one case and were therefore excluded in the final analysis. Table 2 illustrates a comprehensive overview of the main characteristics of cases presented in the literature. Where a source is reported to have more than one case, it means that either more than one building or different versions of the same building were presented in the same study. For example, some studies compare the cost of the real building to its modeled green version. The literature included in Table 2

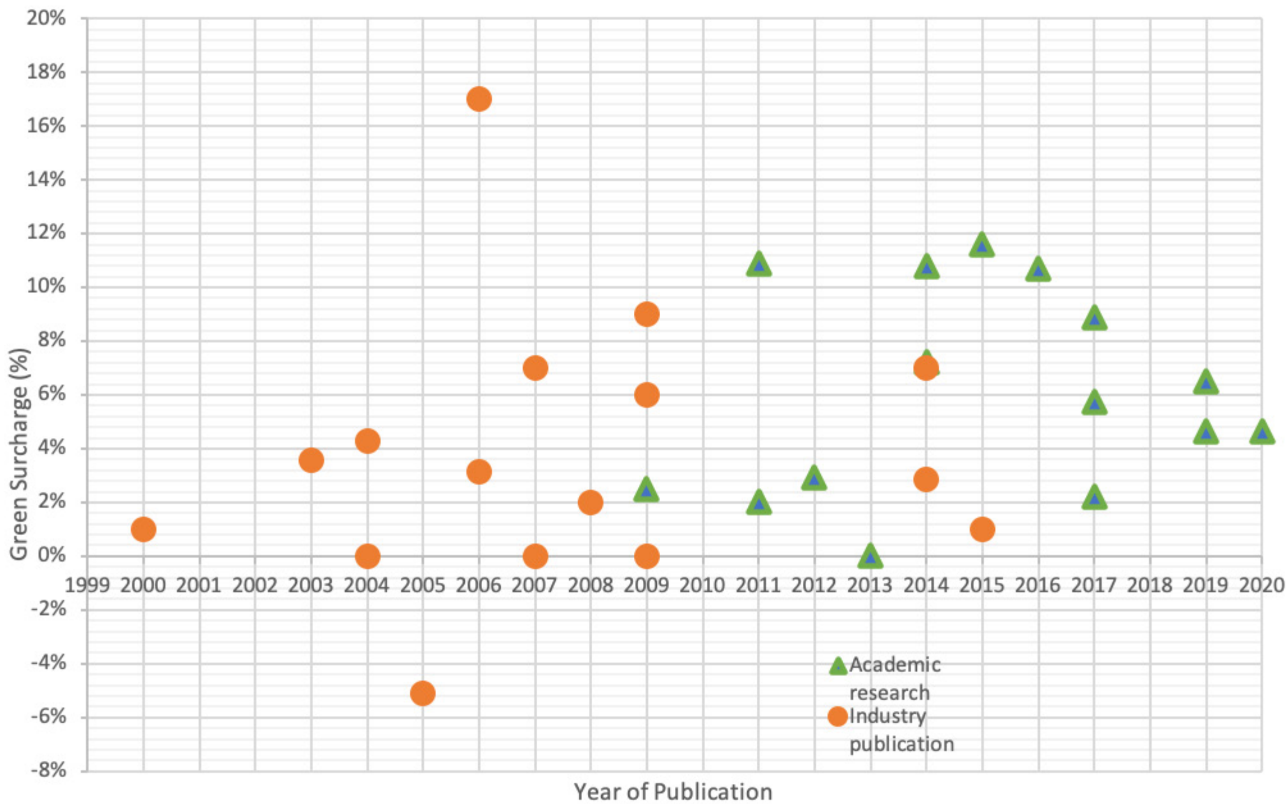

Figure 2. Comparison of studies published by academic researchers and industry experts

was selected based on the following criteria: (i) the publication addresses the green building construction cost surcharge as the main research topic, (ii) the publication relies on empirical data to draw a conclusion, (iii) the publication specifies the cost data resources, and (iv) the publication calculates the GCCS compared to conventional buildings in percentage. During the initial search, a relatively large quantity of publications was found to focus on the life cycle cost of green buildings; the research aim was to quantify the economic benefits of green building through savings during the operation stage. Even though those studies addressed important cost issues of green building and had empirical data, the explanation and information of the capital cost could not be extracted from the data presented in the publication; therefore, we excluded those publications in our review.

The buildings in the case findings differ in climate condition, function, construction type, location, and source of data. The data sources are listed in Table 2; they vary widely, from questionnaires (surveys) to actual construction documents. Consequently, it is not appropriate to directly compare the cases against each other. The cases also differ in size and estimated lifetime. In order to neutralize these differences, the cost figures were normalized per unit of area ($/m2), and then compared in percentages of the additional cost in relation to the base building cost described in equation 1.

Green construction cost surcharge (GCCS) = additional green construction cost / conventional building construction cost (Eq. 1)

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3.0 FINDINGS AND ANALYSIS

A total of 31 studies were included in the final analysis. The total number of green building construction projects included in this review is 1,320, covering four continents and eleven countries. The studies have been assigned numbers according to the date of publication (see Table 2, column 3) that are used throughout the paper.

The first noticeable characteristic about the GCCS from the existing studies is the differences between studies published by academic researchers and industry experts. As illustrated in Figure 1, 65% of the studies were conducted by industry experts and published by trade organizations, professional associations, or green building certification organizations. The data collection and research methods of these studies were typically not well defined or explained in the publications. Furthermore, the studies by industry experts are older, with most of the studies published before 2010 and only three studies published after 2010. On the contrary, the majority of the academic publications are relatively recent, after 2010 (Dwaikat and Ali 2016),

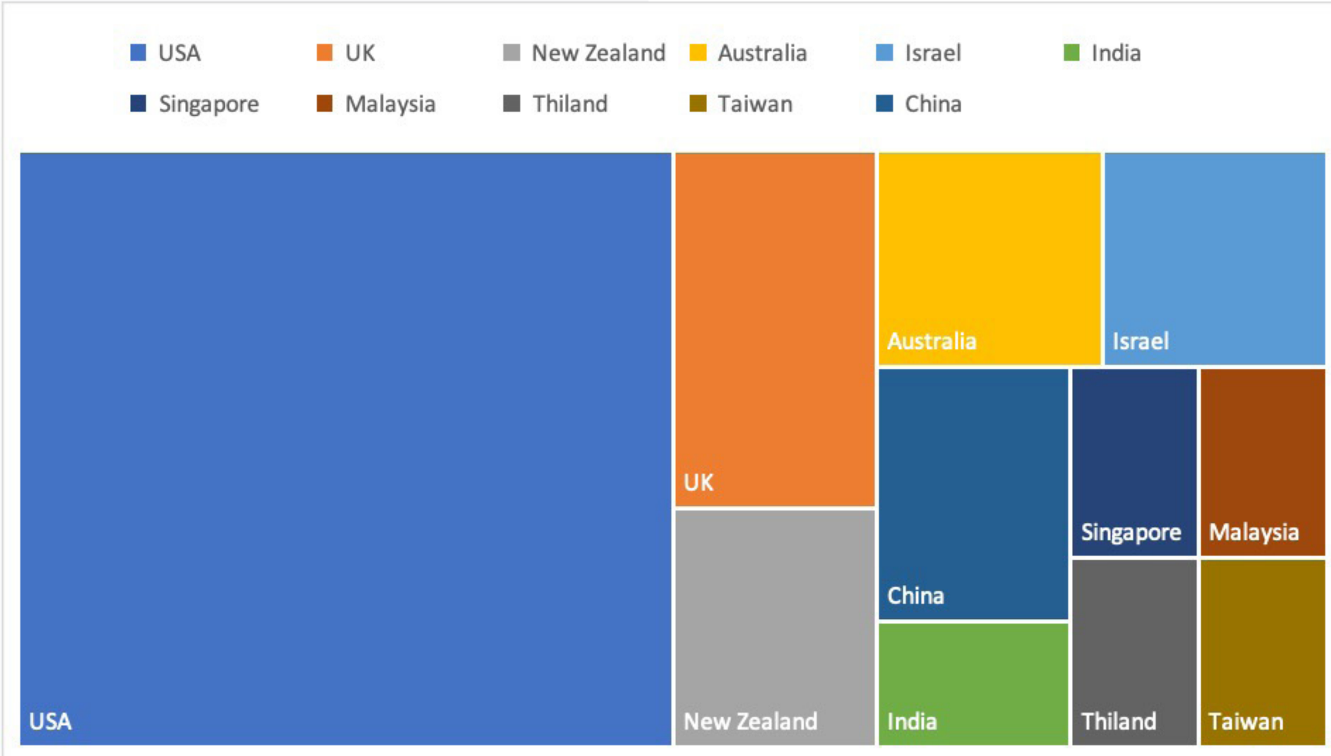

Figure 2. Countries of origin of prior green building construction cost studies

and only one study was conducted and published before 2010. The mean green surcharge cost from the academic research is 10.2%, which is much higher than that of the industry-associated published studies, at 3.06%. It is understandable that in the early period, the primary cost data resources were gathered by industry experts, particularly professionals working in the green building field, and the research and reports based on empirical data demonstrating the economic feasibility certainly has helped promote building green.

The second noticeable characteristic is that the United States appears to be leading the effort in GCCS research. As shown in Figure 2, more than 55% (17 out of 31) of studies were originated from the United States. The rest include three from New Zealand, two from Australia, three from the United Kingdom, two from Israel, two from China (including Hong Kong), one from India, one from Singapore, one from Malaysia, one from Thailand, and one from Taiwan (refer to Figure 2). The earliest found publication is an industry report in 2000, by Xenergy and Sera Architects (2000), and the most cited publication is also an industry publication in 2003 by a team of sustainable consultants commissioned by California's sustainable building task force (Kats et al. 2003). Both studies show no significant green cost surcharge.

3.1 REGIONAL DIFFERENCES

Figure 3 shows that the median value percentage of green surcharge in all regions is less than 5%, with Asia having the lowest value at 2% and Oceania having the highest value at 4%. Even though Asia has the lowest mean value, as illustrated in Figure 3, the majority of projects are actually in the higher green surcharge range (> 5%), which made Asia slightly different from the other regions. When we looked at the mean (average) green surcharge cost, Europe, Asia, and Oceania had less than 5% while the value of the US was higher than 5% (at 7%), and Europe had the lowest value of 3%. The potential explanation of such regional cost differences is offered in section 5.1. The US also had the largest GCCS variation among buildings, from -18.33% to 46%, and Europe had the smallest GCCS variation, from 0% to 6.5%. The wide range of cost differences in the US is an indication of the wide range of construction methods and cost estimation methods, which could potentially cause miscounting and confusion.

3.2 DIFFERENCES AMONG BUILDING TYPES

Figure 4 illustrates that among the different building types, school (K-12) buildings have highest average green cost surcharge, at 18%, which is much higher than all other green building types. The office building types has second highest green cost average surcharge at 6%. The residential building and other building types have an average green surcharge cost, at 4%. And the academic buildings (higher education and other learning facilities) do not show a significant difference between green construction and conventional construction. When looking into the median green cost surcharge, office buildings, residential buildings, and school buildings share a 4% higher

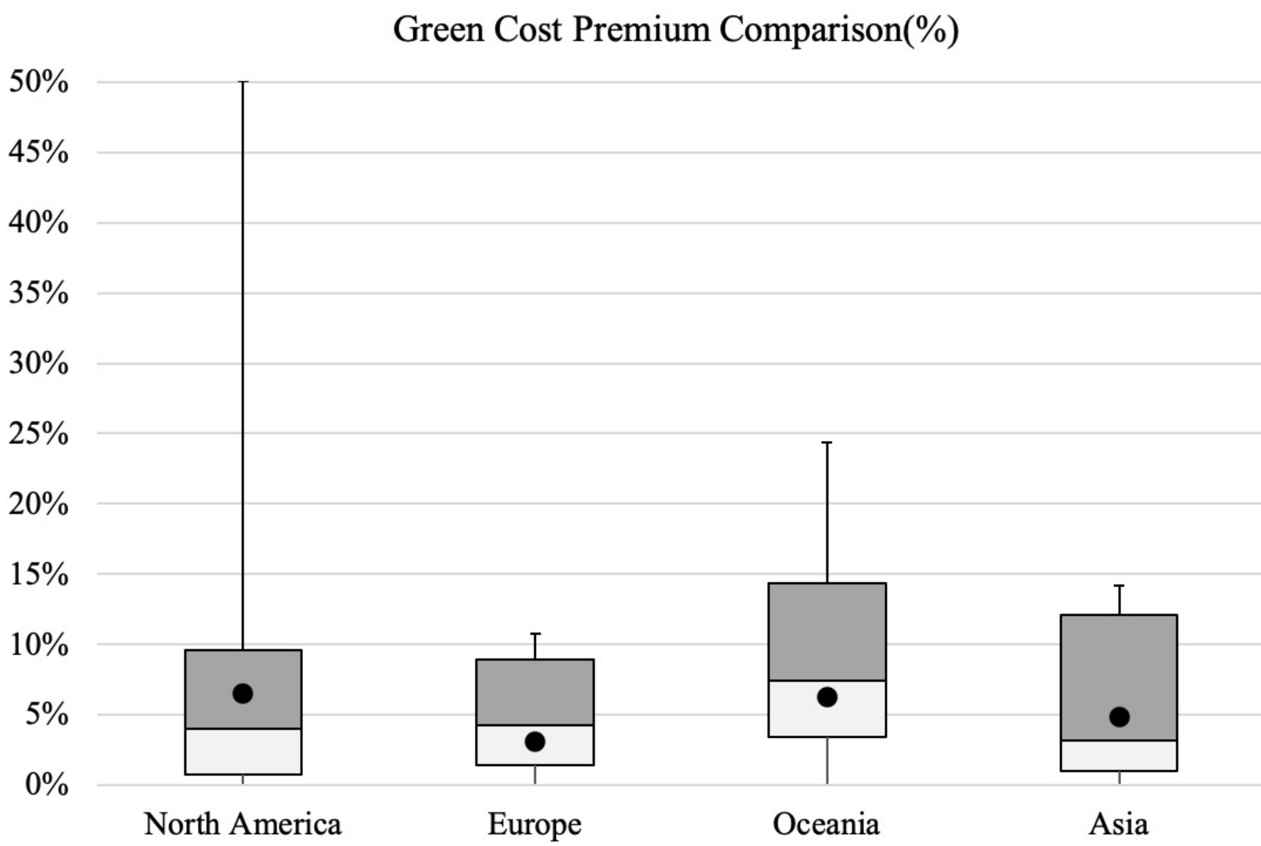

Figure 3. Green cost surcharge comparison across continents

cost than conventional buildings; academic buildings do not show a significant difference, and other commercial buildings have only a 2% higher green surcharge cost. In addition, the majority of school, office, and residential building costs are above the mean, and other commercial building types have an even split between cases with a surcharge cost below and above the median. These findings are aligned with previous studies where the project type was found to be a significant factor affecting the cost surcharge (AIA 2020). Currently, in the United States, school buildings are leading the effort in advancing green building. In 2019, according to a 2019 National New Building Institute report, educational buildings represent the largest portion of net zero energy projects, at 33% (NNBI 2019). Of the 42 net zero energy educational buildings, 12 are K-12 school buildings (Ade and Rehm 2020). Therefore, the higher GCCS of school buildings can be a contributor to public perception of green buildings as being expensive to build.

Among the same building types, the degree of green-ness may play a role in the range of cost premiums seen in the market. For example, a U.S. General Service Administration (GSA 2002) commissioned study showed LEED certified building add "little or no increase in project cost", LEED silver building require 2% premium, LEED gold building can add 7% to the construction cost. Mapp et al. (2011) also identified that the design and construction cost for LEED certified buildings can be within the same overall cost ranges, and added cost is mainly due to the administrative work and outside consultant fee. A more recent studied showed LEED gold and platinum certified building and additional construction cost was found to be 7.43% and 9.43% respectively (Ugur and Leblebici 2018). The higher level of "green-ness" is potentially associated with the higher percentage of additional cost. Such cost difference for different level of LEED certification can potentially explained the higher cost of school buildings, since majority school buildings are seeking higher LEED certification level, higher or equal to silver.

Regardless the difference, overall, based on empirical data collected from the more than 1,300 case buildings globally, both the mean and median green surcharge cost is 7% for all building types counted together. In addition, the distribution between the projects above and below the mean are equal. Hence, 7% can potentially be used as a benchmark to describe the GCCS across building types and regions.

3.2 DIFFERENCES BETWEEN STUDIES AND COST ESTIMATING METHODS

Among the included 31 studies, 22 studies used actual buildings, and the remaining 9 used hypothetical buildings. Table 3 shows

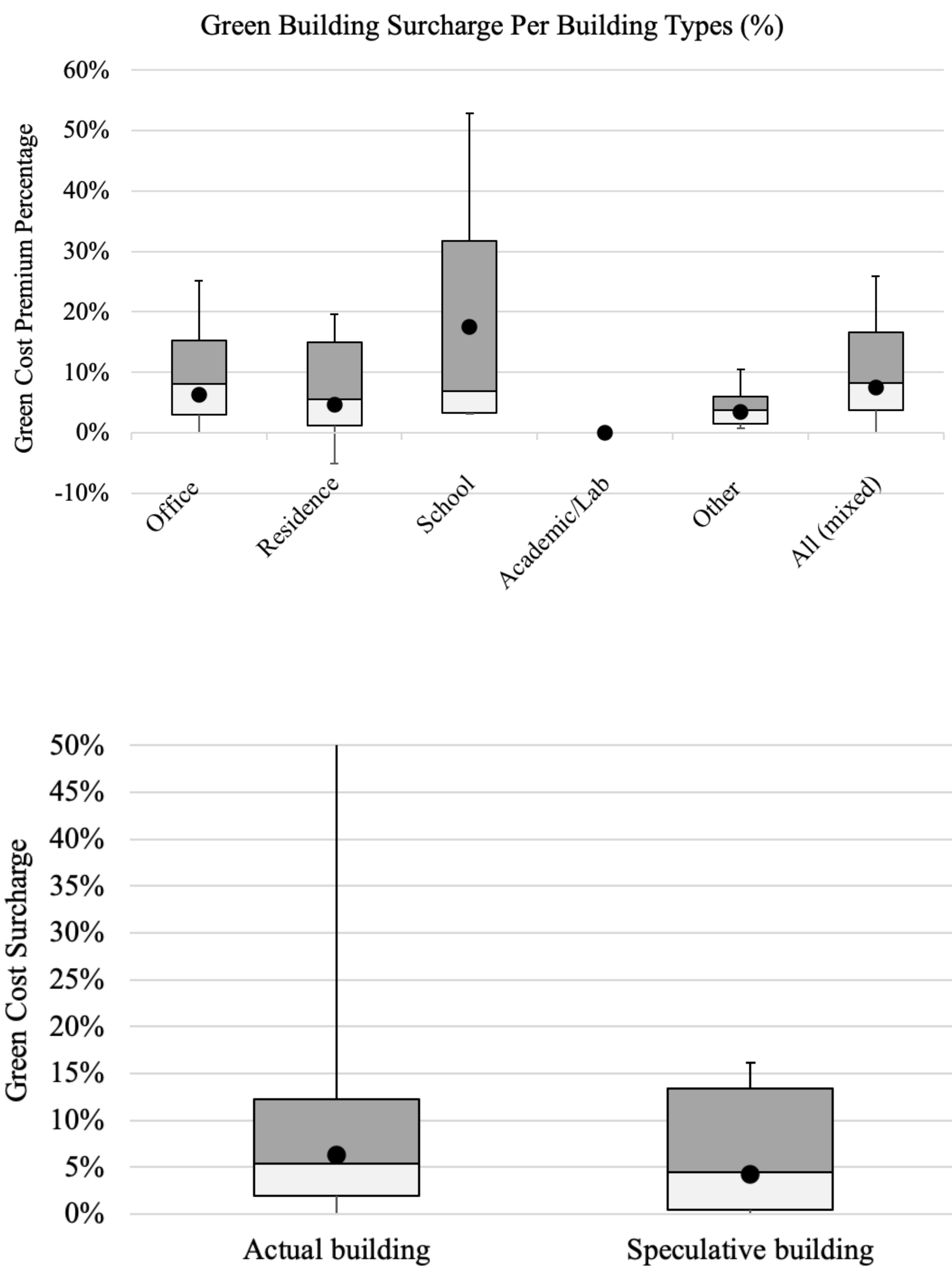

Figure 4. Green building construction cost surcharge comparison between cost estimation methods

the different methods used in the studies, and Figure 5 illustrates the GCCS statistics of the actual buildings and hypothetical buildings. The average GCCS for cases using the actual building cost is 6%, which is slightly higher than that of hypothetical buildings. However, the actual buildings' median GCCS is lower than that of hypothetical buildings, by 2%. This indicates that the majority of the GCCS of the actual building cost is higher than the hypothetical GCCS; this can be explained by the risk and uncertainties that occur during the construction. In addition, actual buildings have a much larger cost variation, from -5% to 46%, which is associated with the uncertainty and cost overrun during the actual construction process. Cost overrun is generally a symptom of inadequate planning and poor management (AIA 2020). It was found that green building projects have higher cost overruns than conventional buildings and more costly than conventional building projects (AIA 2020). Using hypothetical buildings and modeled construction costs might be sufficient to help the public gain an understanding of the average or median green cost surcharge; however, in order to account for uncertainty in a real project and ensure the actual construction cost will be within the budget, using the actual project cost data is critical, since the modeled cost cannot provide an accurate picture of the challenges and uncertainties that occur during construction.

As demonstrated in Table 3, there is no standard process for how the cost data are collected in those studies. Only 21% of studies were able to obtain the actual construction cost data and documents from the project team, and 25% of studies relied on survey or questionnaire responses from the project team members (architect, interior designers, engineers) and clients/developers. Some large public data are available for use. Chegut et al. (2019) used the Royal Institution of Chartered Surveyors' BCIS database, Sun et al. (2019) used the Taiwanese government's public information websites, and Gabay et al. (2014) used data from Israel's Central Bureau of Statistics. As more and more public databases become available to the public and researchers, the transparency of green building construction can be improved, and the mystery around the GCCS can be studied and explained better.

Because of the variety cost data collection methods and the difference between hypothetical building and actual building cost, we then looked into the uncertainty related to cost estimation methods. In general, across different regions, there are five levels of construction cost estimation associated with completeness of the information and maturity of the design, and different levels of estimation often require different cost estimation methods (Hu & Skibniewski 2021). Level 5 represent highest expected accuracy and level 1 represent lowest expected accuracy. For those hypothetical buildings, the project information and detailed data were often lacking, hence the conceptual methods were often used. Conceptual cost model does not rely on the data or factors taken directly from estimated building, instead, conceptual models rely on historical data from similar projects. Because of the relatively new and uniqueness nature of the sustainable building, historical cost data is much less sufficient compared to conventional buildings. Such scarce of the historical data can have impact on the accuracy of cost estimation, therefore, at the same level of project maturity, sustainable building construction cost may have less expected accuracy. In general, such decrease in cost estimation accuracy occurred to all types of sustainable projects across regions.

4.0 CONCLUSIONS

Global concerns over climate change and sustainability have spurred the need for green buildings in the construction industry (Qian and Foong 2013). But the current green construction industry is characterized by fragmentation and poor coordination among project participants (Tagaza and Wilson 2004), which leads to inefficiency, waste, and higher costs (Ofori 2000). Even though the life cycle cost benefits and environmental benefits of green buildings have been extensively studied and documented for decades (Russ et al. 2018), the adoption and promotion of building green still faces tremendous obstacles. Currently, the incremental capital costs are oftentimes solely borne by developers, while environmental benefits and other benefits are split among building owners, operators, and occupants.

This study identified the green cost surcharge difference across regions and building types through the review of published literature. Over 1,300 case buildings covering 11 countries were included in this review. The first finding from this study was that there are regional differences and building type differences; the United States has the highest average green cost surcharge and Europe has the lowest. School buildings have the highest average green cost surcharge while academic buildings have the lowest. Such cost variations can be explained by the direct and indirect cost factors. Despite the differences, both the mean green cost surcharge and median green cost surcharge are 7% for all building types across different countries, which potentially could be used as a green cost surcharge benchmark.

The second finding from this study centers on the GCCS cost data availability and collection methods. Current green building cost data are extremely fragmented and untransparent. There is no agreed-upon framework of what should and could be considered as the GCCS, which leads to many different definitions of the green building cost and green cost surcharge.

In addition, this study also identified the differences between the literature published by industry experts and that by academic researchers. In general, a higher green cost surcharge can be found in academic papers using publicly available databases, whereas industry literature showed no significant green cost surcharge. One can speculate that the literature published by green consultants or industry organizations whose mission is promoting green building might be focusing on the green benefits that have been approved by a large body of research, yet presenting transparent data and solid evidence of green building costs will help the public to fully understand the green building costs and benefits. Only when all stakeholders find the cost surcharge for "going green" to be financially feasible can they be stimulated to voluntarily adopt green practices (Russ et al. 2018). Developers and occupants are the ultimate decision makers of the green building supply and demand.

Overall, this study contributes to the awareness of the fact that there is construction surcharge related to the green building and identified the regional variation of GCCS. This study also try to speculate the possible causes for those variation. This study also has some limitations. First, extra caution should be given since the analysis results were interpreted and generalized according to the sample size, which was quite small compared to the number of existing green buildings around the world. Particularly, data for green school buildings were relatively small and thus might not fully represent an accurate picture of this building type. Secondly, the data collected were based on published literature, and data on cost information were in fact based on survey responders' subjective evaluations (AIA 2020). Lastly, the findings from this review were well interpreted from the included cases, but this may change when additional cases are included in the future. In addition, this study did not delve into the understanding the casual factors of the surcharge, partially due the fact the inconsistent estimation method and data resources. The first step is to develop a well-defined taxonomy of construction surcharges and their detailed description. That will allow the development of an approach to lower the surcharges and allowing better affordability of the green buildings.

Several recommendations can be drawn upon the research findings:

- There is an urgent need for a consistent green building or construction cost definition framework, so that green building costs can be compared in a fair sense, and lessons learned can be shared.
- A publicly available global database focusing on the GCCS would be instrumental to further promote the adoption and practice of green building. Transparent and reliable cost data is the first step to create a more competitive and high-quality green building market.
- Architects, engineers, and contractors are the determining factors of the GCCS through optimized design and construction. However, the influence of design teams during the design and construction stage has not been studied enough. Future research could focus on such indirect influences on the GCCS.

Future studies should aim at better understanding of those GCCS, with ultimate goal of elimination and easier promotion of cost-effective green building construction methods. Especially aims at supply chain variations studies as a means to achieve to this subjective.

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