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ANALYZING AND FORECASTING CONTRACTORS' GREEN BUILDING REVENUES

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The sustainability movement is increasingly impacting the construction industry, which has been quick to adopt innovative methods to deliver sustainable facilities. The literature shows that energy consumption in the building sector is increasing at a rate comparable to those of industrial and transportation sectors, and that buildings are responsible for close to 40 percent of energy use and 74 percent of electricity retail sales. Numerous studies also show that this sector has high potential for energy savings and pollution reduction. There is an opportunity for stakeholders of the architecture, engineering, and construction industry to increase their revenues in delivering green buildings. Accordingly, this study presents quantitative analyses of green contractors' market performance in terms of topline revenue. More than a decade's worth of business data was used to perform statistical analyses to gauge and discover the green building construction revenue growth over the past decade, uncover trends and develop a forecasting model for the next decade. Results indicate that there is an average 3.7 percent growth in green building revenue on a yearly basis, and that green building revenue constitutes about 35 percent of the total revenue for the top 100 green building contractors, with an expected increase of $3 billion every year. Such findings give researchers a retrospective look at the green contractors' market performance to investigate the underlying reasons for such significant growth, while also providing practitioners with a forecasted growth rate informing their decision to grow their green building business.

Keywords: Data analysis, Sustainable, Revenue, Business, United States.

1 INTRODUCTION

Considering the significant negative impact of construction activity on the environment, sustainable construction practices are increasing with time by adopting innovative methods to deliver sustainable facilities (Tan *et al.* 2011). Such methods include reducing waste generation (Tan *et al.* 2011), using Building Information Modelling (BIM) for refurbishment and demolition (Chong *et al.* 2016), and using environmental product declarations to support sustainable construction (Burke *et al.* 2018). A study by the U.S. Energy Information Administration (2021) shows that the residential and commercial building sector is responsible for about 74 percent of electricity retail sales and 40 percent of all U.S. primary energy use. A study in 2015 introduced the possibility of reducing up to 6 Gt CO_2 equivalence per year in the next 20 years conditioned by embracing sustainability in the building sector (Berardi 2015). Although this is an indication that the building sector has high potential for energy savings, a more recent study has noted that this goal is not fully in pursuit due to continuing to expedite fossil fuel-based assets, lack of proper energy-efficiency policies, and insufficient investment in sustainable buildings (Abergel and Delmastro 2020). Despite the stated challenges, there is an opportunity for stakeholders of the architecture, engineering, and construction industry to increase their revenues by delivering green buildings. In particular, contractors that deliver green construction projects are believed to benefit from improvements in reputation that could potentially attract clients and investors interested in sustainable construction. Within the identified need of assessing the green building market trends, this paper aims to analyze the contractors green market revenue using the top 100 green building contractors (GBC) in the United States identified in the years 2007-2020 and predict future market shares from green building revenues (GBR). The paper starts by providing background on green buildings and their business aspect. Then the research methodology is described followed by a discussion of the findings, key conclusions, and future research.

2 BACKGROUND

2.1 History of Green Buildings

Early in 1987, sustainable development (SD) was defined by the Brundtland Report from the World Commission on Environment and Development (WCED) as “the development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED 1987). Sustainable construction (SC) is one dimension of SD, which utilizes technology and knowledge to improve the sustainability of production processes, practices, and designs (Chong *et al.* 2009). One way to achieve the objectives of SD and SC is the occurrence of the green building revolution, which aims to create energy-efficient, healthy, and productive buildings that lessen the negative impacts of buildings on the environment and produce positive benefits (Yudelson 2010). To see this change to the built environment in action, the U.S. Green Building Council (USGBC) was founded in 1993, followed by the launching of the Leadership in Energy and Environmental Design (LEED) green building rating system in 2000 (Yudelson 2010). LEED, among other green rating systems, such as Building Research Establishment Environmental Assessment Method (BREAM), Comprehensive Assessment System for Built Environment Efficiency (CASBEE), and Green Star NZ, aims to unify the criteria against which the sustainable performance or impact of green buildings is assessed (Doan *et al.* 2017). Although multiple green building rating systems have emerged to urge the construction of more sustainable buildings, organizational and procedural difficulties such as risks and unforeseen costs act as barriers that still impede its progress (Hakkinen and Belloni 2011). Thus, there is a need to focus on options to overcome such identified barriers. One option is to focus on the business aspect of green buildings to draw more contractors towards investing in it.

2.2 Business Aspect of Green Buildings

Studies show that since the year 2002, construction clients’ tendency for building sustainable facilities has been increasing, which is demonstrated by adding requirements for their contractors, suppliers, and business analysts to go by sustainable policies in their construction process (Tan *et al.* 2011). A recent issue by Engineering News-Record (ENR) shows that the top 100 green design firms hit a 7.5 percent increase in design revenue in 2019 vs 2018 from projects seeking certification from LEED for their design-standards despite the pandemic situation (ENR 2021). The increase in design revenue for projects seeking LEED certification reflects clients’ contribution to green buildings. Similarly, ENR presented promising results for contractors’ contribution to green buildings; however, more work is yet to be done where they need to understand how their competitiveness is impacted by their sustainability performance. Tan *et al.* (2011) introduced a framework to ensure contractors are implementing sustainable construction practices to improve their business competitiveness. Tan *et al.* (2015) conducted an empirical study to prove that sustainability can increase revenue growth of international contractors and is increasing their market competitiveness. Although these studies show economic benefits, other studies focused on the anticipated financial burden that comes along delivering green buildings. Based on a study conducted on Singapore green building projects, green cost premiums range between 5 percent and 10 percent mainly due to high cost of green technologies and materials, high research and development costs, and lack of needed green expertise (Hwang *et al.* 2017). Accordingly, contractors are considered burdened with providing salaries when hiring staff with green expertise who will be part of the team as well as costs of updating their technologies.

The reviewed studies lacked quantitative market performance comparisons of current top GBC in the U.S., which could serve as a basis for contractors to make more informative decisions about joining the green building sector or expanding their business within it. Such an evaluation would also set the stage for future research around the underlying reasons for the observed growth in green construction and how to promote it further.

3 METHODOLOGY

3.1 Data Collection

The authors collected more than a decade's worth of business data from a well-established professional magazine, ENR, to conduct quantitative analyses of green contractors' market performance (ENR 2021). Green contractors are contractors who construct projects that are registered or certified with third-party environmental standards or rating groups (ENR 2021). The collected data are in terms of topline revenue of the top 100 U.S.A GBC over the years 2007 through 2020. ENR compiles these lists through a survey data collection technique from companies. Specific contractor data collected are (1) rank based on contractors' green buildings revenues, (2) number of accredited staff, (3) revenue from green buildings, and (4) percentage of contractors' revenue generated from green contracting. The rank is for the revenues of projects that have been registered or certified by a third-party organization that sets standards for measuring a building's sustainability performance of environmental impact, energy efficiency, or carbon footprint. These revenues are the GBR. A total of 14 reports were collected, and the GBR performance of 225 contractors was assessed for the years spanning 2007 through 2020. The projects taken by these contractors are dispersed across the U.S and cover the various building sectors, such as commercial offices; educational facilities; etc.

3.2 Data Analysis

The collected data was extracted to Microsoft Excel, managed, and statistically analyzed using R statistical computing software to gauge the green building construction revenue growth over the past decade, to uncover trends, and to develop a forecasting model for the next decade. The authors conducted trend analyses between the years 2007 and 2020 to find the total GBR per year for the top 100 contractors; the share from total revenue; and the average growth percentage by rank. The trend analyses offer a retrospective look on the performance of GBC and highlight the trends of the GBR market. Such information is used to identify a predictive model of the revenues that can be used to forecast future revenues to encourage contractors' participation. One approach to achieve this objective is running different regression models to find which fits the data most accurately, namely first, second, and third order polynomials. The quality of fit of the models is evaluated using the R^2 metric. This is an approximation relying on the linear regression model and previous data and it is not practically expected to achieve the forecasted values. Accordingly, confidence intervals for the predicted values are developed relying on another forecasting technique known as “naïve with a drift”. This method forecasts based on the average of the historical data allowing for an increase or decrease over time referred to as the drift (Hyndman and Athanasopoulos 2018). Finally, the regression model must be validated to ensure its prediction strength and validity by estimating its prediction error. One method to do that is using the leave-one-out cross validation (LOOCV) technique which follows the concept of splitting the data into training and testing where one data point is left out and the model is built on the rest of the data set (Wong 2015). Then the model is tested against the left-out data point and the test error associated with the prediction is recorded. This is repeated across all the data points or in the case of this study across the 14 years and the test error estimates are averaged.

4 RESULTS AND DISCUSSION

4.1 Trends for the Top 100 GBC

Figure 1a shows the continuous increase in top 100 GBC revenue from 2007 to 2020 with exceptional declines in the years 2012, 2014, and 2020. According to ENR (2021), the 4 percent drop in 2012 is likely related to the uncertainty contractors faced when many clients were going for the economic and operational benefits of sustainable construction and did not seek the certifications for their projects. The decline in 2014 was mostly due to one big firm (among the top 15 percent) not participating in the survey of that year (ENR 2021). Finally, the drop in 2020 can be attributed to the effect of the COVID-19 pandemic on construction progress. Figure 1a also shows the increasing trend of GBR with increasing total revenue and percentage shares for the top 100 GBC. There is a steady increase in construction and GBR across the years where the percentage of GBR stabilizes at about 35 percent of the total revenues for the top 100 GBC. This is a relatively large portion encouraging more investment in green buildings. The increase in GBR from 2007 to 2008 is the largest in dollar value. This is because 2007 was the first year the ENR releases and collects the surveys across the contracting firms where many large firms did not participate at the time including contractors that in 2008 and beyond held the highest ranks in GBR. Due to this reason, data from 2007 are not included when determining the average annual growth rate across the years for each rank. The cumulative revenue generated from green buildings projects for the top 100 GBC firms was plotted for all the years and a similar behavior was noted across them all. Accordingly, only that of 2020 is presented in Figure 1b showing that the top five contractors are responsible for about 30 percent of the total GBR of that year and the top one on its own is responsible for about 10 percent. This explains the influence one firm from the top five has on the overall green revenue of each year.

Figure 2 shows the average annual growth rate of total GBR for the top 100 GBC which is 3.7 percent as well as the average annual growth for each rank from 2008 to 2020. About two-thirds of the firms score at or above the average with an average growth rate of 5.7 percent while the bottom one-third score lower than the average with an average of -0.6 percent. The latter result is driven by -2.9 percent, the average growth for the bottom 15 firms, that are losing and not growing their GBR from year to year. To better assess these results, the authors plotted the average growth from year to year, but no trends were noticed to explain the total average or behavior of the ranks. Instead, assessing the participating firms across the years yielded that there is so much turbulence in the firms ranked in the bottom 20 where many of them join for a year or two and drop out while others struggle to increase their GBR and start to step up in the ranks. In general, the top 10-20 ranks are mostly occupied by the same firms; this is supported by Figure 1 (b) where the largest 10-20 contractors own 50-70 percent of the market.

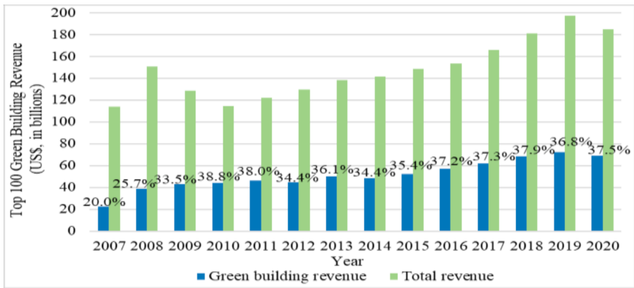

Figure 1a. GBR share from total revenue.

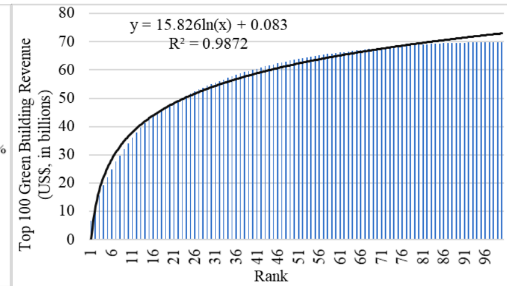

Figure 1b. Cumulative revenue in 2020.

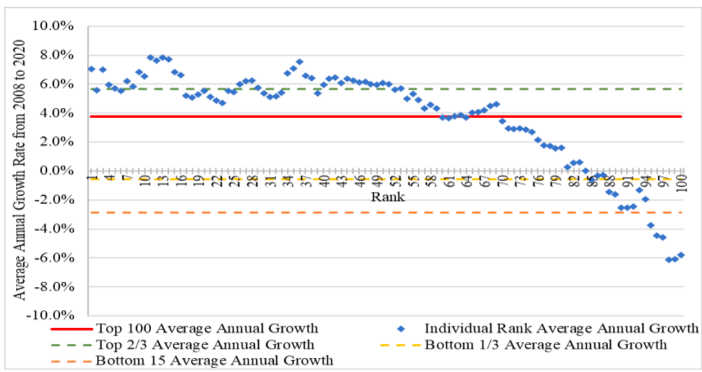

Figure 2. Average annual growth for the top 100 GBC and average annual growth for each rank.

4.2 Regression Analysis and Forecasting

First, second, and third order polynomials were tested. Relying on the significance of the models and the predicted R^2 value, the first order polynomial was chosen with an R^2 value of 91 percent and significant coefficients (compared to insignificant coefficients of the other models). Hence, the linear regression model is the most accurate for analyzing the market trends and forecasting future revenues as shown in Figure 3. Considering future forecasts, the regression model estimates about $3 billion increase in GBR for the top 100 GBC every year to reach about $87 billion in 2025.

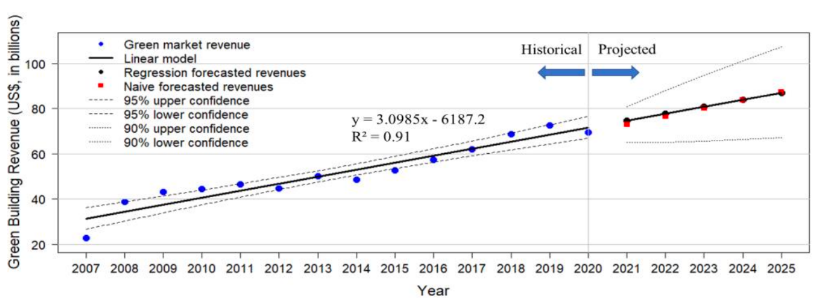

Figure 3. Forecasting model for the top 100 GBC revenues.

The "naïve with a drift" forecasted results are shown in Figure 3 and are almost equal to those in the regression model. Hence, the 90 percent confidence intervals generated from this method were used as bounds to the forecasted revenues, which are expanding when moving into the future. Finally, the cross-validation process yielded an average prediction error of 4.9 percent, which is considered acceptable, further confirming the validity of the predictions.

5 CONCLUSION

This paper assessed market trends for the top 100 GBC and presented a forecasting model for GBR for the next five years. An important finding is that GBR constitutes almost a third of the revenues of these contractors, with a steady projected growth in revenues. The results confirm that contractors can increase their revenues by delivering green buildings, potentially motivating new contractors to join the green construction market. Ongoing work is exploring the causes of the trends observed by analyzing the firms in groups depicting similar growth behaviors and benchmarking their performance against that of the general construction industry. Other dimensions will also be studied such as the number, size, and types of projects.

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