DEVELOPMENT OF A BENCHMARKING AND METRICS MODEL FOR 
ELECTRICAL CONTRACTING FIRMS

By

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Abstract

Despite its noticeable growth and positive future expectations, the electrical contracting industry is facing a number of unique and complex challenges that are creating fierce competition and driving major change. In response, contractors are required to understand the impact of this change on their businesses, study their performance as compared to the industry, be proactive, and continuously identify and seize growth opportunities. Here comes the role of benchmarking which originates as a continuous and systematic way of measuring a firm’s performance and comparing it accordingly with the highest performing in the field, as means to identify opportunities for improvement and growth.

Despite their significance, performance measurement and benchmarking are still not widely adopted by construction firms. A number of construction benchmarking initiatives have been developed in the past; however, most of them share common shortcomings with respect to either being project specific and not measuring the overall performance of a company, being purely financial with all studied metrics being financial ratios, or not measuring the impact of the firm’s management and technological practices on its long-term overall performance. This research fills the missing gap by introducing a benchmarking model for the electrical contracting industry that includes a combination of both financial and non-financial benchmarks. The model can be used by electrical contracting companies to identify areas of weakness, highlight areas of strength, and isolate root opportunities for performance improvement.

A literature review on the previous and current construction benchmarking models, along with interviews with industry experts, was done to identify the metrics to be included in this
benchmarking study. A data-collection questionnaire was developed and used to gather quantitative and qualitative performance data from electrical contracting companies. The analysis and development of benchmarks were then based on a database of twenty-eight electrical contracting firms providing company performance data across the years 2011 through 2018.

Furthermore, the qualitative data collected from participating companies was used to identify the best managerial, operational, technological practices of the highest performing electrical contracting companies. The best practices were identified by statistically analyzing the differences in the net profit percentage between companies implementing a particular practice and those not implementing it. Results of the analysis identify thirteen best practices across five categories, namely prefabrication, technology use, labor management, quality management and evaluation, and productivity and management practices.

Finally, this research presents an interactive online benchmarking tool that was developed to provide electrical contractors with an easy, accessible, and automated way to track industry trends and perform a comprehensive self-performance assessment through a secure and confidential environment.
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Chapter 1. Introduction

1.1 Background

1.1.1 State of the U.S. Construction Sector

The construction industry has always played a major role in the United States economy. In 2018 alone, the U.S. construction sector employed around 7.29 million people (US Census Bureau 2018). According to Statista (2019), the construction spending as a percentage of the U.S. Gross Domestic Product (GDP) stood at 6.36 percent in 2017, and the value added of the construction industry accounted for 4.1 percent the GDP in 2018. While already being one of the largest worldwide, the U.S. construction market is projected to record a Compound Annual Growth Rate (CAGR) of 4.9%, reaching $1.8 trillion by 2023 (Markets 2019). Such positive trends are the result of favorable economic conditions and business environment, ample employment opportunities, and the government’s committed efforts to boost the construction market (Business Wire 2019).

1.1.2 State of the U.S. Electrical Contracting Industry

As part of the booming construction sector, the electrical contracting industry in the U.S. has been experiencing a strong growth. The increased economic activity over the past five years, coupled with access to credit and relatively low interest rates, resulted in an increase in the demand for residential and nonresidential projects, all of which require electrical work. According to the National Electrical Contractors Association (NECA) (2020), the size of the electrical contracting industry is estimated to be over $171 billion, comprising of more than 70,000 electrical contractors employing over 650,000 electricians. The majority of the electrical contractors’ revenue comes from new construction, with the rest coming from modernization/retrofitting in existing buildings, in addition to maintenance, service, and replacement (MRR) work. The type of work varies
between electric power transmission and distribution, installing and maintaining lighting systems, fire alarms, industrial systems (generator, motors, etc.), voice/data/video systems, and building systems integration. With the construction activity surging, along with the fact that MRR is less sensitive to real estate cycles in the first place, the electrical contracting industry is expected to continue growing over the next five years at a rate of 2.1 percent per year, reaching a revenue of $199.5 billion in 2024 (NAICS 2019).

1.1.3 Challenges Faced

Despite the current boom of the U.S. construction industry, researchers continuously report that the industry is still suffering from fragmentation, divided responsibility, conflicting objectives, along with several other wastes and inefficiencies that are resulting in stagnant labor productivity trends (Hanna and Iskandar 2018; S. H. Lee, Thomas, and Tucker 2005). In his study about U.S. productivity trends, Hanna (2012) shows that the productivity of the construction industry continued to decline between 2005 and 2011 at an approximate rate of -0.7 percent annually. In this study, the construction industry was compared to all other non-farm industries whose productivity recorded a steady increase of 1.7 percent per year during the same time period. In fact, the labor productivity data for the construction sector over the time period from 2005 till 2018, published by the U.S Bureau of Labor Statistics, shows a similar trend as illustrated in Figure 1.
The undebatable productivity problem of the construction industry is of major concern to the electrical contracting industry that is classified among the most labor-intensive, with the workforce being its dominant productive resource (Jarkas 2010). And with studies (Hanna et al. 2005, 2008) showing that a slight decrease or increase in labor productivity may have detrimental consequences on the contractor’s profit, the risks for electrical contractors become extremely high.

Aside from the productivity problem, the electrical construction industry is facing a number of challenges, one of which is the aging workforce and shift in leadership. Figure 2 below shows the age composition of electrical contractors responding to surveys done by Electrical Contractor Magazine over the course of twelve years. Information shows that 69 percent of respondents in the 2018 survey were over the age of 55, with 32 percent of the respondents being over the age of 65 (Ross 2018).

Figure 1 U.S. Construction Labor Productivity Trend (U.S. Bureau of Labor Statistics n.d.)
As millennials outtake retiring baby boomers as the largest demographic among U.S. workforce, major change in leadership is inevitable in electrical contracting companies similar to the case of other industries. Uncertainties about companies’ future and stability arise as experienced managers and leaders retire, leaving behind vulnerable companies lacking the years of experience and knowledge required for success in an extremely competitive economy. As many electrical contracting firms are family-owned, things get even more problematic when conflict arise among the generation next in line who are either competing over leadership or not even interested in the family business. Succession issues also arise in diversely held corporations when younger employees are not groomed to take future leadership positions. Without a well-thought-out succession plan in-place, coupled with tactical training of key employees for future leadership roles, the survival of several electrical contracting firms may be jeopardized.

Figure 2 Age Composition of Electrical Contractors Respondents to Surveys
Along with the shift in leadership and change in workforce comes the added challenge of keeping up with the frequent updates in electrical codes, staying informed about the latest technological trends, implementing emerging technologies and methods, and coming up with new ideas and business practices. It’s no secret that the nature of the work and how it is done is changing across all industries. And with a complex electrical trade, technology is especially inescapable with electricians working with more intricate systems, performing high-tech installations, and delivering smart homes. Amidst that, electrical contractors find themselves compelled to monitor the latest trends that are changing the landscapes of the industry and create additional value for customers through implementing new technologies, all while adhering to budgetary constraints. Here comes the additional step of not only investing in technology, but also following up with trainings and concrete implementation plans to fully utilize that technology.

With the increasing role of technology in the electrical trade, the need for skilled labor is growing. However, such high market demand for skilled electricians is facing a looming skilled workers shortage which is posing significant challenges to the electrical contracting industry. According to the Q1 2019 Commercial Construction Index (USG Corporation and U.S. Chamber of Commerce 2019), 40 percent of contractors tend to reject new projects due to the lack of qualified workers needed for these projects, 81 percent of contractors require their current workers to do more work, and 70 percent of contractors struggle to deliver their projects on time. The persistent labor shortage is also adding the extra hurdle of increased labor costs on electrical contractors who are finding themselves obligated to offer higher wage rates, overtime premiums, and benefits to attract and retain sufficient number of electricians. In fact, 63 percent of contractors are experiencing increased labor costs for new work (USG Corporation and U.S. Chamber of
Commerce 2019), which explains why 82 percent of the members of the National Association of Home Builders reported that cost and availability of labor are their biggest challenges (NECA 2018). The problem of skilled labor shortage is due in part to the fact that the number of retirees in the industry is outpacing the number of new joiners. According to NECA, 7,000 workers join the trade each year, while 10,000 retire. Aside from the cause of aging workforce, the number of new electricians joining the industry is by itself decreasing. As vocational education programs and shop classes are being eliminated from public schools, high school students do not get the chance to have a hands-on experience that might be the start of their trade careers. The social pressure for getting into college and having a college degree eliminated the option of trade schools from the mindset of a high school graduate who is living in a society which supports the notion of ‘College or Bust’. All this, coupled with the negative perception that a career as an electrician is just strenuous work with long work hours and no advancement opportunities, have shut the pipeline for new skilled workers. The best way for contractors to cope with that is to find ways to change the overall perception and reputation of a career as an electrician by working with secondary education institutions, unions, and construction industry and electrical trade organizations. They should highlight the trade’s good compensation and benefits, ample apprenticeship programs, exposure to advanced technologies, and clear paths and opportunities for advancement.

1.2 Research Motivation

As shown in the previous section, the construction industry is still experiencing a serious productivity problem, facing the challenge of human capital availability, and being characterized by waste and inefficiencies among others. But given its growing size and significant role in the U.S. economy, the returns on any step taken to improve the overall performance of the industry
would be substantial. In fact, LePatner (2008) anticipated that direct economic growth sufficient to stabilize Social Security in the U.S. could be achieved with only a one-time improvement of 10 percent in construction productivity.

Being a major part of the U.S. construction sector, the performance of the electrical contracting industry is a mere reflection of it. Despite its noticeable growth and positive future expectations, the electrical contracting industry is facing a number of unique and complex challenges that are creating fierce competition and driving major change. In response, contractors are required to understand the impact of this change on their businesses, study their performance as compared to the industry, be proactive, and continuously identify and seize growth opportunities. As such, this thesis investigates how the performance of electrical contracting firms can be improved both operationally and financially amid a growing, yet evermore challenging, construction market.

1.3 Problem Statement

As the construction market hits its highest levels, electrical contractors are searching for ways to improve productivity in order to meet demand and minimize increasing costs. Researchers (Bernold and AbouRizk 2010; CII 2013) found that the best way to increase productivity is through identifying and adopting the best practices, in terms of management and work processes, to satisfy requirement specifications and answer the demands of the clients. The first step in doing so is to establish a continuous improvement mechanism through consistent measurement of the firm’s productivity and performance, manifested by its business and management processes (Zhang, Nasir, and Haas 2017). Despite its significance though, performance measurement is not widely done by construction firms whose managers tend to be to a great extent reluctant and lack training
In fact, most contractors focus on measuring and controlling a range of project variables without investing the needed time and money in measuring the performance of the company as whole (Kaplan and Norton 1992; Lynch and Cross 1995). In such a dynamic and competitive construction market however, a company’s success may be tied to its ability to continually improve its management, quality of work, and operations. To this end, performance measurement remains the key to ceaseless improvement (Luu, Kim, and Huynh 2008). Here comes the role of benchmarking which originates as a continuous and systematic way of measuring a firm’s performance and comparing it accordingly with the highest performing in the field as a way to identify opportunities for improvement and growth (Almström and Kinnander 2011; Costa et al. 2006; El-Mashaleh, Minchin, and O’Brien 2007; McCabe 2001; Spendolini 1992). The knowledge of how well a company stacks up against others in the industry first serves as a learning approach and key support for the organization’s decision making processes (Costa et al. 2006). The lessons learned from the benchmarking process are then used to set improvement goals and implement the necessary adjustments in an organization (Barber 2004; KPI 2000). Amid the changes that are undergoing in the electrical contracting industry, electrical contractors are in need to recognize the impact of these changes on their businesses, to know where they stand with respect to the rest of the market players, and to recognize improvement opportunities. To this end, this study presents the development and implementation of a benchmarking study for the electrical contracting industry.

1.4 Research Objectives

This research presents the development of a benchmarking model for the electrical contracting industry with three main objectives:
1. Provide electrical contracting companies with a number of financial and non-financial benchmarks that they can use collectively to identify areas of weakness, highlight areas of strength, and isolate root opportunities for performance improvement.

2. Develop an interactive online benchmarking tool that electrical contractors can use for tracking industry trends and for self-performance assessment.

3. Identify the best managerial, operational, technological practices of the highest performing electrical contracting companies.

1.5 Research Methodology

The methodology used in this research consists of five main stages, as illustrated by the flowchart in Figure 3 below. In this section, a roadmap of the major research stages is presented, followed by a discussion of the stages and the steps within each stage.
1.5.1 Stage 1

Stage 1 is basically a review of the available literature. It consists of two steps, the first of which is meant to introduce the concept of benchmarking, and the second is meant to study the previously developed benchmarking models in the construction industry. It should be noted that unlike the collected data for this research, the literature review as not restricted to a specific timeframe which in turn allowed the background of this study to be comprehensive, covering all relevant publications and benchmarking initiatives.
1.5.2 Stage 2

The completion of the first stage established a solid basis for Stage 2 which is centered around the research questionnaire. The first step in this stage was the development of the questionnaire that collects quantitative performance data, along with companies’ qualitative characteristics and practices. The metrics and practices included in the questionnaire were based on the benchmarking metrics identified in past benchmarking models in the construction industry, complemented with additional metrics and practices recommended by industry collaborators. The questionnaire, which can be found in Appendix B, ended up being thirteen pages long, comprised of three main sections. The questionnaire starts with an introductory page that explains the research objectives to provide some background for the participating companies. The first section in the questionnaire requests background information about the company regarding distribution of revenue by form of work, delivery method used, company role, market sector, and type of work performed. The second section collects quantitative data needed to calculate the benchmarking metrics used in this study. This section is accompanied by a set of definitions to ensure consistent data reporting. The third section is dedicated for current company managerial and operational practices. The questionnaire ends with a feedback section that was used mainly during the pilot testing step to collect comments and recommendations from participating companies. Following the development of the questionnaire, it was reviewed by industry experts through web conference calls to make sure all key variables and factors needed to answer the research questions were included, the terminology used is clear, and the data requested is available and tracked by companies. Once the review was completed, a pilot testing was conducted to test the questionnaire and improve it before full-scale data collection was performed. Some insights and observations
were drawn out of the pilot testing, driving the addition, deletion, or editing of some questions, all of which resulted in the final version of the questionnaire that was used during the full-scale data collection phase.

1.5.3 Stage 3

During Stage 3, data collection was conducted. The questionnaire was sent via emails to electrical contracting companies in the U.S. and Canada and shared within industry peer groups. Participating companies took two to four weeks on average to fill and send back the questionnaire, either as an MS Word document or as a PDF document. Company responses were accordingly entered in MS Excel to facilitate data analysis afterwards. The second step in this stage is data auditing. Following data entry in Excel, all data was audited to identify any data reporting errors, data entry errors, and major outliers that were detected using the Interquartile Range (IQR) method for outlier detection.

1.5.4 Stage 4

Stage 4 consists of two main steps, one of which is the development of the quantitative benchmarks and the second is the identification of the companies’ best practices. For each of the studied financial and non-financial benchmarking metrics, boxplots showing the industry trends for each of the studied eight years, along with the data percentiles and averages, were established. The qualitative company data with regards to the current practices was also analyzed to determine which practices are the most significant based on statistical testing.
1.5.5 Stage 5

To make the benchmarking process more autonomous and efficient, communicate the research findings to industry professionals, allow new companies to perform self-performance assessment and view where they stack up with respect to the rest of the market players, and turn this benchmarking initiative to a continuous sustainable one, a web-based benchmarking tool was developed. Any electrical contracting company can log into the developed website and fill the research questionnaire online. Their data will be automatically stored in databases from which an R program would extract variables to calculate the benchmarking metrics and create a specialized company report. An admin would then review the report and make sure that no errors exist in the data inputted by companies, and subsequently forwards the report to the participating company.

1.6 Research Scope

The scope of the benchmarking model presented in this research is limited to the electrical construction industry and is to be applied on the company-level and not on the project-level. That being said, the benchmarking concept and methodology used can be implemented in the construction industry in general, with the use of more general metrics that are not electrical construction focused. It should also be noted that this research covers a time frame of 8 years, benchmarking companies’ data from 2011 till 2018 inclusive. Chapter 3 will further discuss the main characteristics of the dataset used in this research.

1.7 Thesis Organization

This thesis report consists of six chapters. Chapter 1 serves as general introduction, providing a general background about the current status of the construction industry in general and the electrical sector in particular, introducing the research motivation, presenting its objectives,
explaining the used methodology, and underlining the scope. *Chapter 2* provides an in-depth literature review in regard to the concept of benchmarking, its benefits, and its limitations, along with a study of the past benchmarking initiatives in the construction industry, the benchmarking metrics that they used, and the lessons learned from them. *Chapter 3* introduces and explains the quantitative financial and non-financial metrics that are used in this benchmarking study, along with the qualitative managerial and technological factors and practices. It also presents a thorough description of the studied dataset in terms of the characteristics of the electrical contracting companies participating in this study. *Chapter 4* presents the developed benchmarks for the quantitative metrics and explains the analysis used to determine the best practices of electrical contracting companies. *Chapter 5* describes the development of an online benchmarking tool that electrical contracting companies can use for self-performance assessment. Finally, *Chapter 6* presents the conclusions and recommendations of this research. The bibliography used for this study can be found in *Appendix A*. The data collection questionnaire developed and used can be found in *Appendix B*. 
2 Chapter 2. Literature Review

Before proceeding to explain how the benchmarking study of electrical contractors was developed and implemented, it is crucial to discuss previous literature relating to benchmarking and its application in the construction industry. In order to carry out a benchmarking project, a thorough understanding of the concept of benchmarking is first required. It is also important to recognize the several benefits and opportunities that benchmarking carries, along with comprehending its limitations and how to interpret and apply the conclusions drawn from it. Next comes the role of studying previous benchmarking initiatives in the construction industries while identifying their best practices and their shortcomings. This will pave the way to studying and identifying the construction industry key financial and operational metrics to be used in this benchmarking research. Hence, in this chapter, we will first discuss the concept of benchmarking, examine its benefits and its limitations, and study previously developed construction industry benchmarking models to draw some insights into the performance measures and metrics that should be included in this benchmarking study.

2.1 Benchmarking Definition

Camp (1989) defined benchmarking as “the continuous process of measuring products, services, and practices against the toughest competitors or those companies recognized as industry leaders.” The American Productivity and Quality Center (APQC) (1993) described benchmarking as “the practice of being humble enough to admit that someone else is better at something and being able to try to learn how to match and even surpass them at it.” According to the Construction Industry Institute (CII), benchmarking is “a systematic process of measuring one’s performance against results from recognized leaders for the purpose of determining best practices that lead to
superior performance when adapted and implemented” (Hudson 1997). Similarly, other researchers each had their own different version of the definition of benchmarking. All such definitions however were similar in essence, defining benchmarking as an organized and recurring process of evaluating an organization’s performance and comparing it against that of similar organizations in key operational and business activities.

Benchmarking can be classified in several ways. If we are referring to what benchmarking is focused on, it can take the form of process benchmarking, strategic benchmarking, or performance benchmarking. Through process benchmarking, firms focus on understanding and optimizing selected production processes in their businesses rather than on the performance of the firm as whole. Strategic benchmarking on the other hand refers to when organizations study the strategic choices and dispositions, business approaches, and business models of other organizations, compare them to their own, and try to identify ways to improve their own strategic positioning and planning (Išoraite 2004). As for performance benchmarking, it corresponds to when corporations compare their performance data, i.e. how well they’re doing in terms of outcomes, against that of other corporations with the goal of learning from the best in class and improving their own processes (Luu, Kim, and Huynh 2008).

Whether it is process benchmarking, strategic benchmarking, or performance benchmarking, it can be applied either internally or externally. Internal benchmarking refers to when an organization collects data pertaining to its own performance and performs comparisons across locations and between years. External benchmarking on the other hand refers to when an organization gauge its own performance against that of its competitors in the same industry (Kozak and Rimmington 1998). That typically requires access to performance data of other companies,
which can be through public financial filings, purchasing industry benchmarking studies, or through forming alliances with noncompetitors, or what is usually referred to as peer groups, to compare performance data and share operational best practices.

2.2 Benefits and Limitations of Benchmarking

Making full use of benchmarking requires first recognizing the benefits and opportunities offered by the benchmarking exercise. The most perceptible benefit of benchmarks is that they enable companies to compare their performance to that pertaining to other firms in the same industry, hence allowing them to identify unusual operating trends, highlight areas of strength, and recognize areas for potential improvement (CLA 2018; Ramirez, Alarcón, and Knights 2004). Benchmarking also leads to the identification of the highest performing contractors, or what we refer to as ‘best in class’, exhibiting exceptional performance due to them adopting best industry practices. This will hence allow firms to adjust their own processes and policies to incorporate these best practices (El-Mashaleh, Minchin, and O’Brien 2007). In fact, the lessons learned from other corporations through the benchmarking process are usually used to promote changes and set improvement plans in an organization (Barber 2004; KPI 2000). Benchmarks can also have a number of indirect benefits. They may serve as motivation for employees for them to establish realistic targets proven to be achievable in other firms (Knuf 2000; McCabe 2001). In addition, they can aid managers in understanding the practices needed to accomplish better performance levels (Camp 1995). In general, the benchmarking process results in continuous learning for both managers and firms, where managers are proactively involved in the whole process instead of depending solely on the results (Barber 2004; Garvin 1993).
With the numerous stated benefits of benchmarking comes a number of limitations. The nature of the construction industry that has always been reluctant to revealing data, along with the considerable fluctuations in productivity, make the benchmarking process in construction intricate and not that straightforward (Zhang, Nasir, and Haas 2017). One of the top limitations of benchmarking is the possibility of inconsistency in collecting data which can subsequently limit to a great extent the usefulness of comparisons (CLA 2018). Benchmarking can be informative only when consistent methods are developed and used to measure the performance of operations. Another challenge that is also related to data collection is the competitive nature of the construction industry that results in creating barriers to data sharing, driving executives to be extremely reluctant to revealing company-specific information that they view as highly confidential. Furthermore, even if companies were willing to share their performance data, time constraints, lack of professional human resources, along with improper management commitment, often form impediments to a successful benchmarking process (Luu, Kim, and Huynh 2008). Another very crucial thing to note is that benchmarking should be utilized as an enhancement tool and not as a way to set targets, as ultimately it is not a magic wand (Lankford 2000). A benchmarking metric should not be used on its own to evaluate a contractor’s operating and financial condition, as variances from benchmarks by themselves may not necessarily result in the best assessment. They should rather be investigated along with the firm’s own operational and financial trend data and in the context of the region in which the firm operates and its specific working structure (CLA 2018). The true value of a benchmarking system comes from identifying the root causes of the difference in performance between an individual company and an industry leader, and this doesn’t happen unless a quantitative benchmarking is accompanied by a qualitative one. The latter is basically a
structured industry questionnaire revealing information on several operational and management dimensions, with the goal of determining the best practices (Ramirez, Alarcón, and Knights 2004). Finally, assuming that all the aforementioned challenges were overcome, benchmarking can only serve its purpose, generating innovation and resulting in performance improvement, if it was undertaken in a receptive environment (Garvin 1993). The creation of such an open environment is usually impeded by the prevalent poor long-term planning and the internal resistance to change within a corporation.

2.3 Benchmarking Initiatives in the Construction industry

The idea of benchmarking originally stemmed from the concept of total quality management (TQM). “Continuous improvement” is one of the key principles of TQM. It requires studying how a process can be changed to increase its efficiency. In order to verify that an improvement occurred however, the performance of a process should be measurable. According to Oswald and Burati (1992), this is achieved through metrics, which they define as “measurable outcomes that indicate the degree of success in achieving some TQM objective”. Fisher, Miertschin, and Pollock (1995) added that in order to evaluate the degree of success, these measurable outcomes need to be compared to something. Here comes the role of benchmarking, which they defined as the process of identifying the value of the metrics that performance measurements are assessed against.

A literature search revealed that prior to 1992, no research work existed that applied the concept of benchmarking in construction. Several research studies and published articles back then focused on TQM and the concept of performance measurement in the construction industry, none of them however was dedicated to establishing benchmarked standards for the construction
industry. Motivated by the fact that there weren’t any organizations dedicated for collecting construction performance data and establishing benchmarks, the Houston Business Roundtable (HBR) formed in early 1992 a benchmark task force, consisting of a group of contractors and owners, to gauge the interest of construction companies in benchmarking, come up with a benchmarking methodology, and implement it (El-Mashaleh, Minchin, and O’Brien 2007). The HBR task force later found that the engineering-procurement-construction (EPC) community has a strong interest in benchmarking and that they were ready to share data (Fisher, Miertschin, and Pollock 1995). Subsequently, in 1995, they published the first benchmarking model applied to the construction industry. Benchmarks for actual versus authorized costs, actual versus target schedule, actual versus estimated construction labor, and change orders versus original authorized cost were developed based on data from 567 projects, collected from 17 companies.

In 1995, CII established the CII Benchmarking and Metrics (BM&M) program with the main goal of providing self-assessment tools to member companies (CII n.d.). Under the guidance of the BM&M committee, Hudson (1997) performed a benchmarking research, titled “Benchmarking Construction Project Execution”, studying numerous project performance measures and associated metrics, such as project cost growth, project schedule growth, recordable incident rate, and total field rework, among others. Industry norms and benchmarks for a number of metrics developed by Hudson were published in the 2002 Benchmarking and Metrics summary report by the CII BM&M committee. The report was compiled based on a database of 1,037 projects that was collected using a paper-based questionnaire. Since then, the CII BM&M program continued collecting project data on an on-going basis via a web-based questionnaire, where each participating company inputs project data and updates it online over the lifecycle of the project.
Participating companies in turn can compare the performance of their projects to the rest of the projects in the database through web-generated reports showing metrics scores, performance quartiles, and graphical representation of project performance overtime. The key benefits of the program, as reported by participating companies, are the cost-effectiveness of the system for benchmarking projects, consistency of performance measures and metrics, and the identification of the industry norms for several performance metrics that were previously unavailable (Costa et al. 2006). Some challenges were reported as well by participating companies and by CII. Companies suffer from the lack of trained human resources needed for inputting project data and studying the system-generated reports. CII, on the other hand, report that the success of the program significantly depends on the corporate commitment of organizations to improvement through benchmarking and implementing the best practices. In addition to a web-based benchmarking system, CII also established Benchmarking Platforms where participants and experts share and discuss the best construction practices and how to implement them.

In 1998, the Construction Best Practice Programme (CBPP) established the construction industry Key Performance Indicators (KPIs) in the United Kingdom, while being supported by national and regional offices of the British government. The initial group of KPIs was developed by a team of construction experts upon an extensive study of construction projects. In 2003, the Construction Excellence was formed upon the merge of the CBPP, Reading Construction Forum, Design Build Foundation, Movement for Innovation, Local Government Task Force, Rethinking Construction, BE, and Construction Clients Group (Construction Excellence n.d.). Ever since then, performance measurement through KPIs and benchmarking has been one of the Construction Excellence core missions. Collecting project data from owners, contractors, subcontractors, and
consultants covering KPIs, such as profitability, safety, client satisfaction, and environmental protection, the Construction Excellence publishes annually the UK Industry Performance Report. The latter maps trends and sets construction industry benchmarks, enabling corporations to evaluate their performance against these benchmarks, identify areas that need improvement, and boost their performance, hence improving the service they provide to their clients and increasing their profitability (The KPI Team 2018). Similar to the CII BM&M program, data is collected through an online software, where each participating company inputs and updates data about its projects using a support handbook that guides its performance measurement. The software in turn analyzes the company’s data against a large sample across the industry.

In 2001, with the support of the Program for Excellence in Production Management of Pontificia Universidad Catolica de Chile, the Corporation for Technical Development (CDT) of the Chilean Chamber of Construction developed the National Benchmarking System for the Chilean construction industry (Markovi et al. 2011). The main goal behind the system was to develop and implement performance measurement in the construction industry. Upon extensive empirical research and literature review (Alarcón and Serpell 1996; Grillo 1997), a set of performance indicators was selected to be part of the benchmarking system, which includes deviation of cost by project, deviation of construction due date, accident rate, client cost complaints, and urgent orders, among others (Markovi et al. 2011). Participating companies would input their data to a computer software that performs performance comparisons using quantitative tools, such as ranking curves, mean, and radar graphs, among others (Costa et al. 2006). To complement the quantitative performance indicators, an evaluation system for managerial practices was later added to the benchmarking initiative. The system collected qualitative data with
the goal of comparing management practices and identifying correlations among performance data using analysis techniques such as factor analysis, multivariate linear regression, and Pearson’s correlation (Ramirez, Alarcón, and Knights 2004). Similar to other benchmarking programs, Chilean companies participating in the program reported facing difficulties as most of them lacked an internal well-structured performance measurement system. This was especially common with the absence of an external demand for performance measurement in Chile, such as industry-wide qualification systems or quality management systems for public clients which were implemented in other countries. Aside from performance measurement, another independent initiative was carried out by the program in Chile; it aimed to form benchmarking clubs consisting of sets of companies conducting meetings and site visits for the purpose of sharing their best practices. Participating companies considered sharing and discussing managerial practices and challenges with other similar companies as an opportunity to learn through real-world experiences, which they believed was more efficient than learning through measures only (Costa et al. 2006).

In 2004, the SISIND-Net Project was launched in Brazil which aims to develop and implement a performance measurement system for benchmarking the Brazilian construction industry. The project was initiated by the Building Innovation Research Unit (NORIE) of the Federal University of Rio Grande do Sul (UFRGS) and the Association of Building Contractors of the State of Rio Grande do Sul (SINDUSCON/RS), with the support of the National Council for Scientific and Technological Development (CNPq) (Markovi et al. 2011). For selecting and defining the metrics to be included in the benchmarking system, the three previous international experiences, namely CII, KPI, and CDT in the US, UK, and Chile respectively, were used as a starting point, along with previous research conducted in Brazil. Ten indicators were chosen,
including cost deviation, time deviation, supplier performance, PPC (percentage of plan completed), non-conformity index for critical processes, and sales time, among others (Marković et al. 2011). Member companies input their data to the project website which they can only use to access graphs and reports derived from the database. Some of the SISIND-Net Project problems identified by Formoso and Lantelme (2000) include the lack of human resources dedicated for performance measurement in companies along with their lack of training, and that companies track certain metrics that are not associated with critical processes only due to the fact that they are not difficult to track. According to Costa et al. (2004), the challenges affecting the effectiveness of the SISIND-Net Project are related to the centralization of the data collection and analysis, ineffective communication and explanation of results, and the limited use of performance measures in the companies’ strategic decision making.

Most of the aforementioned benchmarking models share common shortcomings, especially when the goal is to measure the overall performance of a company from a business perspective. According to (El-Mashaleh, Minchin, and O’Brien 2007; Kagioglou, Cooper, and Aouad 2001), the main limitations of these models are: (1) being project specific, developing project specific benchmarks (e.g. schedule, cost, safety) without providing insight into the overall performance of companies; (2) providing no insight into how a company’s actions, in terms of expended resources and investments, affect its performance; and (3) not measuring the impact of the firm’s management and technological practices on its long-term overall performance.

A more electrical construction industry focused benchmarking initiative has been carried out by the National Electrical Contractors Association (NECA). NECA is the trade association representing the over $171 billion per year U.S. electrical contracting industry, comprising of
electrical contractors working in all aspects of electrical construction. Since 2002, NECA has been publishing an Electrical Contractors Financial Performance Report (FPR) every two years that is based on financial and operating data collected from electrical contractors via a confidential survey. Using the FRP, electrical contractors can measure their performance against industry peers comparative by geographic region, volume size, direct cost and payroll cost. It has also been reported that the FRP can been used as a negotiating tool when dealing with change orders and claims or even when showing bonding companies, suppliers, or the IRS that the company conforms to the ‘standard industry practice’ (NECA 2011). The goal is to allow electrical contractors to identify the strengths and weaknesses of their businesses along with detecting opportunities for performance and profitability improvement. Some of the benchmarking metrics included in FRP are: (1) Liquidity, defined as the ratio of the company’s current assets to its current liabilities, which aims to measure the company’s ability to pay its bills using existing cash; (2) Profit On Sales, defined as the ratio of profit before or after tax to the revenue from sales, which indicates the level of return on investment; (3) Return On Assets, defined as the ratio of profit before or after tax to total assets, which shows how successfully the management is using the firm’s assets to generate profit; and (4) Dept To Equity, defined as the ratio of total liabilities to equity, which measures the company’s leverage and how easy for it to borrow money (Norberg-Johnson 2003).

In 2012, NECA announced its collaboration with the Construction Financial Management Association (CFMA) to improve the financial benchmarking of electrical contractors. CFMA is an organization bringing together construction professionals, including general contractors, subcontractors, suppliers, and engineers, and those serving the construction industry, such as sureties, bankers, and public accountants. Since 1989, CFMA has been collecting financial data
from general contractors and subcontractors and publishing an Annual Financial Survey, which contains financial benchmarks used by accounting and surety professionals in the construction industry. This collaboration between NECA and CFMA resulted in an interactive online benchmarking tool, known as NECA Financial Benchmark, which is built upon CFMA proprietary Construction Financial Benchmark and Financial Survey tools (NECA 2012). The goal behind this joint venture was to make the benchmarking process electronic, where participating electrical contractors can input financial information about their firms via a online survey or through an Excel spreadsheet version of the questionnaire. Each participating contractor will receive in turn a Confidential Performance Report (CPR) containing the his firm’s computed financial metrics compared to the industry norms and to other electrical contractors from the same geographic region, with similar legal form of business, and with the same total revenue size using over 20 financial metrics (NECA and CFMA 2019). The report also contains graphical representation of the electrical contracting industry performance trends, along with an assessment of the company’s particular performance. Along with the CRP, participants receive access to online personalized interactive tools that allows peer group comparisons. Another goal behind this agreement was to make the electrical contracting financial benchmarks accessible to sureties and bankers. The Financial Benchmark contained a number of financial metrics that spanned several categories: (1) Liquidity ratios, such as the current liquidity ratio and the working capital turnover; (2) Profitability ratios, such as return on assets, return on equity, and times interest earned; (3) Leverage ratios, such as dept to equity, revenue to equity, and asset turnover; (4) Efficiency ratios, such as average backlog to working capital, average months in backlog, days in accounts receivable, and operating cycle; (5) Productivity ratios, such as revenue per full-time-equivalent
(FTE) employee and gross profit per FTE employee; and (6) Sales measures such as sales growth. The Financial Benchmarker also provides a detailed breakdown of assets and total revenue expressed as percentages and as dollar values.

Aside from trade associations and non-profit organizations, a number of private companies have been carrying out benchmarking initiatives in the recent years. An example of which is, CliftonLarsonAllen, known as CLA, which offers wealth advisory, outsourcing, audit, tax, and consulting services. CLA has been publishing annual construction benchmark reports that are based on the financial information of participating construction companies throughout the U.S. to determine overall industry trends. CLA has also been publishing benchmarking reports that are specific to the electrical and mechanical construction only, based on financial data collected from privately held, owner-operated mechanical and electrical contractors. The studied metrics are mainly financial ratios that include gross profit as a percentage of revenue, pre-tax income as a percentage of revenue, fixed assets to net worth, pre-tax return on equity, debt to equity ratio, working capital turnover, months in backlog, and equipment purchases as a percentage of depreciation expense (CLA 2018; Schrader 2018).

Both of the previously discussed benchmarking initiatives are purely financial, meaning that the metrics studied only involve financial ratios. Such financial benchmarking studies have been common during the recent years especially due to the involvement of surities which care about determining the risk associated with contractors. These initiatives however do not analyze non-financial data, such as contractor’s safety measures, quality of work, customer satisfaction, timely delivery of work, and performance of workers, among others. Tracking, analyzing, and creating benchmarks for such non-financial data, combined with financial benchmarking, can be
significantly beneficial to a contractor pursuing his or her growth strategy (Ruther 2018). In addition to that, these initiatives only collect and analyze quantitative data, without gathering any qualitative data pertaining to the technology use, labor management, material management, and other important practices and factors that affect the overall company performance.
3 Chapter 3. Data Description

Following the study of the past and current benchmarking initiatives in the construction industry in general and in the electrical contracting sector in specific, identification of the quantitative benchmarking metrics that will be included in this study, along with the qualitative data regarding contractors practices, was carried out. Hence, the first part of this chapter will present and explain the financial and non-financial metrics that are used in this benchmarking study and the technological and managerial factors that were collected to determine contractors’ best practices. And since it is highly significant to know the characteristics of the dataset before drawing conclusions out of the analysis results, the second part of this chapter will provide general description of the electrical contracting companies participating in this research and included in the studied dataset. The questionnaire that was used in the data collection phase is presented in Appendix B.

3.1 Data Variables

3.1.1 Quantitative Benchmarking Metrics

The first part of the research questionnaire filled by participating electrical contractors in this study included a set of 30 numerical variables, presented in Table 1 below, inputted for every year. These variables were used to calculate 23 benchmarking metrics that were chosen on the basis of the review of previous benchmarking initiatives, the advice from electrical construction industry collaborators, and the need to cover both financial and non-financial aspects of companies’ performance. The benchmarking metrics cover the areas of: General Benchmarks, Overall Productivity Measurement, Overall Cost Effectiveness, Staffing, Safety, and Business
Sustainability. It should be noted that some of the 30 variables were added to the questionnaire as a verification tool that the data inputted by contractors is accurate and is what we are asking for.

Table 1 Quantitative Variables in the Study Questionnaire

<table>
<thead>
<tr>
<th>Variable Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Revenue</td>
</tr>
<tr>
<td>Total Expenses of the Company</td>
</tr>
<tr>
<td>Total Cost of Materials Purchased by Your Organization</td>
</tr>
<tr>
<td>Total Payments Disbursed to Subcontractors</td>
</tr>
<tr>
<td>Prefabrication (%)</td>
</tr>
<tr>
<td>Paid Overtime Premium</td>
</tr>
<tr>
<td>Paid Second Shift Premium</td>
</tr>
<tr>
<td>Paid Double Time Premium</td>
</tr>
<tr>
<td>Total Man-Hours Expended of Bargaining Unit Employees (BUE)</td>
</tr>
<tr>
<td>Total Man-Hours Estimated of BUE (Including Approved Change Order Hours)</td>
</tr>
<tr>
<td>Average Full Time Equivalent (FTE) of BUE</td>
</tr>
<tr>
<td>Average Number of Hours Worked by BUE per Week</td>
</tr>
<tr>
<td>Actual/Approximate Turnover Rate of BUE (%)</td>
</tr>
<tr>
<td>Sub-journeymen to Journeymen Ratio (Actual Ratio)</td>
</tr>
<tr>
<td>Journeymen to (Foremen or General Foremen or Superintendent) Ratio (Actual Ratio)</td>
</tr>
<tr>
<td>Total Cost of BUE</td>
</tr>
<tr>
<td>Total Number of FTE of Project Managers/Executives</td>
</tr>
<tr>
<td>Total Cost of Project Managers/Executives</td>
</tr>
<tr>
<td>Total number of FTE of Project Engineers</td>
</tr>
<tr>
<td>Total Cost of Project Engineers</td>
</tr>
<tr>
<td>Fixed (Company) Overhead</td>
</tr>
<tr>
<td>Variable Overhead</td>
</tr>
<tr>
<td>Repeat Business Customers (%)</td>
</tr>
<tr>
<td>Warranty Issues Cost (%)</td>
</tr>
<tr>
<td>OSHA Recordable Incident Rate</td>
</tr>
<tr>
<td>Actual/Approximate Hit Rate</td>
</tr>
<tr>
<td>Gross Profit (%)</td>
</tr>
<tr>
<td>Net Profit (%)</td>
</tr>
</tbody>
</table>
In this section, the financial and non-financial benchmarking metrics will be defined and explained, along with the variables used to calculate them.

### 3.1.1.1 General Benchmarks

#### 3.1.1.1.1 Net Profit Percentage

A key ratio of profitability is net profit percentage which represents the percent of total revenue from construction projects that the company retains after incurring all expenses of the year in question. In other words, it represents how much money a company takes away from every dollar earned. Hence, it is one of the most critical metrics to gauge a company’s financial health and when comparing it to other companies in the same industry.

Companies had to input the dollar value of their total revenue from construction projects, along with the dollar value of their net profit before tax deductions. The latter was used to eliminate data discrepancies due to tax differences between states. Hence, the net profit percentage was computed as follows:

\[
Net\ Profit\ Percentage = \frac{Net\ Profit}{Total\ Revenue\ from\ Construction\ Projects} \times 100
\]

#### 3.1.1.1.2 Gross Profit Percentage

Another ratio of profitability is gross profit percentage which represents the percent of total revenue from construction projects that the company retains after incurring all direct costs of the year in question, consisting of the cost of labor, equipment, materials, and subcontractors. In other words, it represents how much money a company retains for other operating expenses and net
profit. Hence, it measures how well a company controls its costs and efficiently utilizes its resources, materials, and labor.

Companies had to input the dollar value of their gross profit which was used along with the inputted dollar value of total revenue from construction projects to compute the gross profit percentage as follows:

\[
\text{Gross Profit Percentage} = \frac{\text{Gross Profit}}{\text{Total Revenue from Construction Projects}} \times 100
\]

3.1.1.3 Overhead Percentage

Overhead percentage represents the percent of total revenue from construction projects that the company’s total overhead represents, which consists of the fixed, also known as general and administrative (G and A) expense, and variable overheads. Fixed overhead is defined as the set of costs that do not vary as a result of change in workload. These costs are needed in order to operate the business. Some examples of fixed overheads are administrative-personnel salaries, accounting personnel salaries, office personnel salaries, office expenses, company insurance, real estate expenses, etc. Variable overhead on the other hand is defined as the set of costs that are not discretely charged to a specific project and tend to vary depending on the revenue of the company. Maintaining efficiency in a company’s variable and fixed overhead spending relative to its revenue growth provides it with a key competitive advantage over its peers and is often a key determinant of a growing net profit.

Overhead percentage is impacted by how the company allocates project management personnel payroll between overhead and direct labor cost. Hence, to avoid any data discrepancies, companies had to input the dollar value of their fixed and variable overheads excluding project
management costs. The reported overheads dollar values were used along with the inputted dollar value of total revenue from construction projects to compute the overhead percentage as follows:

\[
Overhead\ Percentage = \frac{Fixed\ Overhead + Variable\ Overhead}{Total\ Revenue\ from\ Construction\ Projects} \times 100
\]

3.1.1.4 Hit Rate

Bidding and negotiating new projects impose on contractors the time and money associated with estimating, marketing, public relations, and customer development. Hence, contractors have to be strategic when deciding which projects and how many to invest their estimating dollars in. Here comes the role of keeping track of the winning rate at which a contractor successfully bids on projects. However, instead of using a “Bid-Hit” ratio, which is the number of projects a contractor wins divided by the total number of projects bade for, hit rate was chosen to be included in this benchmarking study. Hit rate is a measure of how successful a contractor’s bidding process is; it represents the ratio of dollars awarded to the company to the dollars bade for, with regards to construction projects only. It is a more robust metric than the Bid-Hit ratio which is highly dependent on the contract size. Given the definition of hit rate, companies had to input it directly as a percentage.

3.1.1.5 Cost of Purchased Materials as Percentage of Total Revenues

From bulk-purchase items such as conductors to highly sophisticated control, communication, and power equipment, materials used by electrical contractors present a major portion of their direct construction costs, hence highly affecting their profit. This means that even a slight increase in material prices can directly reduce contractors’ net profit. Over the past few years, electrical contractors have been facing rising prices of materials as a result of the decrease
in the supply of the commodities – e.g. steel, copper, aluminum, and petroleum – that are used to manufacture electrical construction products and the fierce competition over them. Another significant factor affecting electrical material costs and availability are governments policies with regards to tariffs and international trade restrictions which are indirectly resulting in fluctuating profit margins in contracting companies. Having a benchmark for material spending provides an electrical contractor with insights on where its company stands compared to the rest of the industry and if material cost control is needed.

In the questionnaire, companies had to input the total cost of materials purchased by the company which was used along with the inputted dollar value of total revenue from construction projects to compute cost of purchased materials as percentage total revenues as follows:

\[
\text{Cost of Purchased Materials as Percentage Total Revenues} = \frac{\text{Total Cost of Materials Purchased}}{\text{Total Revenue from Construction Projects}} \times 100
\]

3.1.1.6 Cost of Subcontracting as Percentage of Total Revenues

Although serving as subcontractors on most of their projects, some electrical contractors subcontract part of their work resulting in subcontract costs as one of the main constituents of their direct costs. With that, knowing the industry average cost of subcontracting as a percentage of total revenues helps companies gauge where they stand in terms of the amount of work they are subcontracting.

In the questionnaire, companies had to input the total payments disbursed to subcontractors which was used along with the inputted dollar value of total revenue from construction projects to compute cost of subcontracting as percentage total revenues as follows:
Cost of Subcontracting as Percentage Total Revenues

\[
\text{Cost of Subcontracting as Percentage Total Revenues} = \frac{\text{Total Payments Disbursed to Subcontractors}}{\text{Total Revenue from Construction Projects}} \times 100
\]

3.1.1.2 Overall Productivity Measurement – Analysis by FTE

With the electrical contracting industry being classified among the most labor-intensive, tracking and analyzing labor productivity becomes essential, as any change in labor productivity can largely impact contractor’s profit. Furthermore, having productivity benchmarks can serve as a tool that contractors can use for productivity planning and goal setting. One of the popular methods to gauge overall labor productivity and the efficiency of organizations is analysis by full-time-equivalent (FTE). The latter is a unit of measurement that is used as an indication of the workload of an employed person, so that a fully employed person is 1 FTE, whereas a person who works half the normal load is 0.5 FTE.

The productivity analysis by FTE in this study was segmented by the type of labor, i.e. project management personnel and bargaining unit employees (BUE). Project management personnel correspond to both project managers/executives and to project engineers. BUE correspond to craft workers, which include apprentices, journeymen, foremen, prefab shop workers (if any), material handlers (if any), construction wiremen (if any), etc. Benchmarks for each of the two listed labor types were established to help companies diagnose problems and apply solutions at each labor level. For example, companies can use the developed benchmarks to get an idea about how much money each type of employee ought to bring to the company and if they have more or less than needed employees serving in specific roles. Metrics that were used in the FTE analysis included revenue per FTE, net profit per FTE, and dollar value added per FTE.
Revenue per FTE serves as a metric that gives companies an idea of how much revenue each employee should generate to the company, similarly for net profit per FTE. Value added per FTE on the other hand is based on the concept of total accrued value added (TAVA), a company-level labor productivity metric introduced by Rojas (2008) in his book that explores construction productivity at the level of building and electrical contractors. TAVA is defined as the total revenue minus both cost of materials purchased by the company and payments disbursed to subcontractors. Material costs and subcontracting costs are removed from the total revenue generated by a contracting company to allow for a more consistent comparison between companies which might be using different organizational and financial strategies in the way they execute work. For example, some electrical contractors might be using materials bought and furnished by owners while others might be buying all the materials needed, and some contractors tend to self-perform all their work while others subcontract some installations. Hence, TAVA is used to correct the labor productivity calculation to consider these type of situations, by representing the additional value yielded to a set of materials when they are self-installed in a project (Rojas 2008).

3.1.1.2.1 Revenue per FTE of Project Management Personnel

Companies had to input the total number of FTE of project managers/executives, in addition to the total number of FTE of project engineers. Using the inputted FTE numbers, along with the inputted dollar value of total revenue from construction projects, revenue per FTE of project management personnel was computed as follows:

\[
\text{Revenue per FTE of Project Management Personnel} = \frac{\text{Total Revenue from Construction Projects}}{\text{Number of FTE of Project Engineers} + \text{Number of FTE of Project Managers}}
\]
3.1.1.2.2 Net Profit per FTE of Project Management Personnel

Using the inputted FTE numbers of project managers/executives and project engineers, along with the inputted dollar value of the net profit, net profit per FTE of project management personnel was computed as follows:

\[
Net \text{ Profit per FTE of Project Management Personnel} = \frac{Net \text{ Profit}}{Number \text{ of FTE of Project Engineers} + Number \text{ of FTE of Project Managers}}
\]

3.1.1.2.3 Revenue per FTE of BUE

Companies had to input the average number of FTE of BUE. Using the latter, along with the inputted dollar value of total revenue from construction projects, revenue per FTE of BUE was computed as follows:

\[
Revenue \text{ per FTE of BUE} = \frac{Total \text{ Revenue from Construction Projects}}{Average \text{ Number of FTE of BUE}}
\]

3.1.1.2.4 Net Profit per FTE of BUE

Using the inputted average number of FTE of BUE, along with the inputted dollar value of the net profit, net profit per FTE of BUE was computed as follows:

\[
Net \text{ Profit per FTE of BUE} = \frac{Net \text{ Profit}}{Average \text{ Number of FTE of BUE}}
\]

3.1.1.2.5 Dollar Value Added per FTE of BUE

Using the inputted average number of FTE of BUE, along with the inputted dollar value of total revenue from construction projects, cost of materials purchased, and cost of subcontracting, dollar value added per FTE of BUE was computed as follows:
Dollars Value Added per FTE of BUE

\[
= \frac{\text{Total Revenue from Construction Projects} - \text{Cost of Materials} - \text{Cost of Subcontracting}}{\text{Average Number of FTE of BUE}}
\]

3.1.1.3 Overall Productivity Measurement – Analysis by Hours

Another popular method to measure and track construction labor productivity is analysis by hours. This is especially important when studying the productivity of field workers which are usually paid based on their expanded man-hours. The same metrics that were used in the FTE analysis were also used in the analysis by hours, namely revenue per hour, net profit per hour, and value-added per hour. It should be noted that the analysis by hours was only done for BUEs and not for project management personnel since the latter are not usually paid per hour, they have fixed wages instead.

3.1.1.3.1 Revenue per Hours of BUE

Companies had to input the total man-hours expended of BUE. Using the latter, along with the inputted dollar value of total revenue from construction projects, revenue per hours of BUE was computed as follows:

\[
\text{Revenue per Hours of BUE} = \frac{\text{Total Revenue from Construction Projects}}{\text{Total Man } - \text{Hours Expended of BUE}}
\]

3.1.1.3.2 Net Profit per Hours of BUE

Using the inputted total man-hours expended of BUE, along with the inputted dollar value of the net profit, net profit per hours of BUE was computed as follows:

\[
\text{Net Profit per Hours of BUE} = \frac{\text{Net Profit}}{\text{Total Man } - \text{Hours Expended of BUE}}
\]
3.1.1.3.3 Dollar Value Added per Hours of BUE

Using the inputted total man-hours expended of BUE, along with the inputted dollar value of total revenue from construction projects, cost of materials purchased, and cost of subcontracting, dollar value added per hours of BUE was computed as follows:

\[
\text{Dollar Value Added per Hours of BUE} = \frac{\text{Total Revenue from Construction Projects} - \text{Cost of Materials} - \text{Cost of Subcontracting}}{\text{Total Man - Hours Expended of BUE}}
\]

3.1.1.4 Overall Cost Effectiveness

Another used method to method labor productivity is through doing a cost analysis. It basically resembles the inverse of a cost-benefit analysis where the revenue, net profit, or value added represents the benefit component, and project management costs or BUE costs represent the cost component.

3.1.1.4.1 Revenue per Cost of Project Management Personnel

Companies had to input the total cost of project managers/executives, in addition to the total cost of project engineers. Using the inputted cost numbers, along with the inputted dollar value of total revenue from construction projects, revenue per cost of project management personnel was computed as follows:

\[
\text{Revenue per Cost of Project Management Personnel} = \frac{\text{Total Revenue from Construction Projects}}{\text{Total Cost of Project Engineers} + \text{Total Cost of Project Managers}}
\]
3.1.1.4.2 Net Profit per Cost of Project Management Personnel

Using the inputted cost values of project managers/executives and project engineers, along with the inputted dollar value of the net profit, net profit per cost of project management personnel was computed as follows:

\[
\text{Net Profit per cost of Project Management Personnel} = \frac{\text{Net Profit}}{\text{Total Cost of Project Engineers} + \text{Total Cost of Project Managers}}
\]

3.1.1.4.3 Revenue per Cost of BUE

Companies had to input the total cost of BUE. Using the latter, along with the inputted dollar value of total revenue from construction projects, revenue per cost of BUE was computed as follows:

\[
\text{Revenue per Cost of BUE} = \frac{\text{Total Revenue from Construction Projects}}{\text{Total Cost of BUE}}
\]

3.1.1.4.4 Net Profit per Cost of BUE

Using the inputted total cost of BUE, along with the inputted dollar value of the net profit, net profit per cost of BUE was computed as follows:

\[
\text{Net Profit per Cost of BUE} = \frac{\text{Net Profit}}{\text{Total Cost of BUE}}
\]

3.1.1.4.5 Dollar Value Added per Cost of BUE

Using the inputted total cost of BUE, along with the inputted dollar value of total revenue from construction projects, cost of materials purchased, and cost of subcontracting, dollar value added per cost of BUE was computed as follows:
Dollar Value Added per Cost of BUE

\[
\text{Dollar Value Added per Cost of BUE} = \frac{\text{Total Revenue from Construction Projects} - \text{Cost of Materials} - \text{Cost of Subcontracting}}{\text{Total Cost of BUE}}
\]

3.1.1.5 Staffing

As stated earlier, labor productivity loss can have detrimental effects on electrical contractors due to the labor-intensive nature of the electrical construction industry. With that in mind, factors affecting labor productivity are essential to be included in a benchmarking initiative for the electrical construction industry. Turnover, i.e. workers leaving for jobs elsewhere, is one of these factors that usually receive little attention, yet lead to considerable costs that companies accrue (Hanna 2006). Being able to know where it stands with respect to the rest of the electrical contracting industry in terms of turnover, an electrical contracting company can identify if it has a labor problem and would accordingly work on implementing practices to mitigate these behaviors. Another staffing benchmarking metric that also affect the productivity and profitability of workers is the ratio of their cost relative to one another. This metric can be used by companies to determine if they are overstaffing project management personnel relative to the available BUE and the opposite.

3.1.1.5.1 Turnover Rate of BUE

Turnover rate of BUE represents the total number of separations of BUE that occurred during the year as a percentage of the average number of BUE during that year. Given the definition of turnover rate, companies had to input it directly as a percentage.
3.1.1.5.2 Cost of Project Management Personnel per Cost of BUE

Using the inputted cost values of project managers/executives and project engineers, along with the inputted total cost of BUE, cost of project management personnel per cost of BUE was computed as follows:

\[
\text{Cost of Project Management Personnel per Cost of BUE} = \frac{\text{Total Cost of Project Engineers} + \text{Total Cost of Project Managers}}{\text{Total Cost of BUE}}
\]

3.1.1.6 Safety

Sited as one of construction’s “Fatal Four”, electrocution accounts for 8.5% of the construction worker deaths in 2018 (OSHA n.d.). With that in mind, safety must be an integral concern to electrical contractors. OSHA Recordable Incident Rate was used as the safety metric in this benchmarking study. By tracking and analyzing its safety performance, an electrical contracting company can identify what types of job site safety programs, trainings, mentoring, and policies it needs to enact and implement.

3.1.1.6.1 OSHA Recordable Incident Rate

OSHA Recordable Incident Rate is a mathematical calculation that describes the number of employees per 100 full-time employees that have been involved in a recordable injury or illness. OSHA recordable incident rate was defined in the questionnaire as the number of OSHA recordable cases multiplied by 200,000, and then divided by the total expended man-hours of BUE. The 200,000 figure is a standard base rate to make the calculations comparable across the industry. It refers to 100 workers, working 40 hours per week, 50 weeks per year (OSHA n.d.). Given this definition, companies had to input their calculated recordable incident rate directly.
3.1.1.7 Customer Satisfaction/ Business Sustainability

In an increasingly competitive market, greater attention needs to be placed on company-client relationships. Customer satisfaction provides contracting companies with a sustainable advantage that differentiates them from the rest of the market players, as it is the key to clients’ loyalty and retention and the foundation for long-term financial performance. Customer satisfaction has also been considered to be an indicator of quality. With all that, it was vital to include some parameters in this benchmarking study to measure the level of customer satisfaction in electrical contracting companies.

3.1.1.7.1 Repeat Business Customers

Repeat business customers refers to the percentage of customers who come back for a repeat business with the firm, regarding non-competitive bid work only. It is an indication of how satisfied customers are, driving them to repeat business with the same company. In fact, a study by the Harvard Business Review (Reichheld 2003) shows that the percentage of customers who are extremely likely to recommend the company to other customers is strongly correlated to the company’s growth rate. Adding to that, a high repeat business percentage would decrease the money that a company spends on new client acquisition which includes costs associated with marketing business development efforts.

Given this definition, companies had to input in the questionnaire their calculated repeat business customers percentage directly.
3.1.2 Qualitative Factors and Practices

The second part of the research questionnaire filled by participating electrical contractors in this study is dedicated for qualitative factors and current companies’ practices which will thereafter be used to identify the best practices of electrical contracting companies. These practices were chosen based on a literature review of current construction best practices and based on extensive input from industry collaborators via interviews with electrical contracting companies’ CEOs. Overall, the practices identified spanned 6 categories, namely prefabrication, technology use, labor management, material management, quality management and evaluation, and productivity and management practices, as presented in Table 2 below. While filling the questionnaire, companies had to indicate if they applied each of the listed practices or not, i.e. binary scale (yes or not) was used. It should be noted that the research questionnaire included a few other factors that were not used in the analysis and were hence not presented in Table 2.
<table>
<thead>
<tr>
<th>Table 2 Qualitative Variables in the Study Questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prefabrication</strong></td>
</tr>
<tr>
<td>Own a dedicated prefabrication shop or not</td>
</tr>
<tr>
<td>Prefabrication performed at the company or outsourced</td>
</tr>
<tr>
<td><strong>Technology Use</strong></td>
</tr>
<tr>
<td>BIM use or not</td>
</tr>
<tr>
<td>Field workers/foreman using tablets or not</td>
</tr>
<tr>
<td>Use of 3D printing or not</td>
</tr>
<tr>
<td>Use of 3D scanning or not</td>
</tr>
<tr>
<td>Use of Augmented Reality (AR) / Virtual Reality (VR) or not</td>
</tr>
<tr>
<td>Use of Drones or not</td>
</tr>
<tr>
<td>Use of Artificial Intelligence (AI) or not</td>
</tr>
<tr>
<td><strong>Labor Management</strong></td>
</tr>
<tr>
<td>Use of differed compensation plan (golden handcuffs) for key personnel or not</td>
</tr>
<tr>
<td>Use of incentives for foreman/superintendents based on their labor savings or not</td>
</tr>
<tr>
<td>Use of regular evaluation of the performance of the boards and the directors or not</td>
</tr>
<tr>
<td>Use of management trainings or not</td>
</tr>
<tr>
<td>Use of project management training for field management staff or not</td>
</tr>
<tr>
<td>Use of labor relation training for field management staff or not</td>
</tr>
<tr>
<td>Use of business management training for management staff</td>
</tr>
<tr>
<td>Use of leadership and communication training for field management staff or not</td>
</tr>
<tr>
<td>Use of interpersonal development training for field management staff or not</td>
</tr>
<tr>
<td><strong>Material Management</strong></td>
</tr>
<tr>
<td>Number of vendors is less than 5 or more than 5</td>
</tr>
<tr>
<td>Vendor integration in ordering, delivering, and handling materials via a strategic alliance or not</td>
</tr>
<tr>
<td><strong>Quality Management and Evaluation</strong></td>
</tr>
<tr>
<td>Documenting lessons learned from every project or not</td>
</tr>
<tr>
<td>Is the company part of a peer group or not</td>
</tr>
<tr>
<td><strong>Productivity and Management Practices</strong></td>
</tr>
<tr>
<td>Tracking productivity and percent complete via tracking earned hours, estimated hours, and actual hours at the activity level or not</td>
</tr>
<tr>
<td>Use of lean construction or not</td>
</tr>
<tr>
<td>Use of 80-20 program or not</td>
</tr>
<tr>
<td>Use of dedicated estimating staff or not</td>
</tr>
<tr>
<td>Use of dedicated business development personnel or not</td>
</tr>
<tr>
<td>Use of dedicated logistics planning personnel or not</td>
</tr>
<tr>
<td>Use of dedicated operational risk management (ORM) personnel or not</td>
</tr>
<tr>
<td>Use of dedicated productivity improvement personnel or not</td>
</tr>
<tr>
<td>Teaming up with other companies to increase bonding capacity or not</td>
</tr>
</tbody>
</table>
3.2 Dataset Characteristics

As discussed earlier, one of the major challenges of a benchmarking initiative is the reluctance of company executives to share company-specific information that they view as highly confidential. This made the data collection effort in this study not an easy task. However, generous collaborators from the electrical construction industry showed interest and strong support to the initiative allowing the collection of data from 28 electrical contracting companies. The collaborators commitment facilitated the thorough gathering of financial and non-financial data, along with technological and managerial practices, corresponding to all participating companies across the years 2011 through 2018.

3.2.1 Geographic Location

Participating electric contracting companies are located across the U.S. and Canada, with their headquarters across 11 states and two Canada regions as depicted in Figure 4 below.
Figure 4 Map Showing Geographic Region of Participating Companies’ Headquarters

There was no specific preference to a particular location or region, such that the locations of the participating companies were randomly distributed across the five U.S. regions and Canada as shown in Figure 5 below.
3.2.2 Firm Size

The dataset included smaller sized firms with annual total revenue under $25 Million, mid-sized firms with annual total revenue between $25 Million and $100 Million, and large firms with annual total revenue exceeding $100 Million, as shown in Figure 6 below. The majority of the participating companies (56%) have an annual total revenue between $25 Million and $100 Million.
3.2.3 Form of Work

The form of work carried out by participating companies ranged between bidding work, i.e. new construction with plans and specs, service work, i.e. repairs and upgrades/retrofitting, and negotiated contracts. Figure 7 below shows the distribution of the revenues of participating companies by form of work carried out, with the majority of revenue coming from bidding work.
3.2.4 Delivery Method

The delivery methods used by participating companies ranged between the traditional Design-Bid-Build, Design-Build with in-house design team, Design-Build with a joint venture with the design firm, Design-Assist, and Integrated Project Delivery, among others. Figure 8 below shows the distribution of the revenues of participating companies by the delivery method used, with the majority of revenue coming from Design-Bid-Build work.

![Figure 7 Distribution of Revenue by Form of Work](image)
3.2.5 Company Role

The main roles of participating companies ranged between the being the Sub-contractor, Prime Contractor, Separate Prime with a lead contractor (GC/CM), and Sub-sub-contractor. Figure 9 below shows the distribution of the revenues of participating companies by company role played, with the majority of revenue coming from being the Sub-contractor on a project.
3.2.6 Market Sector

The work of participating companies covers a wide range of market sectors, including institutional, commercial, industrial, data centers, K-12, residential, water/waste/water treatment, and heavy civil work, among others. Figure 10 below shows the distribution of the revenues of participating companies by market sector, with the majority of revenue coming from institutional facilities type of market.
3.2.7 Type of Work

The type of work performed by participating companies ranged between traditional electrical work, i.e. power/lighting, low-voltage, e.g. fire systems, security systems, sound, video, and communication systems, and instrumentation, and transmission power line and substations, among others. Figure 11 below shows the distribution of the revenues of participating companies by type of work performed, with the majority of revenue coming from traditional electrical work.
Figure 11 Distribution of Revenue by Type of Work

Electrical Work 81%

Low-Voltage 13%

Transmission Power Line and Substations 5%

Other 1%
4 Chapter 4. Data Analysis

Chapter 3 presented and explained the quantitative metrics and the qualitative factors used in this research. This chapter presents the analysis of the collected data; more specifically the presentation of the established quantitative benchmarks and the investigation of the effect of the company practices on their performance to identify the most significant practices of electrical contracting companies.

4.1 Quantitative Benchmarks

To represent the quantitative benchmarking data, boxplots were used. A boxplot or box and whisker plot, as illustrated in Figure 12 below, is a non-parametric graphical representation for continuous datasets. It divides the dataset into 4 quartiles, with the median (50th percentile) being the measure of central tendency represented by a thick black line. The height of the box, or the distance between the 25th and 75th percentiles, represents what is known as the Interquartile Range (IQR), which depicts the dispersion or spread of the dataset. The whiskers in the plot each represent 25% of the data on either end. Boxplots have been commonly used in benchmarking as they are clear, self-explanatory, and easily interpretable.
Figure 12 Boxplot Illustration

- Median (50\textsuperscript{th} percentile)
- Mean (average)
- 25\textsuperscript{th} percentile
- 75\textsuperscript{th} percentile
- Limits of normal range
4.1.1 General Benchmarks

4.1.1.1 Net Profit Percentage

Table 3 Net Profit Percentage Descriptive Statistics

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>5.12%</td>
<td>4.50%</td>
<td>5.00%</td>
<td>5.48%</td>
<td>8.18%</td>
<td>8.33%</td>
<td>8.98%</td>
<td>9.98%</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>4.27%</td>
<td>3.71%</td>
<td>2.80%</td>
<td>3.78%</td>
<td>4.00%</td>
<td>3.48%</td>
<td>4.88%</td>
<td>6.08%</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>1.71%</td>
<td>1.30%</td>
<td>1.50%</td>
<td>1.88%</td>
<td>1.36%</td>
<td>1.97%</td>
<td>1.88%</td>
<td>2.72%</td>
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<tr>
<td>Mean (Average)</td>
<td>4.85%</td>
<td>4.16%</td>
<td>3.59%</td>
<td>4.22%</td>
<td>4.86%</td>
<td>4.93%</td>
<td>5.61%</td>
<td>6.11%</td>
</tr>
</tbody>
</table>
The higher the net profit, the more return offered to the owners or reinvested in the company. As shown in Figure 13 above, the net profit reported by electrical contracting companies over the years is centered around 5%, with each year showing a slight decrease or increase in the trend, noting that a steady increase has been seen in the last three years. The lowest net profit reported is -2.5%, signaling a net loss for the company which needs to make major changes in the way it operates in order to stay in business. While some companies reported for some years a net profit percentage exceeding 10%, this represents a rare case and not the norm for profitability in the electrical contracting industry.
4.1.1.2 Gross Profit Percentage

Figure 14 Gross Profit Percentage Boxplots

Table 4 Gross Profit Percentage Descriptive Statistics

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>18.69%</td>
<td>18.80%</td>
<td>19.39%</td>
<td>17.53%</td>
<td>20.90%</td>
<td>21.54%</td>
<td>21.10%</td>
<td>19.65%</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>15.99%</td>
<td>15.88%</td>
<td>14.38%</td>
<td>13.40%</td>
<td>15.30%</td>
<td>19.04%</td>
<td>18.22%</td>
<td>16.74%</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>10.93%</td>
<td>12.93%</td>
<td>11.70%</td>
<td>10.13%</td>
<td>11.64%</td>
<td>15.30%</td>
<td>14.16%</td>
<td>14.64%</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>15.54%</td>
<td>15.84%</td>
<td>15.81%</td>
<td>14.09%</td>
<td>15.78%</td>
<td>18.11%</td>
<td>17.68%</td>
<td>17.33%</td>
</tr>
</tbody>
</table>
The higher the gross profit, the more money left for overhead and net profit. As shown in Figure 14 above, the gross profit reported by electrical contracting companies is relatively centered around 17%, with some fluctuations over the years. It should be noted that a decrease in gross profit percentage was recorded over the last three years. This can generally be attributed to the increase in materials and labor costs, which in turn increases the contractors’ direct costs and hence decreases their gross profit. Some low gross profit percentages have been reported, probably by the same companies reporting net profit losses as shown earlier. The highest reported gross profit percentages exceeded 22%, generally corresponding to the best in class contractors.
4.1.1.3 Overhead Percentage

Figure 15 Overhead Percentage Boxplots

Table 5 Overhead Percentage Descriptive Statistics

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>15.23%</td>
<td>16.65%</td>
<td>16.61%</td>
<td>10.80%</td>
<td>12.71%</td>
<td>12.87%</td>
<td>16.36%</td>
<td>13.94%</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>10.65%</td>
<td>13.57%</td>
<td>12.01%</td>
<td>9.02%</td>
<td>8.49%</td>
<td>10.01%</td>
<td>8.73%</td>
<td>8.80%</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>9.88%</td>
<td>10.54%</td>
<td>10.90%</td>
<td>7.30%</td>
<td>7.88%</td>
<td>8.66%</td>
<td>7.45%</td>
<td>5.09%</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>14.68%</td>
<td>14.09%</td>
<td>14.17%</td>
<td>10.68%</td>
<td>10.44%</td>
<td>10.49%</td>
<td>10.96%</td>
<td>10.03%</td>
</tr>
</tbody>
</table>
Overhead percentages can immensely affect a company’s profitability; reducing overhead costs can offer a company a crucial competitive advantage over its peers. As shown in Figure 15 above, overhead percentage reported by electrical contracting companies is relatively centered around 12%, with minor fluctuations over the years. This figure seems logical as it is the difference between the previously indicated average gross profit (17%) and net profit (5%) percentages. It should be noted that overhead as a percentage of revenue tends to be larger for smaller companies; in addition, companies reporting overhead percentages exceeding 20% probably consider project management personnel costs as overhead and not as part of the direct cost; in other words, they don’t job cost their project management personnel costs.
4.1.1.4 Hit Rate

Figure 16 Hit Rate Boxplots

Table 6 Hit Rate Descriptive Statistics

<table>
<thead>
<tr>
<th>Hit Rate</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>26.16%</td>
<td>35.12%</td>
<td>14.74%</td>
<td>75.06%</td>
<td>41.65%</td>
<td>36.59%</td>
<td>36.30%</td>
<td>35.47%</td>
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<tr>
<td>Median (50th Percentile)</td>
<td>22.11%</td>
<td>35.12%</td>
<td>14.74%</td>
<td>20.80%</td>
<td>23.00%</td>
<td>31.05%</td>
<td>17.40%</td>
<td>27.20%</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>18.05%</td>
<td>35.12%</td>
<td>14.74%</td>
<td>14.50%</td>
<td>15.75%</td>
<td>21.77%</td>
<td>15.25%</td>
<td>16.50%</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>22.11%</td>
<td>35.12%</td>
<td>14.74%</td>
<td>35.66%</td>
<td>31.03%</td>
<td>33.20%</td>
<td>27.94%</td>
<td>30.12%</td>
</tr>
</tbody>
</table>
As shown in Figure 16 above, there is a significant dispersion in the reported hit rate percentages. This is actually predictable as the hit rate is highly dependent on the main form of work a company’s revenue comes from. The reported hit rate values can be grouped into two clusters, the first of which is centered around 15%, which is actually the norm for hard-bid form of work, and the second is centered around 50%, which is common for negotiated jobs. Hence, based on the major form of work a contractor performs, they can check how they stack up with respect to the rest of the industry in terms of hit rate and if their hit rate is actually increasing or decreasing throughout the years.
4.1.1.5 Cost of Purchased Materials as Percentage of Total Revenue

Figure 17 Percentage of Revenue as Cost of Purchased Materials Boxplots

Table 7 Percentage of Revenue as Cost of Purchased Materials Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>75th Percentile</td>
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<td>41.47%</td>
<td>37.17%</td>
<td>33.09%</td>
<td>29.38%</td>
<td>31.37%</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>33.72%</td>
<td>33.03%</td>
<td>33.28%</td>
<td>34.74%</td>
<td>29.44%</td>
<td>27.00%</td>
<td>27.63%</td>
<td>27.04%</td>
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<td>25th Percentile</td>
<td>26.42%</td>
<td>28.83%</td>
<td>26.54%</td>
<td>25.87%</td>
<td>24.89%</td>
<td>25.72%</td>
<td>21.55%</td>
<td>21.14%</td>
</tr>
<tr>
<td>Mean (Average)</td>
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<td>32.97%</td>
<td>33.05%</td>
<td>30.38%</td>
<td>28.76%</td>
<td>25.79%</td>
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</tbody>
</table>
As shown in Figure 17, the cost of materials purchased as a percentage of revenue has been centered around 28%. This has been smaller than the average materials cost for the years before which exceeded 30%. This decrease can be explained by the drop in the price of pipe and tube steel in 2014 (Zarenski 2018) which is a major element used in electrical construction work. However, starting from the summer of 2018, the cost of electrical materials began to rise, as reported by the trade publication Electrical Marketing’s Electrical Price Index (2018). This was mainly driven by tariffs imposed on steel, aluminum, and other installation products and the rising freight prices; and will hence result in an increase in materials cost for electrical contractors in the years following 2018. It should be noted that the very low materials cost as a percentage of revenue shown are probably reported by electrical contracting companies that subcontract most of their work, hence ending up with very little material costs.
4.1.1.6 Cost of Subcontracting as Percentage of Total Revenue

Figure 18 Cost of Subcontracting as Percentage of Total Revenue Boxplots

Table 8 Percentage of Revenue as Cost of Subcontracting Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>7.37%</td>
<td>9.84%</td>
<td>8.24%</td>
<td>12.39%</td>
<td>11.97%</td>
<td>12.17%</td>
<td>12.36%</td>
<td>12.07%</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>6.80%</td>
<td>7.60%</td>
<td>5.56%</td>
<td>5.56%</td>
<td>7.00%</td>
<td>4.61%</td>
<td>4.91%</td>
<td>4.34%</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>2.83%</td>
<td>4.65%</td>
<td>3.93%</td>
<td>3.15%</td>
<td>3.23%</td>
<td>3.21%</td>
<td>3.19%</td>
<td>2.58%</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>6.46%</td>
<td>7.85%</td>
<td>6.90%</td>
<td>6.88%</td>
<td>7.92%</td>
<td>7.33%</td>
<td>7.03%</td>
<td>6.22%</td>
</tr>
</tbody>
</table>
As shown in Figure 18 above, there is a significant dispersion in the reported subcontracting cost as a percentage of total revenue. This is explained by how much work a company decides to self-perform as opposed to subcontract. The average however of the reported subcontracting costs is about 7%.

4.1.2 Overall Productivity Measurement – Analysis by FTE

4.1.2.1 Revenue per FTE of Project Management Personnel

![Figure 19 Revenue per FTE of Project Management Personnel Boxplots](image-url)
Table 9 Revenue per FTE of Project Management Personnel Descriptive Statistics

<table>
<thead>
<tr>
<th>Revenue per FTE of</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>3,360,610</td>
<td>4,196,848</td>
<td>5,841,670</td>
<td>4,575,948</td>
<td>4,260,110</td>
<td>3,516,730</td>
<td>4,036,030</td>
<td>6,633,675</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>2,866,750</td>
<td>3,353,700</td>
<td>3,641,990</td>
<td>2,996,280</td>
<td>3,435,000</td>
<td>3,224,020</td>
<td>2,730,255</td>
<td>4,332,010</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>2,364,260</td>
<td>2,094,510</td>
<td>2,262,332</td>
<td>2,343,248</td>
<td>1,950,360</td>
<td>1,739,775</td>
<td>1,869,055</td>
<td>2,793,158</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>3,627,476</td>
<td>3,467,491</td>
<td>4,458,865</td>
<td>3,802,661</td>
<td>3,894,770</td>
<td>3,111,195</td>
<td>3,151,985</td>
<td>4,672,391</td>
</tr>
</tbody>
</table>

According to Figure 19 above, every FTE of project management personnel should bring into the electrical contracting company around $4.5 Million in revenue on average. Companies can use this metric to assess their operating performance and overall project management personnel efficiency and to determine if they have too many or too little project managers to be maximally efficient. That is especially important due to the high wages and costs of project managers incurred on the company, all of which makes it crucial for a company to check whether its project managers are producing sufficient revenue to justify their expenses.
4.1.2.2 Net Profit per FTE of Project Management Personnel

Figure 20 Net Profit per FTE of Project Management Personnel Boxplots

Table 10 Net Profit per FTE of Project Management Personnel Descriptive Statistics

<table>
<thead>
<tr>
<th>Net Profit per FTE of PM</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>262,247</td>
<td>160,253</td>
<td>242,641</td>
<td>265,904</td>
<td>310,988</td>
<td>233,745</td>
<td>248,067</td>
<td>310,562</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>101,997</td>
<td>86,538</td>
<td>84,914</td>
<td>139,586</td>
<td>64,510</td>
<td>147,254</td>
<td>157,644</td>
<td>227,375</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>87,657</td>
<td>22,683</td>
<td>53,480</td>
<td>55,772</td>
<td>16,239</td>
<td>27,389</td>
<td>50,980</td>
<td>104,298</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>182,073</td>
<td>137,990</td>
<td>146,830</td>
<td>182,379</td>
<td>178,565</td>
<td>149,344</td>
<td>225,178</td>
<td>326,902</td>
</tr>
</tbody>
</table>
According to Figure 20 above, as seen in the last three years, every FTE of project management personnel should be able to generate to the electrical contracting company around $200,000 in net profit on average. An increasing trend has been observed in this metric over the last four years indicating improving productivity performance of management personnel. It should be noted that although this metric might not be a perfect gauge of efficiency since profit is dependent on another set of other financial variables, it can be used by electrical contracting companies as a tool for goal setting and productivity planning.
4.1.2.3 Revenue per FTE of BUE

Figure 21 Revenue per FTE of BUE Boxplots

Table 11 Revenue per FTE of BUE Descriptive Statistics

<table>
<thead>
<tr>
<th>Revenue per FTE of BUE</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>361,803</td>
<td>441,397</td>
<td>387,084</td>
<td>372,060</td>
<td>332,247</td>
<td>330,470</td>
<td>366,125</td>
<td>398,863</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>316,519</td>
<td>311,176</td>
<td>313,924</td>
<td>310,236</td>
<td>301,570</td>
<td>280,616</td>
<td>300,437</td>
<td>358,475</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>281,068</td>
<td>247,892</td>
<td>258,550</td>
<td>231,734</td>
<td>222,760</td>
<td>221,540</td>
<td>227,819</td>
<td>230,480</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>332,747</td>
<td>340,661</td>
<td>331,253</td>
<td>304,001</td>
<td>287,288</td>
<td>283,708</td>
<td>309,474</td>
<td>327,602</td>
</tr>
</tbody>
</table>
As the work of an electrical contracting company is mainly carried out by its craft workers or BUEs, their productivity has a pivotal impact on the company’s overall performance. Based on Figure 21 above, every FTE of BUE should bring into the electrical contracting company around $300,000 in revenue on average. This average has been somehow stable over the years. It should be noted nonetheless that there is a noticeable dispersion in the reported data for this metric, indicating the disparity in the level of labor productivity between companies. Such a metric can be key in identifying the highest performing contractors in the industry.
4.1.2.4 Net Profit per FTE of BUE

Figure 22 Net Profit per FTE of BUE Boxplots

Table 12 Net Profit per FTE of BUE Descriptive Statistics

<table>
<thead>
<tr>
<th>Net Profit per FTE of BUE</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>16,971</td>
<td>17,797</td>
<td>18,118</td>
<td>17,982</td>
<td>27,944</td>
<td>23,149</td>
<td>24,948</td>
<td>30,315</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>13,016</td>
<td>11,322</td>
<td>8,079</td>
<td>11,084</td>
<td>16,342</td>
<td>14,777</td>
<td>13,830</td>
<td>21,435</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>8,899</td>
<td>3,183</td>
<td>4,871</td>
<td>7,056</td>
<td>4,823</td>
<td>7,015</td>
<td>7,495</td>
<td>11,666</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>15,749</td>
<td>16,016</td>
<td>14,187</td>
<td>14,422</td>
<td>15,968</td>
<td>16,941</td>
<td>17,830</td>
<td>21,588</td>
</tr>
</tbody>
</table>
According to Figure 22 above, every FTE of BUE should generate to the electrical contracting company around $17,000 of net profit on average. It should also be noted that there seems to be noticeable spread of the reported data for this metric by the participating companies. Despite that, an electrical contracting company can use the above benchmarking figure to monitor the changes in its labor productivity performance over the years, along with comparing it with industry averages.

4.1.2.5 Dollar Value Added per FTE of BUE

![Boxplots](image)

Figure 23 Dollar Value Added per FTE of BUE Boxplots
Table 13 Dollar Value Added per FTE of BUE Descriptive Statistics

<table>
<thead>
<tr>
<th>Value Added per FTE of BUE</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>227,674</td>
<td>204,530</td>
<td>208,707</td>
<td>197,294</td>
<td>201,158</td>
<td>241,854</td>
<td>258,392</td>
<td>266,197</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>172,396</td>
<td>161,559</td>
<td>163,247</td>
<td>174,503</td>
<td>170,727</td>
<td>189,392</td>
<td>246,557</td>
<td>261,968</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>166,706</td>
<td>136,684</td>
<td>143,450</td>
<td>144,056</td>
<td>135,233</td>
<td>151,554</td>
<td>164,416</td>
<td>180,812</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>194,622</td>
<td>177,009</td>
<td>173,610</td>
<td>174,856</td>
<td>173,196</td>
<td>189,282</td>
<td>217,623</td>
<td>232,278</td>
</tr>
</tbody>
</table>

Dollar value added per FTE of BUE is a more indicative measure of labor productivity when used for comparison reasons between companies. That is because it removes any inconsistencies due to different levels of material costs and subcontracting costs allowing for an unbiased comparison between different electrical contracting companies. Major spread of the reported data for this metric was noticed indicating significant variance in the productivity of craft workers across companies. This can be explained by the different operational and technological practices employed by companies, which seems to be highly impacting the productivity of field laborers.
4.1.3 Overall Productivity Measurement – Analysis by Hours

4.1.3.1 Revenue per Hours of BUE

Figure 24 Revenue per Hours of BUE Boxplots

Table 14 Revenue per Hours of BUE Descriptive Statistics

<table>
<thead>
<tr>
<th>Revenue per Hours of BUE</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>180</td>
<td>222</td>
<td>193</td>
<td>186</td>
<td>168</td>
<td>175</td>
<td>176</td>
<td>204</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>156</td>
<td>161</td>
<td>139</td>
<td>153</td>
<td>149</td>
<td>143</td>
<td>145</td>
<td>161</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>132</td>
<td>124</td>
<td>129</td>
<td>116</td>
<td>114</td>
<td>106</td>
<td>110</td>
<td>117</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>169</td>
<td>174</td>
<td>164</td>
<td>152</td>
<td>145</td>
<td>140</td>
<td>148</td>
<td>161</td>
</tr>
</tbody>
</table>
According to Figure 24 above, every working hour of BUE should generate to the electrical contracting company around $150 of revenue on average. This figure has been to some extent uniform over the years. Such a metric can be of interest for electrical contracting companies when tracking and assessing the productivity of their field laborers, since the latter are usually paid according to their expanded man-hours.

4.1.3.2 Net Profit per Hours of BUE

Figure 25 Net Profit per Hours of BUE Boxplots
Table 15 Net Profit per Hours of BUE Descriptive Statistics

<table>
<thead>
<tr>
<th>Net Profit per Hours of BUE</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>8.01</td>
<td>9.63</td>
<td>10.17</td>
<td>8.79</td>
<td>14.51</td>
<td>9.83</td>
<td>10.08</td>
<td>13.46</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>6.34</td>
<td>5.60</td>
<td>4.79</td>
<td>5.25</td>
<td>5.96</td>
<td>5.70</td>
<td>6.09</td>
<td>9.76</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>4.71</td>
<td>2.60</td>
<td>3.06</td>
<td>3.24</td>
<td>1.32</td>
<td>2.33</td>
<td>3.39</td>
<td>5.00</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>7.64</td>
<td>8.44</td>
<td>7.64</td>
<td>6.46</td>
<td>7.60</td>
<td>7.63</td>
<td>7.50</td>
<td>9.00</td>
</tr>
</tbody>
</table>

According to Figure 25 above, every working hour of BUE should generate to the electrical contracting company around $7 on average in net profit. This figure has been to some extent uniform over the years with a slight increasing trend in the last three years. Some of the points in the figure above are negative; they probably correspond to companies reporting a negative net profit during the same years. Tracking the net profit per expanded man-hour of BUE over time allows an electrical contracting company to identify productive field labor or good crew and the non-productive field labor or bad crew.
4.1.3.3  Dollar Value Added per Hours of BUE

Figure 26 Dollar Value Added per Hours of BUE Boxplots

Table 16 Dollar Value Added per Hours of BUE Descriptive Statistics

<table>
<thead>
<tr>
<th>Value Added per Hours of BUE</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>117</td>
<td>115</td>
<td>105</td>
<td>110</td>
<td>103</td>
<td>124</td>
<td>124</td>
<td>141</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>85</td>
<td>81</td>
<td>86</td>
<td>82</td>
<td>83</td>
<td>91</td>
<td>107</td>
<td>127</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>79</td>
<td>76</td>
<td>72</td>
<td>70</td>
<td>69</td>
<td>65</td>
<td>79</td>
<td>80</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>99</td>
<td>92</td>
<td>88</td>
<td>88</td>
<td>88</td>
<td>93</td>
<td>103</td>
<td>112</td>
</tr>
</tbody>
</table>
As witnessed in the dollar value added per FTE of BUE benchmarking plot, a significant spread in the reported data in also present when investigating the dollar value added per hours of BUE metric. This confirms the varying level of labor productivity between companies which is revealed when the inconsistencies in material and subcontracting spending is removed from the usual productivity metrics. As shown in Figure 26 above, an increasing trend has been witnessed over the last few years which might be attributed to the innovative practices some companies have been implementing, which is boosting in turn their labor productivity.
4.1.4 Overall Cost Effectiveness

4.1.4.1 Revenue per Cost of Project Management Personnel

![Figure 27 Revenue per Cost of Project Management Personnel Boxplots](image)

Table 17 Revenue per Cost of Project Management Personnel Descriptive Statistics

<table>
<thead>
<tr>
<th>Revenue per Cost of PM</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>36.19</td>
<td>40.04</td>
<td>45.70</td>
<td>41.32</td>
<td>39.85</td>
<td>27.71</td>
<td>23.20</td>
<td>29.21</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>30.51</td>
<td>27.47</td>
<td>37.02</td>
<td>27.25</td>
<td>25.50</td>
<td>21.04</td>
<td>20.29</td>
<td>23.77</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>22.59</td>
<td>19.10</td>
<td>18.47</td>
<td>20.04</td>
<td>18.42</td>
<td>16.10</td>
<td>17.53</td>
<td>17.95</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>30.18</td>
<td>29.59</td>
<td>33.69</td>
<td>31.98</td>
<td>30.23</td>
<td>25.04</td>
<td>20.90</td>
<td>27.73</td>
</tr>
</tbody>
</table>
According to Figure 27 above, the revenue generated by project management personnel should be on average around 25 times the cost they accrue on the company. The higher this ration the better for an electrical contractor. Companies can use this benchmarking metric to check if their project management personnel are generating enough revenue as compared to their cost.

4.1.4.2 Net Profit per Cost of Project Management Personnel

Figure 28 Net Profit per Cost of Project Management Personnel Boxplots
<table>
<thead>
<tr>
<th>Net Profit per Cost of PM</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>1.80</td>
<td>1.59</td>
<td>2.22</td>
<td>2.20</td>
<td>2.48</td>
<td>1.87</td>
<td>2.13</td>
<td>2.14</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>1.37</td>
<td>0.97</td>
<td>0.98</td>
<td>1.20</td>
<td>2.15</td>
<td>0.79</td>
<td>1.10</td>
<td>1.21</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>0.91</td>
<td>0.51</td>
<td>0.55</td>
<td>0.39</td>
<td>0.26</td>
<td>0.29</td>
<td>0.35</td>
<td>0.65</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>2.14</td>
<td>1.62</td>
<td>1.59</td>
<td>1.60</td>
<td>1.90</td>
<td>1.07</td>
<td>1.32</td>
<td>1.89</td>
</tr>
</tbody>
</table>

According to Figure 28 above, the net profit generated by project management personnel should be on average around 1.3 times the cost they accrue on the company. There is no significant variance in this metric vertically, i.e. between companies, not horizontally, i.e. across years.
4.1.4.3 Revenue per Cost of BUE

Figure 29 Revenue per Cost of BUE Boxplots

Table 19 Revenue per Cost of BUE Descriptive Statistics

<table>
<thead>
<tr>
<th>Revenue per Cost of BUE</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>2.97</td>
<td>3.02</td>
<td>3.28</td>
<td>3.26</td>
<td>3.34</td>
<td>3.29</td>
<td>3.41</td>
<td>3.33</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>2.67</td>
<td>2.72</td>
<td>2.85</td>
<td>2.86</td>
<td>2.43</td>
<td>2.59</td>
<td>2.29</td>
<td>2.44</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>2.49</td>
<td>2.35</td>
<td>2.42</td>
<td>2.17</td>
<td>2.23</td>
<td>2.10</td>
<td>1.87</td>
<td>1.91</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>2.81</td>
<td>2.91</td>
<td>2.88</td>
<td>2.95</td>
<td>2.85</td>
<td>2.91</td>
<td>2.79</td>
<td>2.85</td>
</tr>
</tbody>
</table>
According to Figure 29 above, the revenue generated by BUEs should be on average around 2.5 times the cost they accrue on the company. The higher this ration the better for an electrical contractor. A decreasing trend in this metric has been observed over the last four years which might be caused by the increase in the wage of skilled workers, hence inversely affecting this metric.
4.1.4.4 Net Profit per Cost of BUE

Figure 30 Net Profit per Cost of BUE Boxplots

Table 20 Net Profit per Cost of BUE Descriptive Statistics

<table>
<thead>
<tr>
<th>Net Profit per Cost of BUE</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>0.15</td>
<td>0.13</td>
<td>0.12</td>
<td>0.16</td>
<td>0.20</td>
<td>0.26</td>
<td>0.29</td>
<td>0.29</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>0.11</td>
<td>0.10</td>
<td>0.10</td>
<td>0.09</td>
<td>0.12</td>
<td>0.11</td>
<td>0.09</td>
<td>0.14</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>0.09</td>
<td>0.03</td>
<td>0.05</td>
<td>0.04</td>
<td>0.04</td>
<td>0.06</td>
<td>0.06</td>
<td>0.07</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>0.14</td>
<td>0.15</td>
<td>0.12</td>
<td>0.15</td>
<td>0.16</td>
<td>0.18</td>
<td>0.18</td>
<td>0.19</td>
</tr>
</tbody>
</table>
Figure 30 above, the net profit generated by BUEs should be on average around 0.2 times the cost they accrue on the company. This average has been generally stable over the years. Although certain companies reported relatively very high values for this metric as shown in the benchmarking figure, they do not represent the norm.
4.1.4.5  Dollar Value Added per Cost of BUE

Figure 31 Dollar Value Added per Cost of BUE Boxplots

Table 21 Dollar Value Added per Cost of BUE Descriptive Statistics

<table>
<thead>
<tr>
<th>Value Added per Cost of BUE</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>1.69</td>
<td>1.65</td>
<td>1.77</td>
<td>1.70</td>
<td>1.68</td>
<td>1.78</td>
<td>1.77</td>
<td>1.78</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>1.54</td>
<td>1.49</td>
<td>1.55</td>
<td>1.53</td>
<td>1.56</td>
<td>1.44</td>
<td>1.48</td>
<td>1.45</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>1.33</td>
<td>1.36</td>
<td>1.39</td>
<td>1.33</td>
<td>1.33</td>
<td>1.38</td>
<td>1.38</td>
<td>1.29</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>1.64</td>
<td>1.59</td>
<td>1.60</td>
<td>1.64</td>
<td>1.65</td>
<td>1.78</td>
<td>1.80</td>
<td>1.80</td>
</tr>
</tbody>
</table>
Figure 31 above, the dollar value added generated by BUEs should be on average around 1.5 times the cost they accrue on the company. This average has also been generally stable over the years with little variance between companies. Although certain companies reported relatively very high values for this metric as shown in the benchmarking figure, they do not represent the norm.
4.1.5 Staffing

4.1.5.1 Turnover Rate of BUE

![Boxplot of Turnover Rate of BUE](image)

**Figure 32 Turnover Rate of BUE Boxplots**

**Table 22 Turnover Rate of BUE Descriptive Statistics**

<table>
<thead>
<tr>
<th>Turnover Rate of BUE</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>65.00%</td>
<td>50.00%</td>
<td>47.25%</td>
<td>48.25%</td>
<td>65.00%</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>43.50%</td>
<td>46.00%</td>
<td>31.50%</td>
<td>32.00%</td>
<td>47.00%</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>20.50%</td>
<td>15.00%</td>
<td>17.25%</td>
<td>16.50%</td>
<td>22.25%</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>43.83%</td>
<td>38.20%</td>
<td>34.67%</td>
<td>34.83%</td>
<td>45.17%</td>
</tr>
</tbody>
</table>
Significant variance in the data reported in regard to turnover rate of BUE has been observed as shown in Figure 32 above, with an average of around 35%, a maximum of 80% and a minimum of 10%. Such high turnover values indicate that many electrical contracting companies are having major problems when it comes to employee retention. High turnover rates are translated to turnover costs accrued on companies including vacancy costs, replacement costs, and training costs, among others related to decreased productivity. The reason for high turnover rate might have to do with improper management and lack of employee retention strategies. In his study titled “The Effects of Absenteeism and Turnover on Labor Productivity for Electrical Contractors” (2006), Hanna reports the top reasons for high employee turnover in the electrical construction industry which include “not enough recognition” from management personnel, “excessive surveillance”, inadequacy of tools and equipment, and not getting along with the other crew members. By tracking the turnover rate of their workers and comparing it to the rest of the market players, electrical contracting companies can determine if they turnover rates are within the average or way above, working on strategies accordingly to overcome this phenomenon.
4.1.5.2 Cost of Project Management Personnel per Cost of BUE

Figure 33 Cost of Project Management Personnel per Cost of BUE Boxplots

Table 23 Cost of Project Management Personnel per Cost of BUE Descriptive Statistics

<table>
<thead>
<tr>
<th>Cost of PM per Cost of BUE</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>0.14</td>
<td>0.14</td>
<td>0.18</td>
<td>0.14</td>
<td>0.16</td>
<td>0.18</td>
<td>0.21</td>
<td>0.17</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>0.11</td>
<td>0.12</td>
<td>0.09</td>
<td>0.12</td>
<td>0.11</td>
<td>0.15</td>
<td>0.15</td>
<td>0.11</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>0.08</td>
<td>0.09</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>0.12</td>
<td>0.11</td>
<td>0.08</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>0.11</td>
<td>0.12</td>
<td>0.12</td>
<td>0.13</td>
<td>0.13</td>
<td>0.16</td>
<td>0.16</td>
<td>0.13</td>
</tr>
</tbody>
</table>
By tracking the cost of project management personnel per cost of BUE and comparing it side-by-side to industry averages using Figure 33 above, electrical contracting companies can assess if they have imbalance in their the number of their management personnel and their field laborers. In other words, they will have an idea if they’re overstaffing project managers relative to the available BUE or the opposite.

4.1.6 Safety

4.1.6.1 OSHA Recordable Incident Rate

Figure 34 OSHA Recordable Incident Rate Boxplots
Table 24 OSHA Recordable Incident Rate (RIR) Descriptive Statistics

<table>
<thead>
<tr>
<th>OSHA RIR</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>4.17</td>
<td>3.20</td>
<td>3.09</td>
<td>2.00</td>
<td>3.18</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>3.08</td>
<td>2.17</td>
<td>1.90</td>
<td>1.83</td>
<td>1.40</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>2.05</td>
<td>1.04</td>
<td>0.96</td>
<td>1.54</td>
<td>1.21</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>3.76</td>
<td>2.33</td>
<td>5.51</td>
<td>2.40</td>
<td>2.49</td>
</tr>
</tbody>
</table>

Tracking OSHA recordable incident rate is necessary for electrical contractors whose type of work poses a major safety risks on workers. It should be noted that the number of data points for the OSHA recordable incident rate in the dataset collected in this study is small for each year, meaning that Figure 34 above should be used with caution as it may not portray the industry average most accurately. It is worth mentioning though the decreasing trend in the OSHA incident rate reported over the years, indicating an improving safety performance of electrical contractors, which might be driven by increased job site safety trainings and more strict safety policies.
4.1.7 Customer Satisfaction / Business Sustainability

4.1.7.1 Repeat Business Customers

![Figure 35 Repeat Business Customers Boxplots](image)

<table>
<thead>
<tr>
<th>Repeat Business Customers</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>75th Percentile</td>
<td>85.00%</td>
<td>85.00%</td>
<td>86.25%</td>
<td>86.25%</td>
<td>91.25%</td>
</tr>
<tr>
<td>Median (50th Percentile)</td>
<td>80.00%</td>
<td>80.00%</td>
<td>82.50%</td>
<td>82.50%</td>
<td>82.50%</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>39.50%</td>
<td>43.50%</td>
<td>44.00%</td>
<td>43.00%</td>
<td>42.00%</td>
</tr>
<tr>
<td>Mean (Average)</td>
<td>61.25%</td>
<td>63.50%</td>
<td>65.25%</td>
<td>64.50%</td>
<td>65.38%</td>
</tr>
</tbody>
</table>
According to Figure 35 above, the average repeat business customer percentage in electrical contracting companies is around 80%. It should be noted that certain companies reported value way lower than the industry average as shown above. Repeat business customers percentage is a metric indicating customer satisfaction and ultimately the quality of the work executed that would drive customers to do more business with the same contractor. Hence, companies should pay sufficient attention on this metric and evaluate their performance with respect to retaining clients.

4.2 Identification of the Best Practices Using Statistical Data Analysis

The second objective of the data-driven analysis is to determine the best practices of electrical contracting companies. The phrase “best practices” in this research refers to the practices that are associated with higher company net profit percentage. The latter was chosen to be the yardstick as it is the main indicator of profitability, which is the main determinant if the company can stay in business or not. The best practices were identified by statistically analyzing the differences in the net profit percentage between companies implementing a particular practice and those not implementing it. Practices associated with significant increase in companies net profit percentages were identified as best practices. To further validate the effectiveness of these practices in influencing companies’ profitability, companies were scored based on their implementation of the identified best practices. The correlation of the computed scores with companies’ net profit percentages was subsequently tested.

4.2.1 Univariate Analysis

Univariate analysis was utilized to study the effect of each practice on the company profitability. Within each of the practices, or qualitative variables, presented in the Chapter 3, the
dataset was divided into samples: companies implementing the practice and companies not implementing it. Two-sample tests were then conducted to compare the net profit percentages between the two samples for each practice. To determine the type of the test that best suits the data, the assumptions of normality and homoscedasticity of the samples first needed to be tested. To check the assumption of normality, Shapiro-Wilk tests were conducted. If both samples were identified to be normally distributed, Levene’s test was subsequently conducted to check the assumption of homoscedasticity. If the assumption of homogeneity of variance is met, two-sample equal-variance t-test was performed, else, Welch's t-test, or unequal variances t-test was performed. On the other hand, if the assumption of normality was not met for both samples, nonparametric Wilcoxon rank-sum test, also known as Wilcoxon–Mann–Whitney test, was used to compare the sample means. Figure 36 illustrates the methodology used when performing the univariate analysis.
The performed two-sample tests were one-sided, with the null hypothesis being that the net profit percentage is equal for both companies implementing a particular practice and those not implementing it. The alternative hypothesis is that the sample of companies implementing the practice have a higher net profit percentage compared to companies not implementing it. P-values
less than 0.1 were used to report statistically significant results at the 90% confidence level. The latter was chosen since it is usually used when sample size is small, as is the case in this research.

4.2.1.1 Sufficiency of Sample Size

It should be noted the sufficiency of the dataset used in this research to perform the statistical analysis was studied. According to Sudman (1983), a sample size of 20 to 50 is recommended; Converse and Presser (1986) recommend a sample size of 25 to 75; whereas according to Fowler (1995), a sample size of 15 to 35 is sufficient. The dataset used in this research is composed of 28 companies, resulting in a size that is acceptable according to all of the mentioned studies.

4.2.1.2 Results of the Univariate Analysis

Of the practices that were presented in Section 3.1.2, 13 practices across five categories were identified significant at least at the 90% confidence level. It should be noted that none of the companies reported implementing the 80-20 program, the use of dedicated logistics planning personnel, or regular evaluation of the performance of the boards and the directors; hence, these practices were not statistically analyzed. Furthermore, all companies in the dataset reported tracking productivity and percent complete via tracking earned hours, estimated hours, and actual hours at the activity level, and the use of dedicated estimating staff; hence, the effectiveness of these practices in influencing companies’ net profit percentages was also not statistically tested as there was no sample population that did not implement these practices. In this section, a summary of the practices whose statistical testing results turned out to be significant is first presented in Table 26, followed by detailed analysis of each the identified best practices.
Table 26 Summary of the Identified Best Practices

<table>
<thead>
<tr>
<th>Category</th>
<th>Practice</th>
<th>P-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prefabrication</td>
<td>Dedicated Prefabrication Shop</td>
<td>0.0133</td>
<td>At 95% Level</td>
</tr>
<tr>
<td></td>
<td>Use of BIM</td>
<td>0.0537</td>
<td>At 90% Level</td>
</tr>
<tr>
<td></td>
<td>Use of Tablets on Site</td>
<td>0.0537</td>
<td>At 90% Level</td>
</tr>
<tr>
<td></td>
<td>Use of Drones</td>
<td>0.0566</td>
<td>At 90% Level</td>
</tr>
<tr>
<td>Technology Use</td>
<td>Management Trainings</td>
<td>0.0509</td>
<td>At 90% Level</td>
</tr>
<tr>
<td></td>
<td>Project Management Trainings for Field Management Personnel</td>
<td>0.0011</td>
<td>At 95% Level</td>
</tr>
<tr>
<td></td>
<td>Labor Relation Training for Field Management Personnel</td>
<td>0.0755</td>
<td>At 90% Level</td>
</tr>
<tr>
<td></td>
<td>Business Management Training for Management Staff</td>
<td>0.0755</td>
<td>At 90% Level</td>
</tr>
<tr>
<td></td>
<td>Leadership and Communication Training for Field Management Personnel</td>
<td>0.0509</td>
<td>At 90% Level</td>
</tr>
<tr>
<td></td>
<td>Interpersonal Development Training for Field Management Personal</td>
<td>0.0666</td>
<td>At 90% Level</td>
</tr>
<tr>
<td>Quality Management and Evaluation</td>
<td>Documenting Lessons Learned from Every Project</td>
<td>0.0871</td>
<td>At 90% Level</td>
</tr>
<tr>
<td></td>
<td>Part of a Peer Review Program</td>
<td>0.0366</td>
<td>At 95% Level</td>
</tr>
<tr>
<td>Productivity and Management Practices</td>
<td>Lean Construction</td>
<td>0.0280</td>
<td>At 95% Level</td>
</tr>
</tbody>
</table>
Dedicated Prefabrication Shop

Figure 37 below presents the boxplots of the net profit percentage of electrical contracting companies having a dedicated prebrication shop and those that don’t.

![Figure 37 Boxplots for Owning Prefab Shop](image)

Table 27 Results of the Statistical Testing for Owning Prefab Shop

<table>
<thead>
<tr>
<th>Statistical Test</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shapiro-Wilk Test</td>
<td></td>
</tr>
<tr>
<td>No Prefab Shop</td>
<td>0.9509</td>
</tr>
<tr>
<td>Dedicated Prefab Shop</td>
<td>0.8788</td>
</tr>
<tr>
<td>Levene’s Test</td>
<td>0.8005</td>
</tr>
<tr>
<td>Two-Sample Equal Variance t-test</td>
<td>0.0133</td>
</tr>
</tbody>
</table>
As shown in Table 27, the resulting high p-values of the Shapiro-Wilk tests provide statistical evidence not to reject the null hypothesis of normality of the samples. Similarly, the resulting high p-value of the Levene’s test provides statistical evidence not to reject the null hypothesis of homogeneity of variance. Hence, two-sample equal variance t-test was conducted providing statistical evidence at the 95% confidence level that the net profit percentage is greater when owning a dedicated prefabrication shop. With electrical contractors constantly facing cost, schedule, and labor challenges, Rounds, Bogus, and Jones (2009) report that prefabrication has the potential to increase productivity, improve quality of the work, reduce the needs and costs associated with the labor force, considerably decrease project duration, and improve safety. These benefits result in indirect cost savings that come from more efficient use of the labor force, reduced wasted material and scrap onsite, and decreased use of expensive tools and miscellaneous materials. Hence, despite the initial cost premium that is incurred on electrical contractors owning dedicated prefabrication shops, the resulting indirect cost benefits can increase an electrical contracting company’s profitability.

Use of BIM

Figure 38 presents the boxplots of the net profit percentage of electrical contracting companies using BIM and those that don’t.
Figure 38 Boxplots for BIM Use

Table 28 Results of the Statistical Testing for Using BIM

<table>
<thead>
<tr>
<th>Statistical Test</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shapiro-Wilk Test</td>
<td></td>
</tr>
<tr>
<td>Not Using BIM</td>
<td>0.0461</td>
</tr>
<tr>
<td>Using BIM</td>
<td>0.8788</td>
</tr>
<tr>
<td>Wilcoxon Rank-Sum Test</td>
<td>0.0537</td>
</tr>
</tbody>
</table>

As shown in Table 28, one of the two samples had a low p-value of the Shapiro-Wilk test providing statistical evidence to reject the null hypothesis of its normality. Hence, the nonparametric Wilcoxon rank-sum test was conducted providing statistical evidence at the 90% confidence level that the net profit percentage is greater when using BIM. This increase in
profitability is attributed to indirect cost savings due to increased coordination and site productivity, which have been reported to outweigh the modeling expenses incurred by companies using BIM (Sattineni and Brock 2019). Savings in time and money can be realized through BIM enabled schedules that enable the visualization of overlapping scheduled activities, subsequently allowing earlier and faster resolutions to conflicts (Kiziltas and Akinci 2010). Furthermore, when utilized for clash detection and more thorough submittal checks, BIM can result in more efficient communication amongst the general contractor and the specialty contractors (Leite, Akinci, and Garrett 2009). Aside from that, BIM use by electrical contractors usually results in eases in field installations as site laborers have more information at their disposal to accurately install electrical components (Ruwanpura, Hewage, and Silva 2012). This level of full and accurate available information is reported to reduce the amount of change orders and Requests for Information (RFI’s), which in turn are translated in reduced rework (Barlish and Sullivan 2012; Leicht and Messner 2008).

Use of Tablets on Site

Figure 39 below presents the boxplots of the net profit percentage of electrical contracting companies whose field workers are using tablets on-site and those that don’t.
Figure 39 Boxplots for Tablets Use On-Site

Table 29 Results of the Statistical Testing for Using Tablets On-Site

<table>
<thead>
<tr>
<th>Statistical Test</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shapiro-Wilk Test</td>
<td></td>
</tr>
<tr>
<td>Not Using Tablets On-Site</td>
<td>0.0326</td>
</tr>
<tr>
<td>Using Tablets On-Site</td>
<td>0.8788</td>
</tr>
<tr>
<td>Wilcoxon Rank-Sum Test</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.0537</td>
</tr>
</tbody>
</table>

As shown in Table 29, one of the two samples had a low p-value of the Shapiro-Wilk test providing statistical evidence to reject the null hypothesis of its normality. Hence, the nonparametric Wilcoxon rank-sum test was conducted providing statistical evidence at the 90% confidence level that the net profit percentage is greater when using field workers use tablets on-
site. With the increased use of BIM, tablets are becoming a necessity onsite for electrical contractors to allow their field workers to view construction drawings, 3D models, and blueprints. They are also being utilized to efficiently create, share, and backup daily reports and safety documentations, perform real-time tracking of the progress of work through progress photos, and efficiently access and verify construction checklists and standards.

**Use of Drones**

Figure 40 below presents the boxplots of the net profit percentage of electrical contracting companies using drones and those that don’t.

![Figure 40 Boxplots for Drones Use](image)
Table 30 Results of the Statistical Testing for Using Drones

<table>
<thead>
<tr>
<th>Statistical Test</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shapiro-Wilk Test</td>
<td></td>
</tr>
<tr>
<td>No Use of Drones</td>
<td>0.6257</td>
</tr>
<tr>
<td>Using Drones</td>
<td>0.6953</td>
</tr>
<tr>
<td>Levene’s Test</td>
<td>0.4112</td>
</tr>
<tr>
<td>Two-Sample Equal Variance t-test</td>
<td>0.0566</td>
</tr>
</tbody>
</table>

As shown in Table 30, the resulting high p-values of the Shapiro-Wilk tests provide statistical evidence not to reject the null hypothesis of normality of the samples. Similarly, the resulting high p-value of the Levene’s test provides statistical evidence not to reject the null hypothesis of homogeneity of variance. Hence, two-sample equal variance t-test was conducted providing statistical evidence at the 90% confidence level that the net profit percentage is greater when using drones. For electrical contractors, especially those involved in utility work, drones are particularly useful and are becoming more widely used. They allow easier site surveying, efficient monitoring of the progress of the work onsite, easier inspection of existing infrastructure, particularly those in difficult to access areas, and obtainable temperature checks of equipment and other components through infrared camera attachments and thermal imaging (Atkinson 2018).

Providing Management Trainings

Figure 41 below presents the boxplots of the net profit percentage of electrical contracting companies providing management trainings and those that don’t.
As shown in Table 31, the resulting high p-values of the Shapiro-Wilk tests provide statistical evidence not to reject the null hypothesis of normality of the samples. Similarly, the resulting high p-value of the Levene’s test provides statistical evidence not to reject the null
hypothesis of homogeneity of variance. Hence, two-sample equal variance t-test was conducted providing statistical evidence at the 90% confidence level that the net profit percentage is greater when providing management trainings. Despite its benefits in terms of developing employees’ skillset, improving risk management, and better employee retention, among others, employee training is still one of the most underrated facets of workforce management in the electrical contracting industry. The latter explains the competitive advantage and increased profitability experienced by electrical contracting companies providing trainings to their employees in the form a continuously evolving part of their careers.

Project Management Trainings for Field Management Personnel

Figure 42 below presents the boxplots of the net profit percentage of electrical contracting companies providing project management trainings for field management personnel and those that don’t.
As shown in Table 32, the resulting high p-values of the Shapiro-Wilk tests provide statistical evidence not to reject the null hypothesis of normality of the samples. Similarly, the resulting high p-value of the Levene’s test provides statistical evidence not to reject the null
hypothesis of homogeneity of variance. Hence, two-sample equal variance t-test was conducted providing statistical evidence at the 95% confidence level that the net profit percentage is greater when providing project management trainings for field management personnel. The main objective of project management trainings is to ensure that field management personnel have the right knowledge, skills, and tools needed to effectively manage the project onsite. Through having a better sense of time and resources, field management personnel will be able to prioritize work tasks and how to allocate time and manpower to complete them. Project management trainings also enable field management personnel to produce a solid record of project progress and completion documents and how to better work with information systems. All of this results in a better-managed work site, increased labor productivity, and hence increased profitability.

Labor Relation Training for Field Management Personnel

Figure 43 below presents the boxplots of the net profit percentage of electrical contracting companies providing labor relation trainings for field management personnel and those that don’t.
As shown in Table 33, one of the two samples had a low p-value of the Shapiro-Wilk test providing statistical evidence to reject the null hypothesis of its normality. Hence, the nonparametric Wilcoxon rank-sum test was conducted providing statistical evidence at the 90% confidence level that the net profit percentage is greater when providing labor relation trainings.
for field management personnel. Acting as front-line supervisors, it is very important for field management personnel to have the needed knowledge and skills for managing craftsmen and operations especially within collective bargaining situations, which is the case with most of electrical contractors who are union contractors. Labor relation trainings allows management personnel to better align management practices to business strategy, understand legal issues and labor laws that every supervisor should know, and develop the right soft skills and tools to negotiate and interact with craftsmen.

**Business Management Training for Management Staff**

Figure 44 below presents the boxplots of the net profit percentage of electrical contracting companies providing business management trainings for management personnel and those that don’t.
Boxplots for Providing Business Management Trainings for Management Personnel

Table 34 Results of the Statistical Testing for Providing Business Management Trainings for Management Personnel

<table>
<thead>
<tr>
<th>Statistical Test</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shapiro-Wilk Test</td>
<td></td>
</tr>
<tr>
<td>No Business Management Training</td>
<td>0.7857</td>
</tr>
<tr>
<td>Providing Business Management Training</td>
<td>0.0421</td>
</tr>
<tr>
<td>Wilcoxon Rank-Sum Test</td>
<td>0.0755</td>
</tr>
</tbody>
</table>

As shown in Table 34, one of the two samples had a low p-value of the Shapiro-Wilk test providing statistical evidence to reject the null hypothesis of its normality. Hence, the nonparametric Wilcoxon rank-sum test was conducted providing statistical evidence at the 90%
confidence level that the net profit percentage is greater when providing business management trainings for management personnel. It is important for companies’ management personnel to be familiar with key business concepts and strategies in order for them to deliver more to their companies. With the high level of competition in the electrical contracting industry, business management trainings can be a real boost to an electrical contracting company’s performance through enabling its people to have a solid understanding of operations, finance, marketing, and innovation concepts, better pinpoint strategic opportunities, and grow the company to be resilient and able to survive during turbulent times and unexpected challenges.

Leadership and Communication Training for Field Management Personnel

Figure 45 below presents the boxplots of the net profit percentage of electrical contracting companies providing leadership and communication trainings for field management personnel and those that don’t.
As shown in Table 35, the resulting high p-values of the Shapiro-Wilk tests provide statistical evidence not to reject the null hypothesis of normality of the samples. Similarly, the
resulting high p-value of the Levene’s test provides statistical evidence not to reject the null hypothesis of homogeneity of variance. Hence, two-sample equal variance t-test was conducted providing statistical evidence at the 90% confidence level that the net profit percentage is greater when providing leadership and communication trainings for field management personnel. As the electrical contracting industry faces increasing worker shortage and shift in leadership as baby boomers retire, the most viable option for companies is to promote from within. That is best to happen when workers have already been trained to become future leaders and managers. Leadership and communication trainings for field management personnel teach them how to set clear goals, efficiently manage and run day-to-day operations, respond to challenges, make ethical and informed decisions, and be supportive and motivating to the rest of the field workers (Boarder States 2018).

**Interpersonal Development Training for Field Management Personnel**

Figure 46 below presents the boxplots of the net profit percentage of electrical contracting companies providing interpersonal development trainings for field management personnel and those that don’t.
As shown in Table 36, the resulting high p-values of the Shapiro-Wilk tests provide statistical evidence not to reject the null hypothesis of normality of the samples. Similarly, the
resulting high p-value of the Levene’s test provides statistical evidence not to reject the null hypothesis of homogeneity of variance. Hence, two-sample equal variance t-test was conducted providing statistical evidence at the 90% confidence level that the net profit percentage is greater when providing interpersonal development trainings for field management personnel. With the electrical contracting industry being characterized as labor intensive, alignment between workers and management and the nature of the relationship become extremely significant. Hence, aside from the technical skills, field management personnel need to possess the interpersonal acumen and soft skills needed to build team morale, motivate crew members, clearly communicate with teams about the scope of their duties and expectations, and solve problems when they arise.

Documenting Lessons Learned from Every Project

Figure 47 below presents the boxplots of the net profit percentage of electrical contracting companies documenting lessons learned from every project and those that don’t.
Table 37 Results of the Statistical Testing for Documenting Lessons Learned from Every Project

<table>
<thead>
<tr>
<th>Statistical Test</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shapiro-Wilk Test</td>
<td></td>
</tr>
<tr>
<td>Not Documenting Lessons Learned</td>
<td>0.9402</td>
</tr>
<tr>
<td>Documenting Lessons Learned</td>
<td>0.9917</td>
</tr>
<tr>
<td>Levene’s Test</td>
<td>0.5568</td>
</tr>
<tr>
<td>Two-Sample Equal Variance t-test</td>
<td>0.0871</td>
</tr>
</tbody>
</table>

As shown in Table 37, the resulting high p-values of the Shapiro-Wilk tests provide statistical evidence not to reject the null hypothesis of normality of the samples. Similarly, the resulting high p-value of the Levene’s test provides statistical evidence not to reject the null
hypothesis of homogeneity of variance. Hence, two-sample equal variance t-test was conducted providing statistical evidence at the 90% confidence level that the net profit percentage is greater when documenting lessons learned from every project. As Newell (2004) says, “companies save money by not reinventing the wheel every time a new project is started”. In fact, project costs can be reduced when past project successes are implemented while avoiding past failures (Parnell, Soper, and Von Bergen 2005). In addition to cost savings, time savings can also be achieved when lessons are documented from projects and then used to decrease the planned duration of current projects (Terrell 1999).

**Part of a Peer Group**

Figure 48 below presents the boxplots of the net profit percentage of electrical contracting companies that are part of a peer group and those that are not.
As shown in Table 38, the resulting high p-values of the Shapiro-Wilk tests provide statistical evidence not to reject the null hypothesis of normality of the samples. Similarly, the resulting high p-value of the Levene’s test provides statistical evidence not to reject the null
hypothesis of homogeneity of variance. Hence, two-sample equal variance t-test was conducted providing statistical evidence at the 95% confidence level that the net profit percentage is greater when being part of a peer group. Peer groups are usually a consortium of electrical contracting companies with similar size, line of work, form of ownership, market served, number of employees, and delivery systems used (FMI n.d.). Peer groups allow financial group comparison and review, along with sharing success strategies for incorporating new processes and procedures. These types of unique forums of successful, progressive thinkers who are open to new ideas, and are willing to share insights and experiences, are a great way to electrical contractors to expand their network, exchange feedback, and uncover novel business opportunities.

**Lean Construction**

Figure 49 below presents the boxplots of the net profit percentage of electrical contracting companies that implement lean concepts and those that do not.
As shown in Table 39, the resulting high p-values of the Shapiro-Wilk tests provide statistical evidence not to reject the null hypothesis of normality of the samples. Similarly, the resulting high p-value of the Levene’s test provides statistical evidence not to reject the null
hypothesis of homogeneity of variance. Hence, two-sample equal variance t-test was conducted providing statistical evidence at the 95% confidence level that the net profit percentage is greater when being applying lean concepts. Lean construction is a holistic management approach that seeks to increase value of construction projects and eradicate waste during project lifecycles (H. W. Lee et al. 2019). Applying lean construction techniques, such as 5S, Last Planner System (LPS), continuous improvement, 5 Whys, prefabrication, modular construction, BIM use, widespread distribution network for materials and equipment, and the use of preassembled rough-in systems, has seen to improve electrical contractors’ performance (IEC 2016; H. W. Lee et al. 2019). The latter is being in the form of improved workers’ safety, more accurate cost estimates, increased labor productivity, less materials and parts waste due to reduced onsite inventory, and reduced onsite installation labor hours which in turn increases profitability.

4.2.2 Scoring Based on Best Practices Implementation

To further validate the effectiveness of the identified best practices in influencing electrical contracting companies’ performance which is chosen to be represented by the net profit percentage, each of the companies in the dataset was scored based on the number of the identified best practices that were implemented. Each of the identified 13 practices was given the same weight, meaning that the score for each company was determined by assigning 7.69% for each of best practices that the company implemented. In other words, a company implementing all 13 best practices would receive a score of 100%. The scores computed for all 28 companies in the dataset ranged between 0% and 92.3%. The main objective behind these scores is to subsequently determine their correlation with the companies’ net profit percentages. To determine which correlation coefficient is the most appropriate to use, the assumption of normality of the data needs
to be checked. Hence, Shapiro-Wilk tests were conducted on the companies’ net profit percentages and on the computed scores. Results are shown in Table 40 below.

Table 40 Normality Tests Results for Scoring Data

<table>
<thead>
<tr>
<th>Statistical Test</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shapiro-Wilk Test</td>
<td></td>
</tr>
<tr>
<td>Companies’ Net Profit Percentages</td>
<td>0.8953</td>
</tr>
<tr>
<td>Companies’ Scores</td>
<td>0.5003</td>
</tr>
</tbody>
</table>

Results of the Shapiro-Wilk tests provide statistical evidence not to reject the null hypothesis of normality of the samples. With the assumption of normality met, Pearson correlation coefficient was chosen as it is the most commonly used correlation statistic, ranging between -1 and 1 with larger absolute values indicating stronger relationship between the two variables (Boslaugh 2012). The resulting Pearson correlation coefficient and its corresponding p-value are presented in Table 41 below.

Table 41 Results of the Correlation between Companies’ Scores and their Net Profit

<table>
<thead>
<tr>
<th>Pearson Correlation Coefficient</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.694</td>
<td>0.0259</td>
</tr>
</tbody>
</table>

The resulting positive correlation indicates that as the level of implementation of best practices, presented by the companies’ scores, increases, their net profit percentages increases. This correlation was proven to be significant at the 95% confidence level.


5 Chapter 5. Development of an Online Benchmarking Tool

To support the electrical contracting industry company-level benchmarking model introduced in this research, a benchmarking tool was developed leveraging efficiencies of web-based technologies. The main objectives of the tool are to:

- Allow electrical contracting companies to do an easy, comprehensive self-assessment of their performance and compare it to the rest of the industry based on approximately 23 key financial and operational metrics that are automatically calculated using the companies’ inputted data and plotted in comparison to industry averages over the years. Consequently, companies will be able to check if they are outperforming, performing inline, or falling short of the rest of the market players. They can also examine the trend in their own performance over the years. All this will result in more informed strategic planning, investigation of current operations, and rectification of under-performing processes.

- Automate the process of data collection, analysis, and visualization through an accurate, efficient, lean, and reliable system that meets companies needs and resource constraints.

- Integrate the findings of the benchmarking initiative into the workflow of electrical contracting companies and allow for a free, accessible, and feasible self-performance assessment through a secure, confidential environment. This will encourage companies to input their data, hence, resulting in a larger database that provides an extensive representation of the industry.
5.1 How the Tool Works

For a company-specific benchmarking report to be generated using the online benchmarking tool, a process consisting of five steps, some of which occurs automatically, is executed as illustrated by the flowchart in Figure 50 below.
Figure 50 How the Online Benchmarking Tool Works

5.1.1 Step 1

Electrical contracting companies can access the online benchmarking tool through a website that is to have the University of Wisconsin-Madison domain name and to be hosted by the university’s web hosting services. Once a company accesses the website, it will land on the website
home page, shown in Figure 51 below, which provides general description of the website, the steps that need to be followed, and the expected outcome once all the steps are completed.

Figure 51 Benchmarking Website Home Page

An account corresponding to the company should accordingly be created. Once that is done, a screen showing a sample generated report is displayed to the user who is asked to continue to the web-based questionnaire in order to generate a similar report corresponding to his company. The questionnaire collects general company information, along with its financial and non-financial data. It should be noted that each item of the data asked for is coupled with context-sensitive help and online glossary in the form of informational text that appears when hovering over the item to ensure that the user fully understands what type of data is asked for before inputting it. A screenshot of one of the questionnaire sections is shown in Figure 52 below.
5.1.2 Step 2

Once Step 1 is completed with the user filling the questionnaire and submitting it, all the inputted data is stored in an online cloud database that is protected to secure the confidentiality of collected data.

5.1.3 Step 3

In this step, a PHP script, which is usually used in web development, is designed to calculate the benchmarking metrics using the data extracted from the first database based on the equations presented in Chapter 3.

5.1.4 Step 4

In this step, the metrics calculated in Step 3 are stored in a second online cloud database that will be used thereafter to generate every company’s personalized report.
5.1.5 Step 5

When completing the web questionnaire, the user is informed that he will receive the company personalized report within one business day. The website administrator is responsible for sending the user the company report. This mechanism is enacted, instead of having the system generating company-personalized reports that can be accessed by the users on the spot, for the purpose of making sure that the inputted data is error free. This will ensure that the accuracy and consistency of the data stored in the research database and presented in the generated reports are maintained. In this step, the website administrator runs an R code that is designed to generate a personalized report for the company in question by extracting the metrics calculated from the second database and generating all the required plots. A data check is then done to make sure that nothing out of the norm indicating an error is witnessed. Subsequently, the company-personalized report is sent via email to the address provided in the web questionnaire.

5.2 Data Confidentiality

Due to the nature of the data collected, while developing the benchmarking tool, it was important to ensure that the data provided by participating companies is maintained confidential. With that, the tool was designed to remove the name of the company once it inputs its information and replace it with a unique code that keeps the profile of the company hidden. The tool generates company-specific reports that only reveal the performance of the company in question with respect to the rest of the industry, with the data of the other participating companies being aggregated to prevent the identification of any individual company. It should also be noted that the benchmarking plots of some metrics that had small sample size were removed from the generated reports to preclude the possible identification of individual companies.
5.3 Tool Output

The tool outputs the results of the benchmarking exercise that can be personalized for each participating company. Each company-specific report generated is comprised of a set of boxplots similar to the ones presented in Chapter 4 for each of the financial and non-financial metrics. In each boxplot, all data points are represented in one color except those pertaining to the company for which the report corresponds to, as depicted in Figure 53 below. This ensures the confidentiality of the data while highlighting the position of the company in question as compared to the rest of the market players. For instance, upon studying Figure 53, company x will notice that the amount of revenue its project management personnel are generating is way below the industry average. This indicates that either company x has a productivity problem when it comes to its project managers, or that it has too many project managers who are not generating to the company an amount of revenue sufficient to justify the costs associated to them. Figure 53 also shows that the performance of company x when it comes to productivity of its project managers has improved over the last four years indicating that what the company has been doing regarding this issue has been working to some extent. Hence, these reports are meant to show companies how they compare to industry averages and to help them pinpoint leverage areas in which their performance can be improved.
Figure 53 Sample Company Personalized Report Plot
6 Chapter 6. Conclusions

This research contributes to the electrical contracting industry as well as to the construction engineering and management community. This chapter provides a summary of the research’s main contributions along with its key results, discusses the main limitations of the research, and ends with a call for future research opportunities.

6.1 Research Main Contributions

The three main objectives that were set out at the beginning of this thesis document were met and provide the following contributions to the electrical contracting industry:

1) This research provided electrical contracting companies with a set of financial and operational benchmarks to continuously improve their business performance and to strengthen their positions in the competitive electrical contracting industry. Choosing to participate in this benchmarking initiative, companies can pinpoint weakness areas in their performance that they were not aware of, areas of strength that they should focus more on and utilize, and potential improvement opportunities.

2) To further facilitate the benchmarking process and allow for easy, self-performance assessment, this research provides a web-based benchmarking interactive tool that allows any electrical contracting company to enter its data and receive in turn a customized analysis report. Not only receiving valuable information about the status of the industry, each company will also be able to know where it stacks up with respect to the rest of the
market players. This tool is an integral part in making the benchmarking initiative presented in this research ongoing and continuous.

3) When evaluating the implementation of a new practice, any electrical contracting company would be interested in any information that can support its benefit/cost analysis of adopting this practice. This research achieves this by using the collected qualitative data from the benchmarking exercise to identify the best practices of electrical contracting companies that have been highly correlated with the companies’ profitability. Hence, electrical contractors can use the information presented to strategically plan and make informed decisions on what to adopt and implement to boost their companies’ performance.

6.2 Research Limitations

Although this research presents significant findings, it is important to note that the main purpose of this study is to develop and implement a benchmarking initiative for the electrical contracting industry, along with presenting a framework on how best practices can be identified. Comprehensive data collection for a benchmarking study requires a significant time frame that is usually longer than the duration of this research. Also, the nature of the data collected, with regards to it being either financial or company confidential information, has made the data collection process challenging as many companies were reluctant to share their information. As a result, the dataset used for this research was comprised of 28 electrical contracting companies, which is smaller than many of the past benchmarking initiatives discussed in the Literature Review. That being said, when inferring the findings of this research, the relatively small size of the dataset should be taken into consideration. On another note, it is important to highlight that the statistical
information and results presented in this research is representative of the companies participating in this benchmarking initiative.

6.3 Future Research

This study presents a benchmarking model for electrical contracting companies and provides an easy, efficient, and autonomous way for continual data collection and benchmarking analysis. Given the relatively small size of the dataset used in this research, future endeavors should definitely include expanding the database to be provide a more accurate and comprehensive representation of the electrical contracting industry.

A similar study of the best practices can also be conducted when a larger dataset is gathered in order to confirm this research’s findings and draw broader conclusions. Expanding the list of qualitative factors and practices is also important to keep up with emerging cutting-edge technologies and innovative project management concepts. Moreover, the qualitative portion of the survey can be expanded to include the level of implementation of each practice, rather than just asking if the practice is being implemented or not, to further study the effect of different levels of practice implementation on company performance.

Finally, future research can study the influence of company practices on companies’ performance with regards to several metrics and not only the net profit percentage. Although profitability remains the number one concern to companies, other performance metrics, including labor productivity, safety performance, and quality of work, among others, should also be studied when identifying the impact of companies’ practices.
Appendix A – Bibliography


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Appendix B – Research Questionnaire

This questionnaire aims to:

- Provide your company, as well as the electrical construction industry, with quantitative measures of performance at the company level.
- Come up with an overall performance score similar to quarterback rating.
- Position your company’s performance relative to the electrical construction industry as a whole.
- Study performance trends in your company and in the electrical construction industry from 2014 to 2018.
- Reveal causes of low performance and identify the best practices for performance improvement in your company and in the electrical construction industry.
- Establish metrics for your company, as well as the electrical construction industry, to evaluate management performance.
- Optimize staffing for your company, as well as the electrical construction industry, in terms of the number of project managers needed and the number of technical staff necessary for different sizes and types of projects.
- Create metrics as well as benchmarks reflecting project manager performance relating to:
  - The annual net profit each project manager should be able to generate.
  - The ability of a project manager to generate profit as a multiple of his or her salary.
  - The amount of work per month (in dollars) that each project manager should be able to manage.
Productivity Assessment – Company Level

Company/Respondent Information

Company name: ________________________________
Respondent name: ________________________________
Respondent Telephone: ________________________________
Respondent Email: ________________________________

You would prefer correspondence via:
☐ Email
☐ Telephone
☐ Other (please specify) ________________________________

When is the most convenient time to reach you during the day? ________________________________

What is the position you hold within your current company? ________________________________
Company Background Information

1. Please specify the percentage of revenue that comes from: *(The percentages should add up to 100%)*
   - [ ] Bidding Work (plans and specs) ______%
   - [ ] Service Work ______%
   - [ ] Other (please specify) ____________%

2. Please specify the percentage of revenue that comes from: *(The percentages should add up to 100%)*
   - [ ] Design-Bid-Build (Hard Money) ______%
   - [ ] Design-Build with in-house design team ______%
   - [ ] Design-Build with a joint-venture with design firm ______%
   - [ ] Design-Assist ______%
   - [ ] Integrated Project Delivery ______%
   - [ ] Other (please specify) ____________%

3. Please identify the percentage of work your company undertakes as: *(The percentages should add up to 100%)*
   - [ ] Prime contractor (contract directly with the owner) ______%
   - [ ] Separate prime with a lead contractor (GC/CM) ______%
   - [ ] Sub-contractor ______%
   - [ ] Sub-sub-contractor ______%
4. Please check the types of market sectors undertaken by your company. For each type checked, indicate the percentage of your company’s total work the sector represents. *The percentages should add up to 100%*
   - Commercial (banks, retail, office buildings, etc.) ___%  
   - Institutional (hospitals, correctional facilities, laboratories, Post-Secondary Education, etc.) ___%  
   - K-12 ___%  
   - Industrial Or Manufacturing ___%  
   - Data Centers ___%  
   - Residential (single and/or multi-family housing, condos, high-rise, etc.) ___%  
   - Water/Waste Water Treatment ___%  
   - Heavy Civil/Highway ___%  
   - Other (please specify) ___________________ ___%  

5. Check the specific types of work provided by your company (check all that apply) and indicate the percentage each contributes to your average annual volume ($) *The percentages should add up to 100%*
   - Electrical Work ___%  
   - Low-Voltage (Fire Alarms, Instrumentation, Datacom etc.) ___%  
   - Transmission Power Line and Substations ___%  
   - Other (please specify) ___________________ ___%  

6. How do you calculate FTE?
   - 1800 hours / year  
   - 2080 hours / year  
   - Other (please specify) ___________________
<table>
<thead>
<tr>
<th></th>
<th>Fiscal Year</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
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<tbody>
<tr>
<td>Total Revenue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Expenses of the Company</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Cost of Materials Purchased by Your Organization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Penalties Disbursed to Subcontractors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profitability (%)</td>
<td>&lt;2 2-5 5-10 &gt;10</td>
<td>&lt;2 2-5 5-10 &gt;10</td>
<td>&lt;2 2-5 5-10 &gt;10</td>
<td>&lt;2 2-5 5-10 &gt;10</td>
<td>&lt;2 2-5 5-10 &gt;10</td>
<td></td>
</tr>
<tr>
<td>Paid Overhead Premiums</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Paid Second Shift Premiums</td>
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<tr>
<td>Paid Double Time Premiums</td>
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<td></td>
<td></td>
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<tr>
<td>Absenteeism (%)</td>
<td>&lt;5 5-10 &gt;10</td>
<td>&lt;5 5-10 &gt;10</td>
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<td>&lt;5 5-10 &gt;10</td>
<td>&lt;5 5-10 &gt;10</td>
<td></td>
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<td>Total Man-Hrs Expended of Bargaining Unit Employees (BUE)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Man-Hrs Estimated BUE (Including Approval of Change Order Hour)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Full Time Equivalents (FTE) of BUE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Number of Hours Worked by BUE per Week</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Actual Approximate Turnover Rate (%) of BUE</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Sub-Journeyman to Journeyman Ratio (Actual Ratio)</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Journeyman to Foremen or General Foremen or Superintendent Ratio (Actual Ratio)</td>
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<tr>
<td>Total Cost (%) BUE</td>
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<tr>
<td>Total Number of FTE of Project Managers/Executives</td>
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<td>Total Cost (%) of Project Managers/Executives</td>
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<tr>
<td>Total number of FTE of Project Engineers</td>
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<tr>
<td>Total Cost (%) of Project Engineers</td>
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<tr>
<td>Fixed (Company) Overhead (%)</td>
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<tr>
<td>Variable overhead (%)</td>
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<tr>
<td>Repeat Business Customers (%)</td>
<td>&lt;1 1-2 2-3 &gt;3</td>
<td>&lt;1 1-2 2-3 &gt;3</td>
<td>&lt;1 1-2 2-3 &gt;3</td>
<td>&lt;1 1-2 2-3 &gt;3</td>
<td>&lt;1 1-2 2-3 &gt;3</td>
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<tr>
<td>Warranty issues Cost (%)</td>
<td>&lt;1 1-2 2-3 &gt;3</td>
<td>&lt;1 1-2 2-3 &gt;3</td>
<td>&lt;1 1-2 2-3 &gt;3</td>
<td>&lt;1 1-2 2-3 &gt;3</td>
<td>&lt;1 1-2 2-3 &gt;3</td>
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<tr>
<td>Experience Modification Rate (EMR)</td>
<td>&lt;0.75 0.75-1 &gt;1</td>
<td>&lt;0.75 0.75-1 &gt;1</td>
<td>&lt;0.75 0.75-1 &gt;1</td>
<td>&lt;0.75 0.75-1 &gt;1</td>
<td>&lt;0.75 0.75-1 &gt;1</td>
<td></td>
</tr>
<tr>
<td>OSHA Recordable Incident Rate (%)</td>
<td>&lt;1 1-2 2-3 &gt;3</td>
<td>&lt;1 1-2 2-3 &gt;3</td>
<td>&lt;1 1-2 2-3 &gt;3</td>
<td>&lt;1 1-2 2-3 &gt;3</td>
<td>&lt;1 1-2 2-3 &gt;3</td>
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<tr>
<td>Actual Approximate Hit Rate (%)</td>
<td></td>
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<tr>
<td>Gross Profit (%)</td>
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<tr>
<td>Net Profit (%)</td>
<td></td>
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</tbody>
</table>
1. Prefabrication (%): Total hours spent in prefabrication work as a percentage of total hours utilized by the company (if not tracked, please provide an estimate).

2. Absenteeism (%): Percentage of days bargaining unit employees' were absent annually.

3. Bargaining Unit Employees (BUE): craft workers including apprentices, journeymen, foremen, pre-fab shop workers (if any), material handlers (if any), construction w ремen (if any), etc.

4. Estimated Man-Hours shall be used for awarded projects.

5. Full time Equivalent (FTE): A unit of measurement that is used as an indication of the workload of an employed person, so that a fully employed person is 1 FTE, a person who works half the normal load is 0.5 FTE, and so on.

6. Turnover Rate (%): Total number of separations of BUE that occurred during the year as a percentage of the average number of BUE during that year.

7. Fixed Company Overhead: Set of costs that do not vary as a result of change in workload. These costs are needed in order to operate the business. Some examples of fixed overheads are administrative-personnel salaries, accounting personnel salaries, office personnel salaries, office expenses, company insurance, real estate expenses, etc.

8. Variable Overhead: Set of costs that are not discretely charged to a specific project and tend to vary depending on the company revenue.

9. Repeat Business Customers (%): Percentage of customers who come back for a repeat business with the firm (regarding non-competitive bid work only).

10. OSHA Recordable Incident Rate: Number of OSHA recordable cases multiplied by 200,000, and then divided by total man-hours of BUE.

11. Hit Rate: dollars awarded divided by dollars bid or for (regarding construction projects only).

12. Gross Profit shall be calculated according to the equation below.

\[
\text{Gross Profit} = \frac{\text{Total Sale Revenue} - \text{Direct Cost (Labor, Equipment, Material and Subcontractors)}}{\text{Total Sale Revenue}}
\]

13. Net Profit shall be reported before tax deductions.

*Cost shall include salary/wages, fringe benefits, and burden.
### Current Company Practices

#### 1) Prefabrication

1.1 Do you own a dedicated prefabrication shop?
   - [ ] Yes
   - [ ] No

1.2 Where is prefabrication typically performed at your company? (check all that apply)
   - [ ] On project’s site
   - [ ] In the company’s shop
   - [ ] Outsourced
   - [ ] None

#### 2) Technology Use

2.1 How would you characterize your company’s level of involvement in BIM?
   - [ ] Not using BIM within our company
   - [ ] Using existing BIM tools but are not creating our own tools within our company
   - [ ] Always outsourcing the BIM component
   - [ ] Creating BIM tools to use within our company

2.2 If you are currently using BIM, how many BIM staff members are typically in your company?
   - [ ] [ ] staff members

2.3 What technology is your company using that utilizes a completed BIM model?
   - [ ] Total stations (e.g. Trimble)
   - [ ] GPS surveying
   - [ ] We are not using any additional technology
   - [ ] Other (please specify):

2.4 What data storage method does your company use?
   - [ ] Mainframe storage
   - [ ] Cloud storage

2.5 Do your field workers/foremen use tablets (iPad, etc.) on site?
   - [ ] Yes
   - [ ] No

2.6 What other new technology is your company utilizing?
   - [ ] 3D Printing
   - [ ] 3D Scanning
   - [ ] Augmented Reality (AR) / Virtual Reality (VR)
   - [ ] Artificial Intelligence (AI)
   - [ ] Drones
   - [ ] Other (please specify):
### 3) Labor Management

3.1 How do you incentivize Project Managers/Executives?
- [ ] Annual formal incentive plans
- [ ] Discretionary bonus plans

3.2 What factor(s) do you take into consideration while calculating Project Managers/Executives incentives? (check all that apply)
- [ ] Profit per year
- [ ] Management performance
- [ ] Safety performance
- [ ] Customer satisfaction
- [ ] Other (please specify):

3.3 Do you have a differentiated compensation plan (golden handcuffs or restricted stock plan) for your key people? If yes, for how many? [ ] Yes, for ___ personnel [ ] No

3.4 Do you incentivize foremen/superintendents based on their labor savings? If yes, how much do you offer them for each hour of labor saved?
- [ ] Yes, ___ $/man-hour saved [ ] No

3.5 Is your company suffering from shortage of qualified Project Managers/Executives?
- [ ] Yes [ ] No

3.6 If the answer to the previous question was yes, then what is your company doing to mitigate that problem?
- [ ] Offering internships and co-op programs to college students to attract new talent
- [ ] Offering training and mentorship programs to superintendents to prepare for their promotion to Project Managers
- [ ] Other (please specify): ________________

3.7 Does your company conduct regular evaluation of the overall performance of its board and the performance of its individual directors?
- [ ] Yes [ ] No

3.8 How many instruction hours of management training are undertaken per person per year?
- [ ] None
- [ ] 1-10 hours
- [ ] 11-20 hours
- [ ] 21-30 hours
- [ ] >30 hours

3.9 Please mark the types of training undertaken by your field management staff (check all that apply)
- [ ] Project management
- [ ] Leadership and Communication
- [ ] Labor Relations
- [ ] Interpersonal/development training
- [ ] Business Management
- [ ] Other (please specify): __________
4) Material Management

4.1 On average, how many vendors does your company buy most of your material from on a yearly basis?
□ 1-2 vendors □ 3-5 vendors □ 6-10 vendors □ >10 vendors

4.2 Who handles material purchasing?
□ Field management staff (e.g. Project managers, supervisors, etc.) purchase all materials
□ A company-wide purchasing department handles material purchases
□ Vendor integration in ordering, delivering, and handling materials via a strategic alliance

5) Quality Management and Evaluation

5.1 Do you document lessons learned from each project?
□ Yes □ No

5.2 How do you gauge customer satisfaction at the end of each project? (check all that apply)
□ General judgement by project supervisor □ Through post-job external closeout meetings
□ Through evaluation phone calls □ Through evaluation questionnaires
□ Through tracking % of repeat business customers □ Other (please specify): ____________________________

5.3 Are you a part of a peer review program?
□ Yes □ No

6) Productivity and Management Practices

6.1 How does your company track productivity and measure percent complete? (check all that apply)
□ Project manager/supervisor opinion of percent complete
□ Tracking percent complete by actual installed quantities
□ Tracking earned hours, estimated hours, and actual hours at the activity level
□ Other (please specify): ____________________________

6.2 Is your company currently using any of the following productivity improvement programs? (check all that apply)
□ Vendor integration □ 80-20 program □ Lean construction □ Dedicated company-wide productivity improvement teams
□ Other (please specify): ____________________________
6.3 What enterprise management software is your company using? (check all that apply)
- ProCore – by Procore Technologies
- Vista – by Viewpoint
- JD Edwards – by Oracle
- eSUB Construction Software – by eSUB Inc.
- Compass – by Microsoft SharePoint
- COINS – by Construction Industry Solutions
- IFS Applications: ERP Software – by IFS
- Other (please specify) ____________

6.4 How would you categorize your company’s estimating practices?
- Project managers estimate and manage
- Dedicated estimating staff
- Other (please specify) ____________

6.5 What are other innovative management and productivity enhancement practices successfully undertaken by your company?
- Other (please specify) ____________

6.6 Do you have dedicated Business Development* personnel? If yes, how many? (*Those responsible for developing marketing strategies and managing relationships with clients)
- Yes, ___ personnel
- No

6.7 Do you have dedicated Logistics Planning personnel? If yes, how many?
- Yes, ___ personnel
- No

6.8 Do you have dedicated Operational Risk Management (ORM) personnel? If yes, how many?
- Yes, ___ personnel
- No

6.9 Do you have dedicated Productivity Improvement personnel? If yes, please elaborate more about their type of work.
- Yes, __________________________
- No

6.10 What is your degree of difficulty in obtaining bonds?
- Easy
- Moderately difficult
- Very difficult

6.11 How frequent do you team up with other companies to increase your bonding capacity?
- None
- Once per year
- Twice per year
- > Three times per year
You have completed the questionnaire. Please take a moment to evaluate the questionnaire by providing your feedback below.

Did you face any difficulties while answering the questionnaire?
□ Yes, (please elaborate) □ No

Was any of the questions unclear or difficult to comprehend?
□ Yes, (please elaborate) □ No

If you believe the questionnaire is missing certain elements/questions, please use the space below to describe them.

______________________________________________________________________________________

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Please use the space below to provide any further comments/feedback.

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Thank You for Helping Improving the Electrical Construction Industry.

We truly appreciate your time and effort; it will further the research process and allow for the accomplishment of findings that you can use to significantly enhance your company.