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A Critical Analysis of the Structural Changes Related to Craft Demographics Influencing Craft Supply and Demand in the United States Across Multiple Dimensions

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A CRITICAL ANALYSIS OF THE STRUCTURAL CHANGES RELATED TO CRAFT DEMOGRAPHICS INFLUENCING CRAFT SUPPLY AND DEMAND IN THE UNITED STATES ACROSS MULTIPLE DIMENSIONS

by

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A DISSERTATION
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has been approved for the Department of Civil, Environmental, and Architectural Engineering

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Professor Paul M. Goodrum

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Professor Keith R. Molenaar

Date_______________________

The final copy of this dissertation has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards of scholarly work in the above mentioned discipline.

EXECUTIVE SUMMARY

Mohammed Albattah (Ph.D., Civil Engineering)

A Critical Analysis of the Structural Changes Related To Craft Demographics Influencing Craft Supply And Demand in the United States across Multiple Dimensions

Dissertation directed by: Professor Paul M. Goodrum

Purpose: To explore and perform critical analyses of the structural changes related to craft demographics that are currently influencing craft supply and demand in the United States across multiple dimensions.

Problem: There is limited recent academic research that has examined the emerging dynamics of the construction labor market in the U.S. The departure of the overall dissertation effort occurs along three fronts: 1) understanding how the current craft shortage varies by the construction industry's occupations, and geography locations; 2) understanding how structural changes in craft perception of the intrinsic and extrinsic job characteristics influence their motivation for work; and 3) understanding the multiskilling strategy, and the influence of race (Hispanic vs. non-Hispanic) on that strategy.

Background: The U.S construction industry faces a workforce shortage, primarily among highly skilled trades, for two reasons: 1) strong construction demand across multiple industry sectors; and 2) low supply levels of skilled craft workers (Komarnicki 2012; Glavin 2013; Wilder 2013; Shelar 2013). By definition, highly skilled trades require specialized education or training, which can take years to complete *(e.g. carpenters, electricians, and pipefitters),* and low skilled trades are those requiring minimal to no training and instruction *(e.g. general helpers)* (Vereen et al. 2013). A primary factor for the low supply of craft workers is current workers leaving the construction industry, either for other industries or retirement (Belman 2013). The shortage of skilled labor in the construction industry is not a recent issue, but rather a cyclical problem (Dainty et. al. 2004; Castaneda et. al. 2005). The U.S. Bureau of Labor Statistics (BLS) predicted that the U.S. construction industry will be the fastest growing industry in the nation over the next decade with an estimated 1.6 million new jobs (Glavin 2013; Gonzales 2013). Because of such

rapid growth, 76% of construction companies in the U.S. are having difficulties finding qualified workers to fill job openings (AGC 2015).

Intellectual Merit: The objective of this research is to shed light on what causes heterogeneous shortages, with regard to occupations and geographical regions, in the U.S. construction workforce and to examine a possible strategy that could mitigate these shortages. Chapter 2 focuses on measuring national and regional craft shortages by using a public data set *(US BLS' Current Population Survey (CPS))* and applying Veneri's (1999) strategy *(combined available indicators)*. Chapter 3 focuses on motivations that could retain the current craft workers by using a public data set *(General Social Survey (GSS))* and applying a Chi-Square analysis on the long-term trends of craft workers satisfaction and their preferences (intrinsic rewards vs. extrinsic rewards). Chapter 4 focuses on a multiskilling strategy that meets the preferences of how current workers like to be rewarded using the *National Craft Assessment and Certification Program (NCACP)* data set from National Center for Construction Education and Research (NCCER) and applying Categorical Principal Component Analysis (CATPCA) among Hispanic and non-Hispanic craft workers.

Broader Impact: This research on the construction labor market in the U.S. will accelerate a dialogue necessary to solve its labor shortages. The metric in chapter 2 has the potential for assisting future researchers in construction or other industries, to define the workforce availability by exclusively using public data sets. Therefore, they can apply a different sample size to similar or differing data sets. Owners and industry leaders may use this evidence in early stages of projects to mitigate the craft shortages by applying alternative management approaches. Furthermore, the construction community and educators within vocational programs may reference this chapter to direct future workers to trades in high demand. Chapter 3 will guide the industry's future recruiting and retention strategies, which should emphasize the extrinsic nature of working in the construction industry—i.e. wages. Finally, the findings in Chapter 4 show skill development amongst Hispanics and non-Hispanics. Researchers and industry leaders may use this chapter to help improve the career progression among Hispanic craft workers in the United States.

DEDICATION

To my mother, Wafigah Alrammah, and my father Abdullah Albattah, for all of the love and support they have given to me since my birth. Today, I am happy to share with you my dissertation as announcement to achieve our goal. To my wife, Taiba Alramah, for her love, patience, and wisdom during our journey to get my degree, which was filled with ups and downs. I would not achieve this goal without your unlimited support. To my kids, Jood and Leen, you kept changing my mode and provide me with the necessary energy to keep the work up. Last but not least, my sister, May, and brothers, Mazen, Abdulrahman, and Abdulaziz for all your encouragement and prayers to have success in my life. I love you all my wonderful family.

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1. INTRODUCTION

1.1 Background and Motivation

Construction is one of the largest economic industries in the United States. In 2014, construction accounted for 3.8% of the U.S.'s Gross Domestic Product (GDP) (BEA 2015), and in 2012 construction employed approximately 9 million workers (Dong et al. 2014).

Currently, the construction industry faces workforce shortages, mainly in highly skilled trades, for two combined reasons: 1) the high demand for construction projects; and 2) the low number of skilled craft workers (Komarnicki 2012; Glavin 2013; Wilder 2013; Shelar 2013). Shah and Burke (2005) defined a skill as "an ability to perform a productive task at a certain level of competence"; further, the Australian Business Characteristics Survey (BCS) defined a skills shortage as "an insufficient supply of appropriately qualified workers available or willing to work under existing market conditions" (Healy et. al. 2011). The skills requirements are, however, qualitative, and can be met by formal education and training or informal training through experience on the jobsite. Vereen (2013) defined highly skilled trades as those requiring specialized education or training which take years to complete (i.e. carpenters, electricians, and pipefitters) and defined low skilled trades as those requiring minimal to no training and instruction (i.e. general helpers, and roofers).

The shortage of skilled construction workers is connected to the overall health of the economy and is thus cyclical (Dainty et. al. 2004; Castaneda et. al. 2005). Periods of economic recession have direct negative impacts on the industry's health (e.g., reduced construction volume) as well as indirect impacts (e.g., loss of craft workers as they migrate to other industries). Meanwhile periods of economic expansion have positive impacts on the industry's health (e.g. increased demand for construction projects) and therefore a higher demand for workers. In this latter, critical labor market shortages occur partly as a result of the loss of workers during the preceding recession (FMI 2013).

For example, during a period of economic recovery in the early 1980's that followed a recession, the Business Roundtable predicted that a shortage of skilled craft workers would hamper the growth of both the open shop and union construction sectors by the late 1980s (BRT 1983). The prediction was confirmed by a 1996 Business Roundtable study that found that 60% of its surveyed members were experiencing a shortage of skilled craft workers, and 75% of the respondents indicated that the shortage had worsened in the five years prior to the study (BRT 1997). The shortage of craft workers apparently has further worsened in the 2000's. In 2001, the Construction Users Roundtable (CURT) conducted a survey in which 82% of the respondents reported shortages on their projects. In addition, 78% of the same respondents indicated that the shortage had worsened in the three years prior to the study (CURT 2001). In 2007, that number had risen to 86% (Sawyer and Rubin 2007).

During the most recent economic downturn that began in 2008, the U.S. construction industry experienced immediate increases in unemployment as a result of the decrease in demand for construction projects. Yet, the 2008 economic downturn also preceded what is now considered the longest economic recovery period in construction and all other U.S. industries (Fridley 2013). The Bureau of Labor Statistics (BLS) estimates that the U.S. construction industry will be the fastest growing industry over the next decade, which will create an estimated 1.6 million jobs (Glavin 2013; Gonzales 2013). However during periods of high regional construction volume, hiring and retaining skilled craft workers is challenging because companies must compete for a relatively fixed craft labor pool that shrink during periods of unemployment in the preceding recessions as unemployed craft workers seek jobs in other industries (FMI 2013).

Because of the high demand for construction projects, companies are losing money due to the lack of skilled craft workers. According to the Associated General Contractor (AGC), 76% of construction companies in the U.S. are having difficulty finding qualified workers to fill job openings (AGC 2015), specifically in the Gulf Coast region (Wilder 2013).

In addition to the cyclical economic periods, there are three significant reasons for the low number of skilled craft workers in specialized trades. One reason is that more skilled workers are leaving the industry. This is due, in part, to the aging population. In 2010, 39% (3.5 million) of the U.S. construction workforce was a Baby Boomer[1], many of whom had already reached the normal retirement age (which varies from age 65 to age 67) (SSB 2014; CPWR 2013). Just a decade earlier, 49% of the construction workers were Baby Boomers (4.6 million) (CPWR 2007). At the same time when many skilled workers reached retirement age, many existing workers left the construction industry for other industries, especially during the Great Recession (2008 – 2009). Second, there has also been a lack of new workers entering the construction industry (Druker and White, 1996). Finally, the low number of skilled craft workers can also be attributed to a mismatch between current skills of workers and the demand for certain skills (the skills gap). Figure 1 is an influence diagram showing the reasons and their sources that contribute to the workforce shortages. The rectangles represent major reasons “consequences” of the sub-reasons (circles). The colors represent the direction of the sequence from sub-reasons to major reasons; from gray to yellow and light orange to blue to purple to red (the problem).

[1] The Baby Boomers are generation of workers born between 1946 and 1964 (UNJSPF 2015).

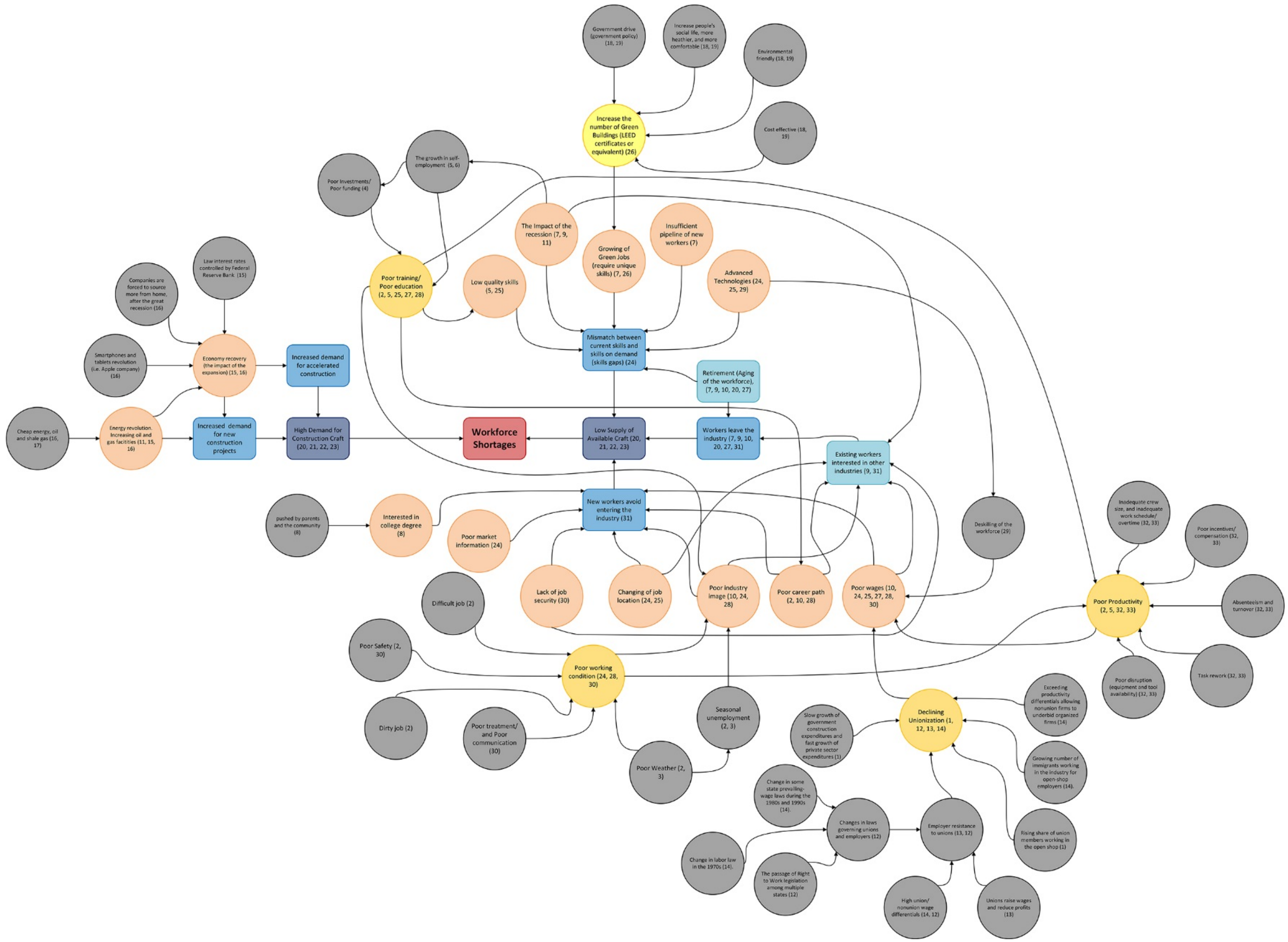

Figure 1: Workforce Shortages and its Reasons in the Construction Industry

Note: Reference code for Figure 1 include (full citations are included in the References: (1) – Allen (1988), (2) – ILO (2001), (3) – Gunderson (2001), (4) – Watson (2007), (5) – Dainty et al. (2004), (6) – Mackenzie et al. (2000), (7) – ASTD (2012), (8) – Olsen et al. (2012), (9) – Belman (2013), (10) – Makhene and Thwala (2009), (11) – FMI (2013), (12) – Linneman et al. (1990), (13) – Kleiner (2001), (14) – Belman and Voos (2006), (15) – Schoen (2014), (16) – Clinch (2014), (17) – CNBC (2014), (18) – Green Resource Council (2015), (19) – O'Mara and Bates (2012), (20) – Komarnicki (2012), (21) – Glavin (2013), (22) – Wilder (2013), (23) – Shelar (2013), (24) – Shah and Burke (2005), (25) – Healy et al. (2011), (26) – USGBC (2013), (27) – Watson (2007), (28) – Castaneda et al. (2005), (29) – Agapiou et al. (1995), (30) – CII (2000), (31) – Druker and White (1996), (32) – Dai et al. (2009), (33) – Shashank et at. (2014).

There is no single solution to resolve the shortage problem. Multiple approaches are needed to minimize the shortage (Komarnicki 2012; Healy et. al. 2011). Some solutions focus on retaining current craft workers (e.g. by increasing workers job satisfaction), others focus on attracting new craft workers to the industry (e.g. by enhancing vocational programs at high schools), and other solutions are based on creating different management approaches (e.g. prefabrication, modularization, and relocation of craft workers). Figure 2 indicates suggested solutions, some of which are currently in place in some companies. The rectangles represent major strategies "consequences" of the sub-strategies (circles). The colors represent the direction of the sequence from sub-strategies to major strategies; from gray to yellow and light orange to blue to purple to red (the optimum mitigation).

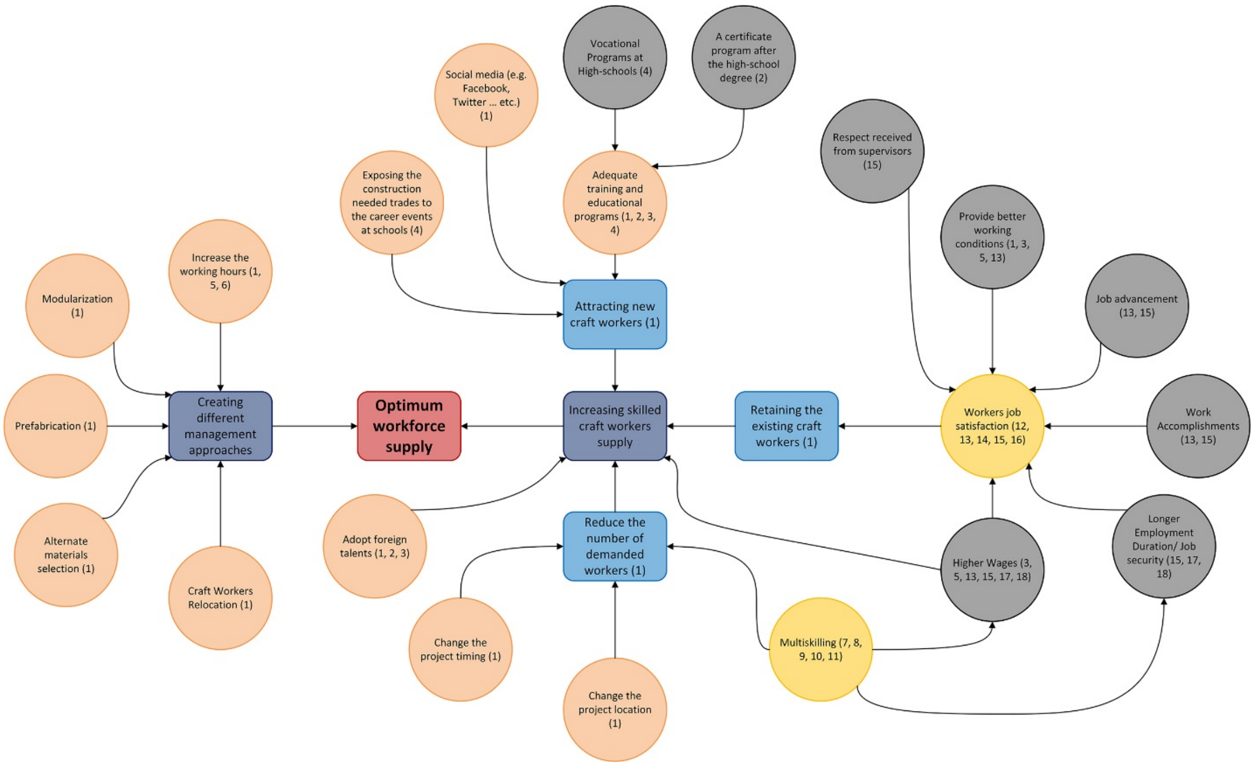

Figure 2: Mitigation Strategies for Minimizing the Workforce Shortages

Note: Reference code for Figure 2 include (full citations are included in the References: (1) – CURT (2015), (2) – Gonzales (2013), (3) – Komarnicki (2012), (4) – Dainty et al. (2004), (5) – Healy et al. (2011), (6) – Shah and Burke (2005), (7) – Burleson (1997), (8) – Gomar et al. (2002), (9) – Wang et al. (2009), (10) – Carley et al. (2003), (11) – Haas et al. (1999), (12) – Borcherding and Oglesby (1974), (13) – Herzberg et al. (1959), (14) – Hackman and Oldham (1976), (15) – Gazioglu and Tansel (2006), (16) – Blanchflower and Oswald (1999), (17) – Aletraris (2010), (18) – Rose (2003).

1.2 Dissertation Organization

This dissertation is presented in a three journal paper format. Each chapter from chapter 2 to chapter 4 is a stand-alone paper for publication that contains its own introduction, literature review, methodology, results, conclusion, and references. An overlap in some aspects of these three papers (i.e. introduction and literature review) should be expected because of the independent nature of them. The conclusion (chapter 5) summarizes the overarching findings of the three papers (chapters 2, 3, and 4) and provides suggestions for future research.

1.3 Research Objectives and Dissertation Format

The main objectives of this research are threefold. First, the research provides a new metric to measure workforce availability in the construction industry's trades in the United States (nationally and regionally). Second, the dissertation studies the factors (intrinsic rewards vs. extrinsic rewards) that help retain current craft workers in the construction industry. Third, the research examines the differences in multiskilling among Hispanic and non-Hispanic craft workers. Figure 3 is a conceptual overview of research questions and dissertation format.

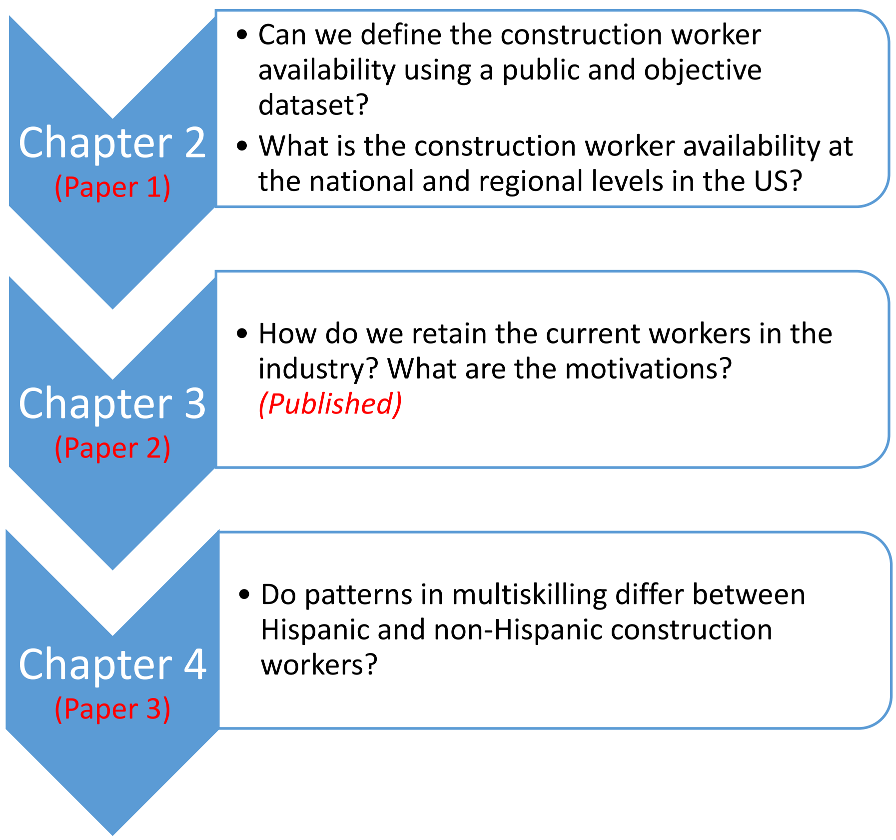

Figure 3: Conceptual Overview of Research Questions and Dissertation Format

To meet the research objectives, the author has addressed the following hypotheses:

1- The future demand of highly skilled craft workers in construction will be greater than its predicted supply.

- The demand varies by regions and by trades.
- The craft worker availability can be determined by using a method that uses a combination of available indicators (unemployment rate, employment growth rate, wage growth rate).

2- Although some workers avoid the construction industry and some leave the industry, current construction workers are satisfied with their jobs. (Paper 2 is published in *the Canadian Journal of Civil Engineering*).

- Understanding the craft workers' characteristics and motivations helps to implement the right strategy for retaining current craft workers.
- Extrinsic rewards are the motivation for current craft workers to stay in the construction industry.

3- Since multiskilling[2] is one of the strategies that meets craft workers' preferences (Burleson 1997; Haas et al 1999; Gomar et al 2002; Carley et al 2003) and increases the craft workers supply (Burleson 1997), Hispanic workers in the construction industry have different skills trends and skill combinations than non-Hispanic workers.

- The number of Hispanic workers in the construction industry has increased sharply during the last two decades, and most of them work in low skilled crafts.

[2] Burleson (1997) define the multiskilling as "a labor utilization strategy in which workers possess a range of skills that are appropriate for more than one work process and that are used flexibly on a project or within an organization."

- There is a difference in skill concentration between Hispanic and non-Hispanic workers among those with a single skill. This difference also applies among multi-skilled individuals, among those with a dual-skill,[3] and those who seek more than two skills.
- The effects of formal training on multiskilling individuals influences the skill combinations among Hispanic and non-Hispanic workers who had dual-skill and who seek more than two skills.

1.4 Research Scope

The author has used multiple U.S. data sources including the Current Population Survey (CPS) by the BLS; the General Social Survey (GSS) from the National Opinion Research Center (NORC), University of Chicago; and the National Craft Assessment and Certification Program (NCACP) from the National Center for Construction Education and Research (NCCER) datasets. The analysis of the dissertation papers focuses solely on craft trades, filtering out managers, superintendents, foremen, inspectors, office staff, and engineers.

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[3] Dual-skill individual is a worker who has certification in two different trades.

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2. A NEW METRIC OF WORKFORCE AVAILABILITY AMONG CONSTRUCTION OCCUPATIONS AND REGIONS IN THE U.S.

2.1 ABSTRACT

The United States construction market is facing a shortfall of skilled craft workers due to increasing labor demands. There are initial indications that the shortages are already having a significant impact on project performance in the industrial construction sector. This paper's contribution to the overall body of knowledge is to apply a new metric (multi-indicator strategy), using a public dataset, to measure national and regional craft worker availability in the construction industry. While there are many indicators for identifying the shortage, this author focuses on three indicators (employment growth rate, wage growth rate, and unemployment rate) that can be used based on their availability in U.S. public datasets. The multi-indicator strategy with a ranking scale is applied using the U.S. Bureau of Labor Statistics' Current Population Survey (CPS) dataset. The findings show that craft worker availability at the national level is different than the craft worker availability at the regional level for different occupations. The most affected occupation was "pipe-layers, plumbers, pipefitters, and steamfitters" which is more related to industrial projects, and the most affected regions were the U.S. West and South.

2.2 INTRODUCTION

Construction is one of the largest economic industries in the United States. In 2014, construction accounted for 3.8% of the U.S. Gross Domestic Product (GDP) (BEA 2015), and in 2012, construction employed approximately 9 million workers (Dong et al. 2014).

Currently, the construction industry faces workforce shortages, mainly among highly skilled occupations because of two combined factors: 1) the high demand for construction projects; and

2) the low number of skilled craft workers (Komarnicki 2012; Glavin 2013; Wilder 2013; Shelar 2013). Shah and Burke (2005) defined a skill as “an ability to perform a productive task at a certain level of competence”; further, the Australian Business Characteristics Survey (BCS) defined a skills shortage as “an insufficient supply of appropriately qualified workers available or willing to work under existing market conditions” (Healy et. al. 2011). The skills requirements, however, are qualitative, and can be met by formal education and training, or informal training through experience on the jobsite. Vereen (2013) defined highly skilled occupations as requiring specialized education or training which take years to complete (i.e. carpenters, electricians, and pipefitters); and defined low skilled occupations as requiring minimal amount or no training and instruction (i.e. general helpers and roofers).

Higher skilled occupations in construction are experiencing greater shortages in comparison to lower skilled occupations. After the Great Recession (2008 – 2009), electricians, pipefitters, welders, boilermakers, millwrights, and ironworkers were among the skilled crafts in the greatest demand among construction industry occupations in the U.S. (Wilder 2013; Shelar 2013; Gonzales 2013). All mentioned occupations are related more to industrial projects. Further, Karimi et al. (2016) found that the shortages are already having a significant impact on project performance in the industrial construction sector.

The shortage of skilled construction workers is connected to the overall health of the economy and is thus cyclical (Dainty et. al. 2004; Castaneda et. al. 2005). Periods of economic recession have direct negative impacts on the industry’s health (e.g., reduced construction volume) as well as indirect impacts (e.g., loss of craft workers as they migrate to other industries). Periods of economic expansion have positive impacts on the industry’s health (e.g. increased demand for construction projects), and therefore there is a higher demand for workers.

In the latter, a critical labor market, shortages occur partly as a result of the loss of workers during the time of recession (FMI 2013).

For example, during a period of economic recovery in the early 1980's that followed a recession, the Business Roundtable predicted that a shortage of skilled craft workers would hamper the growth of both open shop and union construction sectors by the late 1980s (BRT 1983). The prediction was confirmed by a 1996 Business Roundtable study that found that 60% of its surveyed members were experiencing a shortage of skilled craft workers; 75% of the respondents indicated that the shortage had worsened in the five years prior to the study (BRT 1997). The shortage of craft workers worsened further in the 2000's. In 2001, the Construction Users Roundtable (CURT) conducted a survey in which 82% of the respondents reported shortages on their projects. In addition, 78% of the same respondents indicated that the shortage had worsened in the three years prior to the study (CURT 2001). In 2007, that number had risen to 86% (Sawyer and Rubin 2007).

During the most recent economic downturn that began in 2008, the U.S. construction industry experienced immediate increases in unemployment as a result of the decrease in demand for construction projects. Yet the economic downturn also preceded what is now considered the longest economic recovery period in the construction industry along with all other U.S. industries (Fridley 2013). In addition, the Bureau of Labor Statistics (BLS) estimates that the U.S. construction industry will be the fastest growing industry over the next decade, which will create an estimated 1.6 million jobs (Glavin 2013; Gonzales 2013). However in periods of high regional construction volume, hiring and retaining skilled craft workers is challenging because companies must compete for a relatively fixed craft labor pool that shrank in the period of unemployment in the preceding recessions as unemployed craft workers sought jobs in other industries (FMI 2013).

Due to this high demand for construction, companies are losing money due to the lack of skilled craft workers. According to the Associated General Contractor (AGC), 79% of construction companies in the U.S. are having difficulties finding qualified workers to fill job openings (AGC 2015), especially in the Gulf Coast region (Wilder 2013).

An effect of a skills shortage is increased wages, which is both a solution and a problem for completing a project. Employers can attract new workers with higher wages, but projects become costlier for the owner. Indeed if wages increase, the project costs will increase (Healy et. al. 2011; Shah and Burke 2005; Mackenzie et al. 2000). Matt Clark, senior workforce development manager for KBR, believes that if we do not solve the shortage problem, owners will cancel projects because costs will be too high and the return on investment will be low (Wilder 2013). Workforce shortages can also delay construction projects, which likewise could increase the cost (Gonzales 2013). Market analysts noticed a decrease of training investments because of the labor shortages. These trends create an unsatisfactory quality of laborers' skills (Briscoe et al., 2000) because companies become more lenient with their employment requirements, thereby affecting the quality of work (Richardson 2007).

Looking into the future, a study by Vereen (2013) forecasted the craft demand for skilled construction labor in the U.S. considers multiple factors (labor demand, interest rate, material prices, construction output, productivity, and real wages). Vereen (2013) used monthly data between 1990 and 2011 from multiple datasets. Moreover, she applied the Vector Auto Regression (VAR) model for the forecasting and found that a range between 5.3 and 6.3 million skilled workers will be in demand by 2022, which means the current skilled workforce needs to increase by 1.3 to 3 million workers by 2022. Furthermore, this also means 145,000 to 330,000 new workers need to be added annually to meet the demand. This result did not take into account the retirement of the Baby Boomers, though, which will make the demand for workers even higher.

2.2.1 Research Objectives

The main objective of this study was to apply a new metric that measures national and regional craft worker availability. Most of the previous studies in the construction industry conducted a survey or interview to determine the shortages. This study used a public dataset by applying a multi-indicator strategy, an uncharted territory in construction research. This revealed the level of shortage and surplus among occupations and regions, showing the most affected regions by occupation in the construction industry.

2.2.2 Scope

The author used the U.S. Bureau of Labor Statistics' Current Population Survey (CPS) dataset to study craft worker availability. The analysis focused on craft occupations, filtering out managers, superintendents, foremen, inspectors, office staff, and engineers. At the regional level, the author used the census region borders that are already used by CPS. There are four regions include West (13 states), South (17 states, including DC), Midwest (12 states), and Northeast (9 states). Figure 4 shows these regions on the U.S. map.

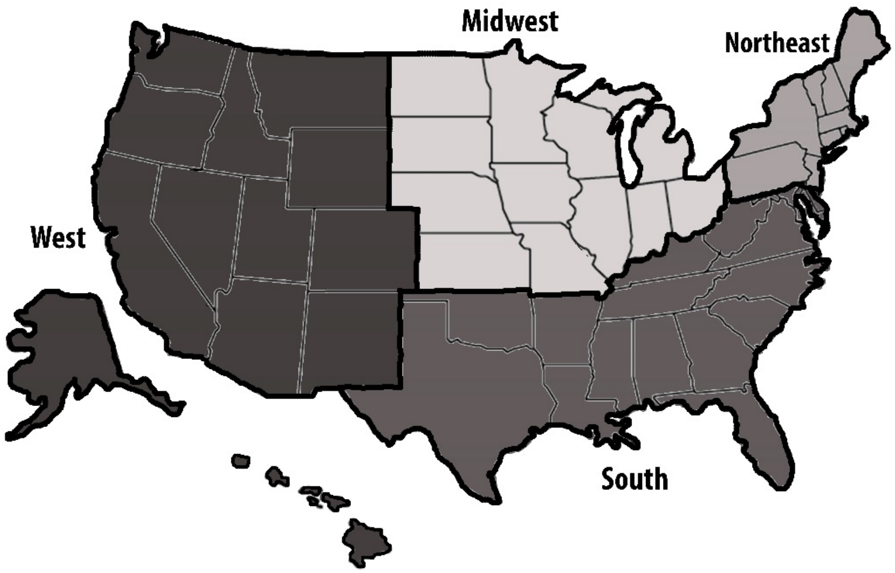

Figure 4: The U.S. Regions

2.3 LITERATURE REVIEW

There are varying opinions about how economists, employers, and unions define the skills shortages. Shah and Burke (2005) address these different perspectives in their journal paper. From the economists' perspective, there is a skills shortage when there are not enough qualified workers who are willing to work under current market conditions with current average wages. Moreover, the skills shortages according to economists could happen in a particular occupation or region. Employers feel there is a skills shortage when they find it difficult to recruit workers to their firms, resulting in an increase in labor costs, especially in the critical labor market. From the unions' perspective, there is a skills shortage when the workers in the critical labor market do not have quality skills (Shah and Burke, 2005).

2.3.1 Reasons for Skills Shortages

Many do agree that the skills shortage issue is multifaceted (Watson 2007; Healy et. al. 2011; Dainty et. al. 2004). There are long-term reasons for skills shortages including a lack of training and inability to attract new workers. There are also short-term reasons for shortages, such as an increasing demand for highly skilled workers and the retirement of the Baby Boomer generation of workers (born between 1946 and 1965). Yet this should not be a problem if there is enough of a supply of workers. Instead, Druker and White (1996) found that the primary cause of the skills shortage was workers leaving construction for other industries and fewer workers entering the industry. Table 1 is a list of reasons for construction workforce shortages from previous studies discussed above, and including additional studies not specifically addressed.

Table 1: Reason for Construction Workforce Shortages from Previous Studies

Reason for Construction Workforce Shortages	Reference (Previous Studies)
Energy revolution (Increasing oil and gas facilities)	FMI 2013; Schoen 2014; Clinch 2014
Economic recovery (the impact of the expansion)	Schoen 2014; Clinch 2014
Changing skill requirements (make it harder)	Watson 2007; Haskel and Martin 1993
Poor education/poor training	Watson 2007; Healy et. al. 2011; Haskel and Martin 1993; Castaneda et. al. 2005
Aging of the workforce/retirement	Watson 2007; Komarnicki 2012; Gonzales 2013; Wilder 2013; Fujita 2014
Lack of specific knowledge (i.e. new technology)	Agapiou et al. 1995; Goodrum and Gangwar 2004; Healy et. al. 2011; Watson 2007
Lack of industrial relations and immigration on skills development	Watson 2007
Poor market information	Shah and Burke 2005
Poor wages	Watson 2007; Shah and Burke 2005; Haskel and Martin 1993; Castaneda et. al. 2005; Healy et. al. 2011; CII 2000; Makhene and Thwala 2009
Poor industry image	Shah and Burke 2005; Dainty et. al. 2004; Castaneda et. al. 2005
Poor working conditions	Shah and Burke 2005; Castaneda et. al. 2005; CII 2000
Geographic location of the job	Healy et. al. 2011; Shah and Burke 2005
Lack of job security	CII 2000
Poor treatment	CII 2000
Poor safety	CII 2000
Lack of a worker-oriented career path	Castaneda et. al. 2005; Makhene and Thwala 2009
Interested in college degree (pushed by parents)	Olsen et. al. 2012
Growing of green jobs (require unique skills)	ASTD 2012; USGBC 2013

2.3.2 Shortage Indicators

During construction, employers and industry leaders know there may be a skills shortage when there are hard-to-fill vacancies, a skills gap, and recruitment difficulties (Haskel and Martin 2001; Shah and Burke 2005). Hard-to-fill vacancies are related to highly skilled occupations. It is hard to find craft workers in highly skilled occupations (i.e. electricians, and pipefitters) during labor market crises. Skills gaps are related to existing workers or new workers who fail to meet the task and/or requirements in terms of quality and productivity. Recruitment difficulties result when a company has trouble finding workers to fill job openings. Most likely there are qualified workers, who could fill a position, yet there are a few factors that interfere with filling a position such as a lack of advertising, low offers of pay and benefits, and geographical location (Shah and Burke 2005). Further, Haskel and Martin (1993) used the 1984 Workplace Industrial Relation Survey (WIRS) to examine correlations between skills shortages and vacancy duration, and they found that companies had to try harder and wait longer during shortages to find workers. Moreover, they found that union firms and those providing profit-related pay suffered less that other firms in term of hiring. Nevertheless, they also found that neither raising wages, nor high unemployment rates (surplus of workers), played a role in reducing the skills shortages (Healy et. al. 2011).

There also are many data indicators for skilled worker shortages. Shah and Burke (2005) state in their study that some indicators include vacancy rate, unemployment rate, net vacancies, and wages. Vacancy rates will increase if hard-to-fill jobs also increase. Typically, hard-to-fill jobs are those that require unique skills, or jobs that people are avoiding because of their nature or location. Next, a lower unemployment rate can also be an indicator of skilled worker shortages, because these are times when fewer people are seeking jobs. However, the unemployment rate could be skewed when people are voluntarily unemployed or not qualified for work. Net vacancies are a combination of vacancy rate and unemployment rate (Shah and Burke 2005). Yet, this indicator will not work until we have enough available statistics about vacancies and unemployment (Roy et. al. 1996). When the number of vacancies is higher than the number of unemployed workers, then a shortage is applied by economists and vice versa. Lastly, high wages could be an indicator of skills shortages, while surpluses push wages down. There are other figures to help analyze the skills shortages such as the number of worker-hours (i.e. overtime), lenient employment requirements, and the immigration/emigration ratio in an occupation, (Shah and Burke 2005).

2.3.2.1 Multi-Indicator Strategy

Cohen (1995) states that supply and demand can be predicted by using a number of indicators. These indicators, along with background information on the various occupations as well as knowing how the labor market works, will yield more effective results (Cohen 1995). To this end, Cohen developed an innovative approach for measuring labor shortages using public and private labor market information. Cohen (1994) defined seven indicators (unemployment rate, employment change rate, change in wage rate, BLS predicted employment growth, replacement demand, labor certifications, and annual flows of supply and demand) to measure the labor market shortage on an occupational level using a number of public and private datasets. The author of this paper used three indicators (unemployment rate, employment change rate, and wage change rate) because they are available in the CPS, a public dataset. Cohen stated that the unemployment rate is the most direct single indicator of labor shortages, and in general, a low unemployment rate would suggest a labor shortage. However, the unemployment rate could also be low when there is a perfect balance of supply and demand (Cohen 1995). In addition, the employment change rate by occupation usually reflects the trend in demand for workers in that occupation. Therefore, an increase in the employment change rate will indicate an increase in demand, and vice versa. Yet this statement is not true if a fixed labor supply exists (Cohen 1995). According to Cohen (1995), based on the traditional economic theory, wages will increase if the demand for workers exceeds supply. Therefore, rapidly rising wages are also an indicator of labor shortages. However, this indicator may lead to the wrong conclusion because wages may change for different reasons, such as wages in unionized industries (Cohen 1995). Nevertheless, Cohen stated that it is difficult to measure supply and demand in the labor force using available datasets. This difficulty is exposed if we apply such indicators on different datasets that result in different conclusions or because of the weaknesses in the data (i.e. small sample size).

Cohen (1995) studied the overall workforce occupations nationally, on a number of datasets from 1989 to 1992, using the above seven indicators together, and then ranked the occupations based on its shortage severity. The top three occupations with the greatest shortages were "other natural scientists," "veterinarians," and "physical therapists." Occupations related to the construction industry did not rank in the top 100 occupations experiencing skills shortages. Yet his method may not be applicable to the construction industry's skills shortages because the construction industry's shortages are cyclical in nature while most of the other industries' shortages are not (Dainty et. al. 2004; Bennett 2005). Further, Cohen's study period from 1989-1992 includes a recession year (1991) which could bias the results among construction occupations (Cohen 1995).

Further, Cohen (1995) divided the occupations into two groups (executive occupations and professional specialty occupations) and used a combination of two indicators (unemployment rate and employment change rate) to study the shortages at the state level using the CPS data from 1989 to 1992. A limitation of the sample size prevented Cohen from using the "change in wage rate" indicator at the state level. There were no severe shortages of executive occupations in any state, although, eight states (Colorado, Delaware, Georgia, Nebraska, Nevada, New Mexico, Tennessee, and Washington) had a severe shortage among professional specialty occupations.

Building on Cohen's work, Veneri (1999) investigated whether an occupational labor shortage can be identified using available public data. She used CPS and Occupational Employment Statistics (OES) datasets to assess the existence of the potential for a shortage considering all occupations in all industries. Three combined indicators were used in each occupation to identify the shortages: 1) employment growth rate, 2) unemployment rate, and 3) wages growth rate following the Cohen (1995) multi-indicator strategy. Veneri (1999) used these indicators on occupations for the 1992-1997 period. Veneri (1999) created a baseline with an average rate of all occupations at each indicator, and considered a shortage in an occupation only if the occupation's employment growth rate was at least 50% higher than the baseline, *and* the occupation's unemployment rate was at least 30% lower than the baseline, *and* the occupation's wage growth rate was at least 30% higher than the baseline. The author of this study applied this methodology with further modifications in the benchmarks that will be discussed in the next section. Figure 5 shows the main difference between the Cohen and Veneri methods.

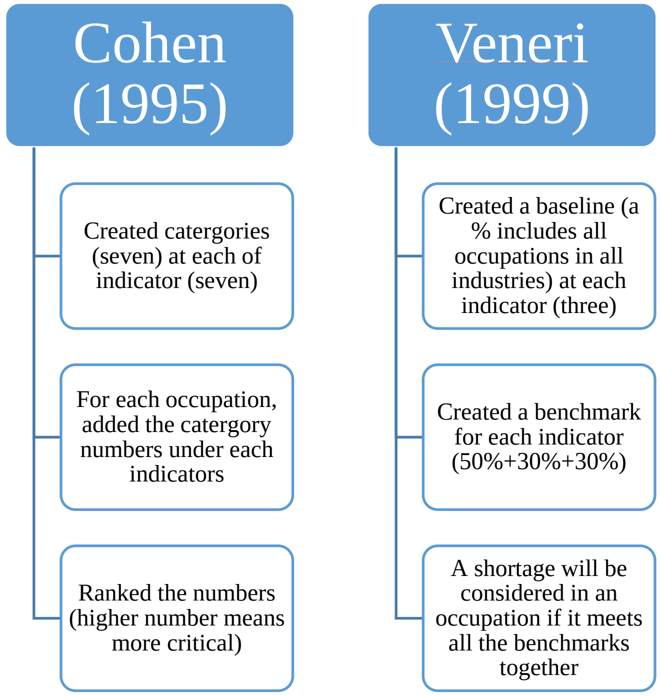

Figure 5: Differences in Multi-Indicator Methods between Cohen and Veneri

Because of the comparability of data from the CPS and OES, only 68 occupations were included in the analysis. Yet only 7 out of the 68 occupations met the three conditions (benchmarks) discussed above (50% higher than the average employment growth, and 30% lower than the average unemployment rate, and 30% higher than the average wage growth rate); these occupations were “management analysts,” “special education teachers,” “dental hygienists,” “marketing, advertising and public relations managers,” “airplane pilots and navigators,” “purchasing agents and buyers,” and “mechanical engineers.” Nevertheless, not all of the seven occupations met the employment growth rate benchmark by using the OES dataset (Table 2).

Table 2: Occupations that met Veneri's Shortages Requirements for the 1992-97 Period (Veneri 1999)

Occupation	Employment Growth Rate		Median Weekly Earnings	Unemployment Rate
	% Change 1992-97 (CPS)	% Change 1992-96 (OES)	% Change 1992-97 (CPS)	Average 1992-97 (CPS)
Total, all occupations	9.9	9.8	13.0	5.1
Management analysis	83.3	7.8	17.9	1.8
Teachers, special education	43.8	13.9	24.2	1.6
Dental hygienists	43.8	23.2	19.6	1.1
Managers, marketing, advertising, and public relations	39.0	9.5	19.8	2.3
Airplane pilots and navigators	25.8	30.7	21.9	1.1
Purchasing agents and buyers	22.0	1.9	17.7	2.5
Mechanical engineers	16.1	.8	18.3	1.6

* a gray cells represents the baseline. CPS = Current Population Survey. OES = Occupational Employment Statistics.

Veneri (1999) also showed results for other occupations that did not meet the above shortage benchmarks. The reason behind showing these occupations is that there was anecdotal evidence of a shortage, including articles in newspapers and journal publications. What interests the author of this study is that three of these occupations are related to the construction industry (carpenters, electricians, and plumbers-pipefitters-and steamfitters). All of these occupations meet the 50% employment growth rate's benchmark, but none of them met the 30% unemployment rate's benchmark. However, only "plumbers, pipefitters, and steamfitters" met the 30% wage growth rate's benchmark. Therefore, based on Veneri's methodology, the shortage was not applicable in these three occupations.

Some studies agreed with Veneri that combining indicators with anecdotal information will reveal better results identifying labor shortages in certain occupations (Passmore 2000; Castaneda et. al. 2003; Barnow et. al. 2013). Other studies, however, disagree with her methods and benchmarks, since they did not show a labor shortage in occupations that have anecdotal evidence of a shortage (Martin and Ruhs 2011).

The author of this study believes that the baseline of the Veneri methodology must account for industrial context and therefore must be revised, which affects the results for the construction industry's occupations. Because the construction industry has a cyclical nature of employment, it should have its own baseline. Therefore, occupations in the construction industry can be compared with a baseline within the construction industry, considering all its occupations. As Veneri said,

> The labor market data should be combined with background information on the occupation and knowledge of workings of the labor market…Current and potential occupational shortages can best be analyzed on a case by case basis, and the analysis should focus on one occupation or a group of related occupations and should provide a detailed investigation into factors affecting supply and demand (Veneri 1999).

Because of the cyclical nature of the construction industry, the unemployment rate for the construction industry is usually higher than the unemployment rate for all industries (all occupations), making it an indicator that deserves further attention.

2.3.3 Unemployment Rate

Among the multi-indicator measures, the author analyzed the unemployment rate, using both the actual unemployment rate and the natural unemployment rate. Past studies used only the actual unemployment rate. The actual unemployment rate equals the number of unemployed workers divided by the number of all workers in the labor force (employed workers plus unemployed workers). The labor workforce includes all people who are 16 years old and older, except people who are retired, full-time students, homemakers, volunteers, military personnel, or incarcerated individuals. Unemployed workers include people who do not have a job but are available to work, are looking for a job, temporarily laid off, fired, or have quit a job. Nevertheless, there are a number of factors that bias the unemployment measurement. First, discouraged workers, those who stop looking for employment but are still classified as unemployed, are difficult to track. In addition, the methodology for determining the unemployment rate counts part-time workers as employed, despite how many hours per week they are working. For example, a part-time worker could be working as little as one hour per week, yet still be considered employed. Lastly, some workers may not be working in a field that directly applies to their skillset—i.e. an engineer who works as a salesman, (BLS 2014).

2.3.3.1 Natural Unemployment Rate

Even when the economy is optimal, there still will be unemployed workers. Therefore, the unemployment rate will never reach zero. There are a number of articles that show that “zero,” or the natural unemployment rate for all industries, is between 4% and 6% (Marshall 2013). The unemployment rate is a combination of structural, frictional, and cyclical unemployment. Structural unemployment refers to workers who do not have the required skills to enter into the workforce, and thus there are no jobs for them. Frictional unemployment occurs when workers have the required skills but have not found a job yet (e.g. a carpenter who finished his job at one project and is looking for employment on another project). Cyclical unemployment covers workers who have the required skills for the job, but a lack of demand prevents companies from hiring them (i.e. a company has ten carpenters, and they layoff three of them because their business revenues decline and they must maintain their profit margins). However, natural unemployment rate or “zero” unemployment rate is the full employment of the unemployed, and becomes true when cyclical unemployment is equal to zero. Therefore, the natural unemployment rate equals the structural unemployment rate plus the frictional unemployment rate (Levernier and Yang 2011).

2.4 RESEARCH METHODOLOGY

The author applied the Current Population Survey (CPS) dataset to measure current skills shortages. The CPS raw data is obtained using DataFerrett, from the U.S. Census Bureau. There are 22 datasets in DataFerrett that include the CPS, the American Community Survey (ACS), the American Housing Survey (AHS), and the Public Libraries Survey (PLS). DataFerrett is publicly accessible via the Internet, and is updated on a monthly basis. The author applied these monthly microdata from 2011 to 2015. The CPS identifies the occupation of survey respondents with 3 and 4-digit occupation classification codes as defined by the U. S. Census Bureau. The author used these code numbers to identify and include only construction craft workers (hourly paid) in the analysis. Supervisors, managers, engineers, and administrators were not included in the analysis. In total, there are **158,762** construction craft workers in the dataset. Using the CPS data, the author used the multi-indicator method that was used by Cohen (1995), and then Veneri (1999), but with further modifications. First, the author created a baseline that included just occupations in the construction industry at each indicator, as opposed to using occupations from all industries. Second, the author created a ranking system to determine workforce availability (shortage and surplus), instead of using a benchmark system, which allowed the author to determine the severity of the shortages or amount of surplus. It is important to mention that the results of the workforce availability in different occupations are based on the relative availability of all construction workers in the occupations that are included in the baseline. Therefore, if the shortage applied to the all occupations in the baseline, the results are still going to show surplus for some occupations, and vise-versa for the surplus if it applied to the all occupations in the baseline. The following are the steps that the author applied in this research:

1) Identify a period of study during a time of economic growth (the chosen period for this study is 2011-2015).

2) Create a baseline (an average percentage that includes all occupations in the construction industry) at each indicator. In this study, the indicators are employment growth rate, wage

growth rate (adjusted for inflation – 2015 dollar amount), and unemployment rate *(the author will show and compare the results applying the multi-indicator method to the natural unemployment rate, and applying the multi-indicator method to the actual unemployment rate)*.

3) Create eight categories based on the 10% threshold to indicate the severity of shortages or the amount of surplus between occupations. Four of the categories represent the shortages (an index of red scale – the lighter the color, the lower the shortage, and the darker the color the greater the shortage), where the first category (the lightest one) will include percentages from 1% to 10%; the second category will include percentages from 11% to 20%; the third category will include percentages from 21% to 30%; and the fourth category (the darkest one) will include percentages from 31% and above. The other four categories represent a surplus (an index of green scale – the lighter color indicates a lower surplus; and the darker color will have a greater negative number, meaning more surplus). Each category will have the same percentage range of its identical positive category but with negative numbers, Figure 6.

Workers Surplus (%)		**Workers Shortage (%)**	
	from -1% to -10%		from 1% to 10%
	from -11% to -20%		from 11% to 20%
	from -21% to -30%		from 21% to 30%
	from -31% and below		from 31% and above

Figure 6: Workforce Availability Scale

4) Calculate an average percentage *(from 2011 to 2015)* for each occupation, at each of the three indicators, and then calculate the difference between the percentage at each occupation and the overall industry baseline. After that, the difference percentages from all three indicators for each occupation will be added together, using Equation 1. It is important to mention that under the unemployment rate indictor, a shortage will be considered if the

occupation rate is lower than the baseline rate, and vise-versa for the surplus. For the employment growth rate and wage growth rate indicators the opposite is true; a surplus will be considered if the occupation rate is lower than the baseline rate, and vise-versa for the shortage. Therefore, when the final result for each occupation is calculated, the result sign for the unemployment rate indicator will need to be changed by adding (-), Equation 1.

Equation 1. Availability Level

$$Availability\ Level = (\mathrm{a} - \mathrm{A}) + (\mathrm{b} - \mathrm{B}) - (\mathrm{c} - \mathrm{C}^{4})$$

A = Employment Growth Rate *(% of change from 2011 to 2015)* for the baseline, a = Employment Growth Rate *(% of change from 2011 to 2015)* for such occupation, B = Average Hourly Earnings *(% of change from 2011 to 2015)* for the baseline, b = Average Hourly Earnings *(% of change from 2011 to 2015)* for such occupation, C = Average Unemployment Rate *(average from 2011 to 2015)* for the baseline, c = Average Unemployment Rate *(average from 2011 to 2015)* for such occupation.

For example, the average employment growth rate for electricians, from 2011 to 2015, was 3.96%, while the baseline was 2.94%, so the difference is 1.02%; the average wage growth rate for electricians was -0.74%, while the baseline was -1.60%, so the difference is 0.87%; the average unemployment rate for electricians was 9.29%, while the baseline was 13.27%, so the difference is (-)-3.98%. Then, the difference percentages in all three indicators will be added together, so the workforce availability percentage for electricians is 5.87%.

5) Assign at category color based on the results, using the workforce availability scale.

[4] The multi-indicator method that applied natural unemployment rate shows more availability results than the multi-indicator method that applied actual unemployment rate. The natural unemployment rate excludes the workers who are on layoff *(cyclical unemployment)* because, in fact, they are not looking for a job. Therefore, the number of unemployed workers among natural unemployment rate indicator is less than the number of unemployed workers among actual unemployment rate indicator.

2.5 RESULTS

There are two main parts in this section: 1) the results on worker availability by occupation at the national level, and 2) worker availability by occupation at a regional level. The author will show and compare two different result sets: results applying the multi-indicator method to the actual unemployment rate, and results applying the multi-indicator method to the natural unemployment rate at both the national and regional levels.

2.5.1 Results Applied to the Multi-Indicator Method to the Actual Unemployment Rate

All previous studies that apply the multi-indicator method used the actual unemployment rate as an indicator (Cohen 1995; Veneri 1999). The studies which considered the unemployment rate as a single indicator, used the actual unemployment rate as well (Shah and Burke 2005; Roy et. al. 1996; Haskel and Martin 1993).

At the national level, the CPS dataset covers 20 construction occupations. Ten construction occupations (each with less than 2% of the total sampled respondents) were excluded from this analysis. The author ranked the 10 remaining occupations based on their workforce availability, Table 3. A worker shortage was found in six occupations (60%); the most affected occupation was “pipe-layers, plumbers, pipefitters, and steamfitters” (22.55% above the baseline). A workers surplus was found in four occupations (40%); the occupation with the greatest surplus was “roofers” (20.47% below the baseline), Table 3.

Table 3: Workforce Availability among Construction Occupations at National Level (Actual Unemployment Indicator vs. Natural Unemployment Indicator)

Occupation	Employment Growth Rate	Average Hourly Earnings	Actual Unemployment Rate	**Availability Level**	Natural Unemployment Rate	**Availability Level**
	% Change 2011-2015	% Change 2011-2015	Average 2011-2015	The Baseline	Average 2011-2015	The Baseline
Total, all occupations in the construction industry	**2.94%**	**-1.60%**	**13.27%**	**0%**	**10.06%**	**0%**
	0.00%	**0.00%**	**0.00%**		**0.00%**	
Carpenters	-9.89%	-1.53%	12.06%	-11.55%	9.36%	-12.06%
	-12.83%	0.07%	(-)-1.21%		(-)-0.70%	
Electricians	3.96%	-0.74%	9.29%	5.87%	6.65%	5.30%
	1.02%	0.87%	(-)-3.98%		(-)-3.41%	
Pipe-layers, plumbers, pipefitters, and steamfitters	13.03%	7.63%	10.05%	22.55%	7.33%	22.06%
	10.09%	9.24%	(-)-3.22%		(-)-2.73%	
Construction equipment operators (except crane)	-13.03%	-4.49%	12.66%	-18.24%	6.66%	-15.45%
	-15.97%	-2.88%	(-)-0.61%		(-)-3.40%	
Brickmasons, blockmasons, and stonemasons	12.89%	-21.96%	15.77%	-12.90%	10.57%	-10.91%
	9.95%	-20.35%	(-)2.50%		(-)0.51%	
Carpet, floor, and tile installers and finishers	-5.00%	16.14%	12.91%	10.16%	10.42%	9.44%
	-7.94%	17.74%	(-)-0.36%		(-)0.36%	
Drywall installers, concrete and terrazzo finishers, and plasterers	-2.16%	5.44%	14.85%	0.37%	11.18%	0.83%
	-5.10%	7.05%	(-)1.58%		(-)1.12%	
Painters, construction and maintenance, and Paperhangers	-0.82%	2.82%	12.86%	1.07%	10.20%	0.52%
	-3.76%	4.42%	(-)-0.41%		(-)0.14%	
Roofers	-8.05%	-7.61%	16.74%	-20.47%	12.39%	-19.33%
	-10.99%	-6.01%	(-)3.47%		(-)2.33%	
Construction laborers and helpers	20.17%	0.99%	16.88%	16.22%	13.53%	16.36%
	17.23%	2.60%	(-)3.61%		(-)3.47%	

At the regional level, among the remaining 10 construction occupations, the author excluded any occupation with less than 2% of the total sample respondents in any region. The author ranked the five remaining occupations based on their workforce availability, Table 4. In the Northeastern region, the most affected occupation with the greatest shortage was “pipe-layers, plumbers, pipefitters, and steamfitters” (41.42% above the baseline) while the occupation with the greatest surplus was “construction equipment operators” (53.38% below the baseline). In the Midwestern region, the most affected occupation with the greatest shortage was “electricians” (13.42% above the baseline) while the occupation with the greatest surplus was “carpenters” (33.21% below the baseline), Table 4.

Table 4: Workforce Availability among Construction Occupations at the Regional Level (Actual Unemployment Indicator vs. Natural Unemployment Indicator)

Occupation	Employment Growth Rate	Average Hourly Earnings	Actual Unemployment Rate	**Availability Level**	Natural Unemployment Rate	**Availability Level**
	% Change 2011-2015	% Change 2011-2015	Average 2011-2015	The Baseline	Average 2011-2015	The Baseline
Total, all occupations in the construction industry	**2.94%** **0.00%**	**-1.60%** **0.00%**	**13.27%** **0.00%**	**0%**	**10.06%** **0.00%**	**0%**
Northeast						
Carpenters	-32.08% -35.02%	50.05% 51.65%	11.23% (-)-2.04%	18.67%	8.31% (-)-1.75%	18.38%
Electricians	-10.00% -12.94%	0.79% 2.39%	8.95% (-)-4.32%	-6.23%	5.92% (-)-4.14%	-6.41%
Pipe-layers, plumbers, pipefitters, and steamfitters	4.37% 1.43%	34.29% 35.89%	9.17% (-)-4.10%	41.42%	6.50% (-)-3.56%	40.88%
Construction equipment operators (except crane)	-30.10% -33.04%	-19.97% -18.37%	15.24% (-)1.97%	-53.38%	5.61% (-)-4.45%	-46.96%
Construction laborers and helpers	0.41% -2.53%	6.74% 8.34%	18.78% (-)5.51%	0.30%	14.38% (-)4.32%	1.49%
Midwest						
Carpenters	-33.04% -35.98%	-0.78% 0.82%	11.32% (-)-1.95%	-33.21%	7.72% (-)-2.34%	-32.82%
Electricians	12.73% 9.79%	-2.34% -0.74%	8.90% (-)-4.37%	13.42%	5.28% (-)-4.78%	13.83%
Pipe-layers, plumbers, pipefitters, and steamfitters	-4.49% -7.43%	8.55% 10.15%	9.76% (-)-3.51%	6.23%	5.91% (-)-4.15%	6.87%
Construction equipment operators (except crane)	-27.90% -30.84%	-0.02% 1.59%	12.22% (-)-1.05%	-28.20%	3.87% (-)-6.19%	-22.76%
Construction laborers and helpers	-0.61% -3.55%	3.11% 4.71%	16.54% (-)3.27%	-2.11%	11.42% (-)1.36%	-0.20%
South						
Carpenters	5.82% 2.88%	-5.93% -4.33%	10.98% (-)-2.29%	0.84%	9.27% (-)-0.79%	-0.66%
Electricians	9.26% 6.32%	4.39% 5.99%	9.08% (-)-4.19%	16.50%	7.43% (-)-2.63%	14.94%
Pipe-layers, plumbers, pipefitters, and steamfitters	31.12% 28.18%	-6.25% -4.65%	9.34% (-)-3.93%	27.46%	7.65% (-)-2.41%	25.94%
Construction equipment operators (except crane)	-0.27% -3.21%	13.71% 15.31%	9.99% (-)-3.28%	15.38%	7.20% (-)-2.86%	14.96%
Construction laborers and helpers	28.33% 25.39%	3.12% 4.72%	15.70% (-)2.43%	27.68%	13.54% (-)3.48%	26.63%
West						
Carpenters	19.48% 16.54%	6.93% 8.53%	15.16% (-)1.89%	23.18%	12.25% (-)2.19%	22.88%
Electricians	2.95% 0.01%	16.22% 17.82%	10.12% (-)-3.15%	20.98%	7.37% (-)-2.69%	20.52%
Pipe-layers, plumbers, pipefitters, and steamfitters	16.42% 13.48%	30.37% 31.97%	11.75% (-)-1.52%	46.97%	9.14% (-)-0.92%	46.37%
Construction equipment operators (except crane)	-1.43% -4.37%	-0.11% 1.49%	14.46% (-)1.19%	-4.07%	9.36% (-)-0.70%	-2.18%
Construction laborers and helpers	40.12% 37.18%	2.02% 3.62%	17.44% (-)4.17%	36.63%	14.51% (-)4.45%	36.35%

In the U.S. Southern region, all occupations have shortages. The most affected occupation with the greatest shortage was “construction laborers and helpers” (27.68% above the baseline) while the occupation with the smallest shortage was “carpenters” (0.84% above the baseline). In the Western region, the most affected occupation with the greatest shortage was “pipe-layers, plumbers, pipefitters, and steamfitters” (46.97% above the baseline) while the only occupation with a surplus was “construction equipment operators” (4.07% below the baseline), Table 4.

2.5.2 Results Applied to the Multi-Indicator Method to the Natural Unemployment Rate

The author of this study applied the natural unemployment rate because it is more conservative and accurate because the number of unemployed workers is less. The natural unemployment rate excludes the workers who are on layoff because, in fact, they are not looking for a job. To better measure the workforce availability, the unemployment rate should include only the unemployed workers who are looking for a job.

Similar to the previous (national level) analysis, the author only included 10 construction occupations which each have more than 2% of the total sampled respondents. The author ranked these ten occupations based on their workforce availability, Table 3. A worker shortage was found in six occupations (60%); the most affected one was “pipe-layers, plumbers, pipefitters, and steamfitters” (22.06% above the baseline). A worker surplus was found in four occupations (40%); the occupation with the greatest surplus was “roofers” (19.33% below the baseline), Table 3.

At the regional level analysis of the natural unemployment rate, the author excluded any occupation with less than 2% of the total sample respondents in any region. The author ranked the five remaining occupations based on their workforce availability, Table 4. In the

Northeastern region, the most affected occupation with the greatest shortage was “pipe-layers, plumbers, pipefitters, and steamfitters” (40.88% above the baseline) while the occupation with the greatest surplus was “construction equipment operators” (46.96% below the baseline). In the Midwestern region, the most affected occupation with the greatest shortage was “electricians” (13.83% above the baseline), while the occupation with the greatest surplus was “carpenters” (32.82% below the baseline), Table 4.

In the Southern region, the most affected occupation with the greatest shortage was “construction laborers and helpers” (26.63% above the baseline) while the only occupation with a surplus was “carpenters” (0.66% below the baseline). In the Western region, the most affected occupation with the greatest shortage was “pipe-layers, plumbers, pipefitters, and steamfitters” (46.37% above the baseline) while the only occupation with a surplus was “construction equipment operators” (2.18% below the baseline), Table 4.

2.6 DISCUSSION

There are two major limitations when the CPS dataset is used. First, the small sample size in a number of occupations prevents the author from applying the workface availability analysis on them nationally and regionally. Second, the CPS used to have a variable would allow a breakdown and analysis of the dataset by state, which gave the flexibility to design the number of regions on the U.S. map that would give more accurate results; this variable was suspended in March 2014.

In general, the multi-indicator method that applies the natural unemployment rate has more conservative results than the multi-indicator method that applies the actual unemployment rate. However, the ranking results (colors) are the same for both multi-indicator methods. The only ranking difference is found to the “carpenters” occupation in the Southern region. This occupation was in the shortage category, 0% to 10% when the actual unemployment rate was applied, and moved to the surplus category, 0% to 10% when the natural unemployment rate was applied. The reason behind this major shift is that this occupation, like all other occupations, had less unemployed workers (more availability) when the natural unemployment rate was applied. Further, this occupation was close to the baseline (0%).

By looking at the national level results, we can tell that most of the occupations with a surplus of workers were related more often to the residential and the commercial sectors. However, the highly demanded occupation (“pipe-layers, plumbers, pipefitters, and steamfitters”) with a shortage of workers was more related to the industrial sector. On the other hand, the occupation of “construction laborers and helpers” was the second most demanded occupation at the national level and in the Western region, while it was the most demanded occupation in the Southern region. The author believes that this occupation is a good indicator of construction projects’ demand in general.

The regions that had the greatest shortage of workers were the West and the South respectively. However, the occupations in demand varied by region. The most demanded occupation in the Northeastern and the Western regions was “pipe-layers, plumbers, pipefitters, and steamfitters”; in the Midwestern region it was “electricians”; and in the Southern region it was “construction laborers and helpers.”

The findings of this research have similarities and differences compared to other prior research efforts, Table 5. At the national level, the similarities among occupations shortages between the findings of this research and the findings of the other research include “electricians” (AGC 2016; AGC 2015; AGC 2014; USGBC 2013), “plumbers” (AGC 2016; AGC 2014), “pipefitters” (AGC 2013), “laborers” (AGC 2013), and “concrete finishers/cement mason” (AGC 2013; USGBC 2013). In the Northeastern region, AGC (2015) found that “carpenters” were hardest to find while AGC (2016) found that “plumbers” were hardest to find; this study’s findings show a shortage for both of these occupations, in addition to the “construction laborers and helpers” occupation. In the Midwestern region, CII (2015), using the CLMA[5] data, found that “electricians” and “welders” were hardest to find; this study’s findings show a shortage among “electricians” in addition to the “pipe-layers, plumbers, pipefitters, and steamfitters” occupation. In the Southern region, CII (2015) found that “electricians,” “pipefitters” and “welders” were hardest to find while Wilder (2013) found that “pipefitters,” “welders,” and “ironworkers” were hardest to find; this study’s findings show a shortage on the “electricians” and “pipefitters” occupations, in addition to the “construction equipment operators” and “construction laborers and helpers” occupations. In the Western region, AGC (2014) found that “plumbers” were hardest to find; this study’s findings show a shortage in that occupation, in addition to the “electricians,” “carpenters” and “construction laborers and helpers” occupations. There are four main reasons behind the differences between this research and other research: 1) other research used subjective data while this research used objective data; 2) other research data focused on one sector in the construction industry (i.e. commercial, or industrial) while this research data included all sectors in the construction industry; 3) some variables in this research data (the CPS data) combined skills into one occupation, like “pipe-layers, plumbers, pipefitters,

[5] Construction Labor Market Analyzer (CLMA) is “an online application that helps owners, contractors, labor providers and the construction industry overall understand the skilled labor market and manage project labor risk” (CLMA 2015). All of the industrial projects in the CLMA are actual projects whether provided directly by the owner or input and managed by the CLMA analysts. For Non-Industrial Information CLMA analysts obtain the entire McGraw Hill Dodge (Dodge Analytics) portfolio. CLMA analysts transfer these future projects into estimated number of workers in a particular trade and in a specific region. However, the Bureau of Labor Statistics (BLS) provides estimates of the number of people in a particular trade and in a specific region (the number includes industrial and non-industrial workers). The authors of the CII RT-318 used the BLS number as an estimated supply and CLMA number as an estimated demand.

and steamfitters," while the other research data treated each skill as one occupation; and 4) other research used a one-year study period while this research used a five-year study period. For the differences among occupations shortages between the findings of this research and the findings of the other research, see Table 5. Both previous research and this research found that the demand for craft workers varied by region and by occupation. Despite the differences behind the methods of the data collections, analyses, and results between this research and the other research, the similarities in the findings validates the metric used in this study.

Table 5: Construction Craft Shortages, Nationally and Regionally, from Previous Studies

#	Reference	Sector	Method Used	National Crafts shortages (All)	National Craft Shortage (Top 5)	Study Regions Number	Region Shortage (Rank)	Trade Shortage by Region (the hardest to fill)
1	AGC[£] (2016)	Mainly Commercial	Survey	69%[₽]	carpenters, electricians, roofers, plumbers, and concrete workers	4	**1st:** Midwest (77%[₽]), **2nd:** South (74%[₽]), **3rd:** West (71%[₽]), **4th:** Northeast (57%[₽])	**Midwest**: carpenters. **South:** cement masons. **West:** bricklayers. **Northeast:** plumbers.
2	CII[¥] RT318 (2015)	Mainly Industrial	CLMA[©]	N/A	N/A	9	**1st:** Southwest[1], Southeast[1], Mid-Atlantic[1], **2nd:** Midwest[2], **3rd:** Rocky Mountain[3]	**Southwest[1]:** electricians, pipefitters, and welders. **Southeast[1]:** electricians, pipefitters, and welders. **Mid-Atlantic[1]:** electricians, pipefitters, and welders. **Midwest[2]:** electricians, and welders. **All other regions:** welders.
3	AGC[£] (2015)	Mainly Commercial	Survey	79%[₽]	carpenters, sheet metal installers, concrete workers, electricians, and equipment operators	4	**1st:** Midwest (85%[₽]), **2nd:** South (83%[₽]), **3rd:** West (81%[₽]), **4th:** Northeast (73%[₽])	**Midwest**: carpenters. **South:** carpenters. **West:** millwrights and painters. **Northeast:** carpenters.
4	AGC[£] (2014)	Mainly Commercial	Survey	83%[₽]	carpenters, roofers, equipment operators, plumbers, and electricians	4	**1st:** South (86%[₽]), **2nd:** Midwest (84%[₽]), **3rd:** West (82%[₽]), **4th:** Northeast (67%[₽])	**South:** roofers. **Midwest**: carpenters. **West:** plumbers. **Northeast:** electricians.
5	AGC[£] (2013)	Mainly Commercial	Survey	74%[₽]	laborers, carpenters, cement mason, pipefitters/welders, and equipment operators	N/A	N/A	N/A
6	USGBC[€] (2013) McGraw-Hill data	Non-Industrial	Survey	49%[₽]	carpenters, electricians, boilermakers, concrete finisher/cement mason and ironworkers/ welders	N/A	N/A	N/A
7	Wilder (2013)	Industrial	Survey	N/A	N/A	1	Gulf Coast[1]	welders, pipefitters, ironworkers

© Construction Labor Market Analyzer
¥ Construction Industry Institute
£ The Associated General Contractors
€ The U.S. Green Building Council

₽ Percentage by the participants
1 Part of the South region with the 4 region's borders
2 Part of the Midwest region with the 4 region's borders
3 Part of the West region with the 4 region's borders

2.7 CONCLUSION

Using the CPS dataset, this paper examined the craft worker availability nationally and regionally by applying a multi-indicator method, which is a new metric in the construction industry. The paper's contribution to the overall body of knowledge is the application of this metric to the construction industry using a public dataset. The data of this study is focused on the economic growth period from 2011 to 2015. The study revealed the level of shortage and surplus among occupations and regions, showing the most affected regions by occupation in the construction industry. The study yielded the following findings:

- The demand of the craft workers varied by region and by occupation.
- The multi-indicator method that applied the natural unemployment rate had more conservative results than the multi-indicator method that applied the actual unemployment rate, because it includes fewer unemployed workers by excluding workers who are not looking for a job.
- At the national level, the most affected occupation (the one with the greatest shortage) was "pipe-layers, plumbers, pipefitters, and steamfitters," while the most available occupation (the one with the greatest surplus) was "roofers."
- The regions with the greatest shortage of workers were the Western and Southern regions.
- The occupation with the greatest shortage in the Northeastern and Western regions was "pipe-layers, plumbers, pipefitters, and steamfitters"; in the Midwestern region it was "electricians;" and in the Southern region it was "construction laborers and helpers."

- The occupation in the lowest demand in the Northeastern and Western regions was "construction equipment operators," and in the Midwestern and Southern regions it was "carpenters."

This multi-indicator methodology will help industry leaders and project managers to predict shortages in certain occupations and in certain regions at the early stages of a project (e.g. planning phase) and to plan an approach to mitigate the shortage. Also, it will help vocational program educators focus on occupations that have future demand. Finally, the multi-indicator methodology will help researchers in the construction industry, or in other industries, to identify the availability of craft workers using the same or different datasets, and eventually contribute to the industry's body of knowledge.

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3. A LONGITUDINAL ANALYSIS OF THE CHANGES IN US CRAFT WORKERS' SATISFACTION AND JOB PREFERENCES

This chapter (Paper 2) is published to the *Canadian Journal of Civil Engineering*. Reference: Albattah, M. A., Shan, Y., Goodrum, P. M., & Taylor, T. R. (2016). “Relationships between Cycles of Economic Expansion in Construction and Craft Workers’ Job Satisfaction and Preferences.” *Canadian Journal of Civil Engineering*, (ja).

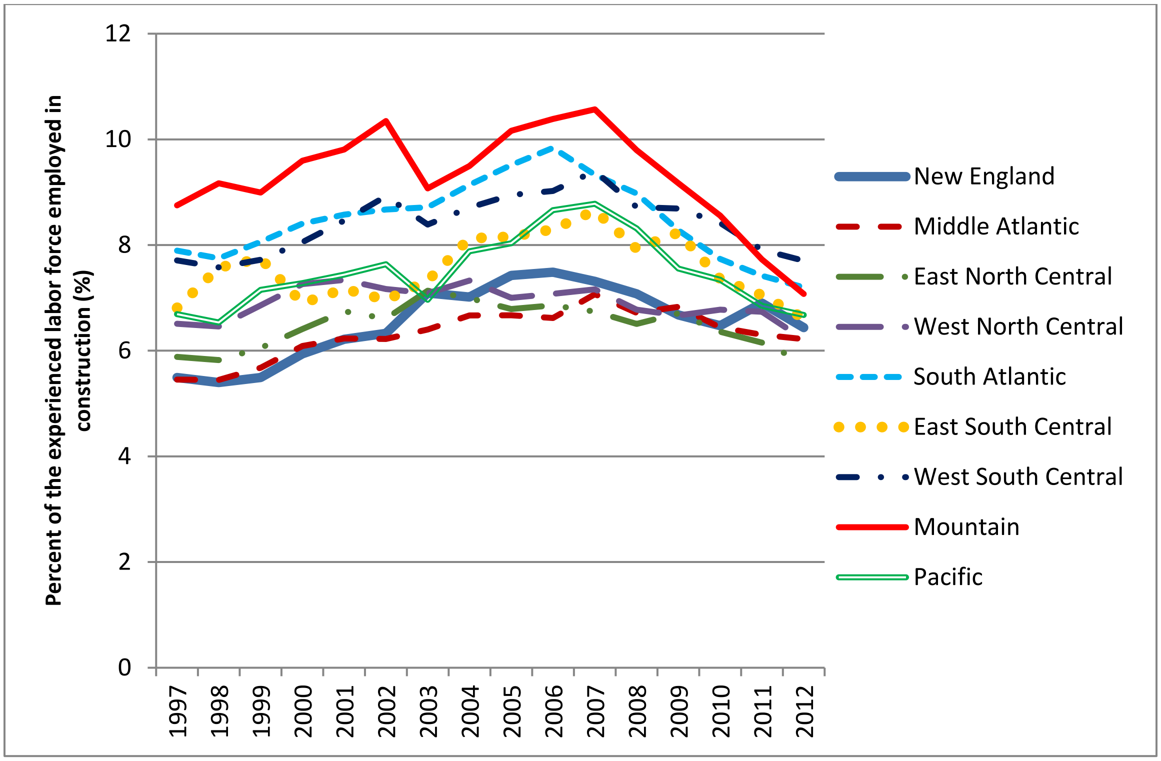
3.1 ABSTRACT

When construction craft workers consider potential career alternatives, overall job satisfaction is a fundamental factor that influences their retention and productivity. This paper analyzes changes in job satisfaction and job preferences of craft workers in the U.S. construction industry across successive economic recession-expansion cycles. The analysis used data from the General Social Survey (GSS) collected from 1974 to 2014 and compared job satisfaction and preferences of construction craft workers with those in other industries. The author found that job preferences of the sampled construction respondents changed with each successive recession-expansion cycle and that the desire for high income became more prevalent than that for a sense of accomplishment in physical work, which has traditionally been the top job preference among construction workers in general. Overall job satisfaction among sampled construction respondents was equal to or slightly exceeded the overall job satisfaction of sampled respondents in other industries. Industry craft recruitment efforts can use these insights to design future recruitment and retention strategies.

3.2 INTRODUCTION

Because the demand for construction in the U.S. hinges on the overall health of the U.S. economy, periods of economic recession have direct negative impacts (e.g., reduced construction volume) and indirect impacts (e.g., loss of craft workers as they migrate to other industries) on the industry's health. Although the percentage varies by different sectors of the construction industry, labor costs make up a significant portion of total project costs for all construction projects. Craft workers face challenges related to the transient nature of construction, difficult working conditions, high unemployment, and a high risk of injury. These challenges are compounded by the cyclical nature of the construction industry that results from economic cycles of recession and expansion. During the most recent economic downturn that began in 2008, the U.S. construction industry experienced not only immediate increases in unemployment, but it also began what is now considered the longest economic recovery period that also affected all other U.S. industries (Fridley 2013). During periods of high regional construction volume, hiring and retaining skilled craft workers is challenging because companies must compete for a relatively fixed craft labor pool. Similarly, the craft labor pool may shrink during extended periods of unemployment during recessions as unemployed craft workers seek jobs in other industries. This study explores changes in job satisfaction and preferences among construction craft workers across multiple recession-expansion cycles and discusses how these trends could influence future worker recruitment and retention efforts. The data were separated into economic cycles, with each cycle beginning with a recessionary period characterized by rising unemployment rates and followed by an expansionary period.

According to the Bureau of Labor Statistics (BLS 2015), the construction unemployment rate in 2014 fell to 8.9%, suggesting that the industry is currently undergoing expansion. Moreover, anecdotal evidence showed that regional craft shortages, at least along the U.S. Gulf Coast, were beginning to hinder some owners' ability to begin construction projects (Wilder 2013). Several factors might account for these shortages, including declining real wages; an unattractive public image of construction careers (Salter 1997); and the retirement of skilled craft workers among the Baby Boomer generation (Choi 2009). Also, the percentage of the experienced civilian workforce employed in the construction industry has declined in recent years (Figure 7), with this reduction beginning prior to the start of the 2008 Great Recession[6]. Borcherding and Oglesby (1974); Shikdar and Das (2003) argued that job satisfaction is one of the main factors that increase worker productivity. As such, future industry recruiting and retention activities should take into account a holistic analysis of construction workers' job satisfaction over the recession-expansion cycles from 1974 to 2014 as well as a longitudinal understanding of the changes in job preferences among construction craft workers.



Resource: Bureau of Labor Statistics (Current Population Survey (CPS)).

Figure 7: Percent of the Experienced Civilian Labor Force Employed in the Construction Industry by U.S. Region

[6] Great Recession is the recession period that starts at the fourth quarter of 2007 and ends at the fourth quarter of 2009 (Katz 2014).

3.3 LITERATURE REVIEW

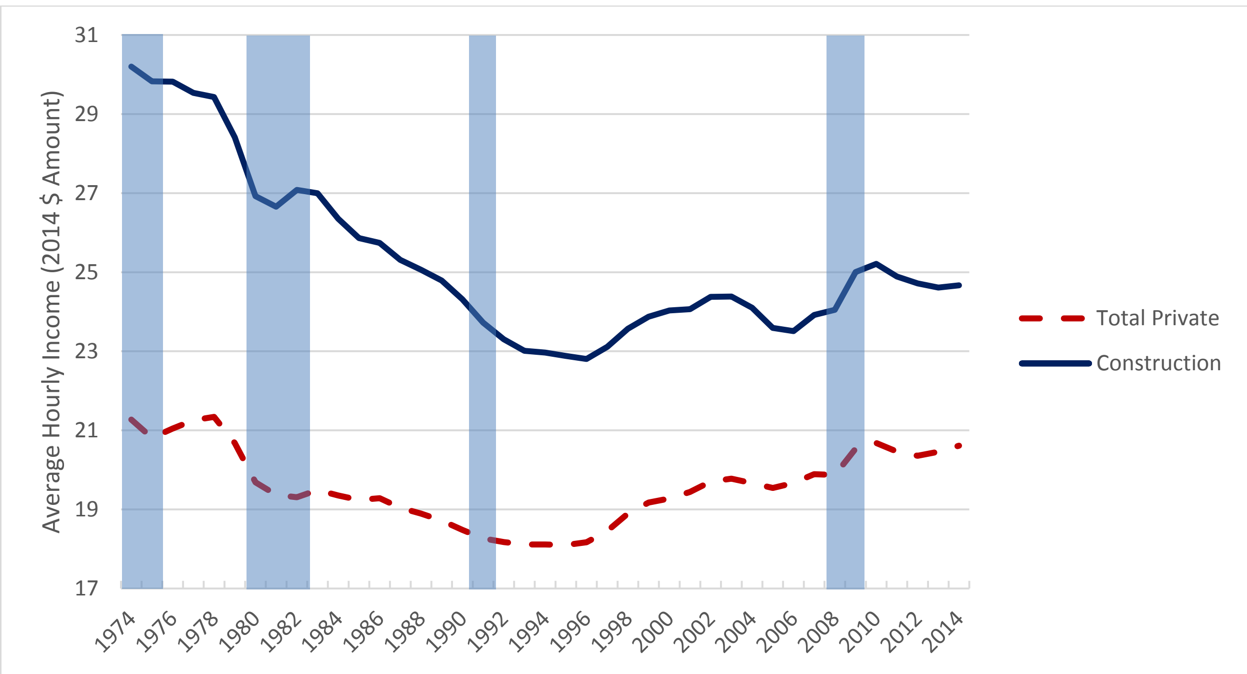
Job satisfaction is a "pleasurable or positive emotional state resulting from appraisal of one's job or job experiences" (Locke 1976). Scholars have presented several models to explain job satisfaction, including the Affect Theory, Dispositional Theory, Motivation-Hygiene Theory, and the Job Characteristic Model. According to Locke's (1976) Affect Theory, the discrepancy between what workers want and what they have in a job determines how satisfied they are with their jobs. Dispositional Theory focuses on the inner disposition of individuals, which causes them to have tendencies toward a certain level of satisfaction regardless of the nature of their jobs (Fisher and Hanna 1931; Hoppock 1935; Smith 1955; Weitz 1952). Herzberg et al. (1959) presented the Two-factor Theory, also known as the Motivation-Hygiene Theory. This explains that workplace satisfaction is driven by motivation factors (e.g., achievement in work, recognition, chances for advancement) and hygiene factors (e.g., pay, company policies, supervisory practices, and working conditions). The Job Characteristics Model addresses how particular job characteristics (e.g., skill variety, task identity, task significance, autonomy, and feedback) impact job satisfaction (Hackman and Oldham 1976). Each model provides some insights into the factors that could influence job satisfaction, but it is challenging to quantify which of these models explains the factors that are most likely to influence the satisfaction of construction craft workers.

Understanding workers' preferred job characteristics is critical for increasing their positive behavior. Gazioglu and Tansel (2006) studied and compared satisfaction, basing their investigation on four job characteristics. Ranked in order of importance, these are sense of achievement, respect received from supervisors, influence over job, and job salary. This ranking was developed using the 1997 Workplace Employees Relationship Survey of 28,240 participants. In addition, Gazioglu and Tansel (2006) studied the effects of individual worker characteristics, including age, education, and job characteristics (e.g., job security and industrial composition) to explore their combined influence on job satisfaction. They found that very young and older workers were more satisfied than middle-aged workers, and workers who have a high education level were less satisfied than workers who have a low education level. Aletraris (2010) found that temporary workers were younger, had less education, and were less satisfied with their jobs than permanent workers. More specifically, temporary workers expressed less satisfaction with their actual work, work hours, and job security. This finding aligns with Gazioglu and Tansel's (2006) finding that greater job security increased worker satisfaction. Blanchflower and Oswald (1999) uncovered similar findings in their study of approximately 50,000 participants across 18 countries using three surveys (International Social Survey Programme, Eurobarometer Surveys, and the U.S. General Social Surveys). They found that job satisfaction remained high in European countries, while between 1973 and 1998 it steadily declined in the U.S. In spite of these differences, Gazioglu and Tansel (2006) also observed that the construction sector typically has a higher job satisfaction level than other sectors, such as manufacturing, financial services, and the wholesale and the retail trades.

To effectively compete for labor resources, construction companies need to understand the type of rewards that produce the highest level of job satisfaction among their workers. Aletraris (2010) and Rose (2003) categorized job rewards into two groups, extrinsic and intrinsic, that reflect Herzberg's Motivation-Hygiene Theory. Extrinsic rewards reflect tangible aspects of a job (i.e., wages, family-friendly benefits, and job security), while intrinsic rewards are intangible features of a job (i.e., autonomy, physical nature of the work, control over the timing and duration of work, high incidence of non-standard work schedules, relation with manager, and job stress).

The scarcity of craft workers in the U.S. was the subject of numerous research studies toward the end of the 1990s. Those studies revealed that many construction workers only considered their job as a source of a paycheck, not as a career (Coia 1997; Reid 1997; Rowings et al. 1996). In part, Rowings et al. (1996) attributed this transitional perspective to inadequate organizational investment, lack of chances for advancement, and the cyclical nature of construction work. Other research efforts have acknowledged that a lack of continuous employment and declining real wages are other primary discouraging factors for construction craft workers (Coia 1997; Reid 1997).

The author of this paper examined trends in average hourly income from 1974 to 2014 using Current Employment Statistics (CES) data from the Bureau of Labor Statistics (BLS) and compared the construction industry to all private industries. Dollar values were adjusted to 2014 levels using the all urban consumer price index (CPI-U) (Figure 8). Workers in the construction industry earned $5.53/hr. less in real income in 2014 than in 1974. Workers in all private industries also experienced a decline in real wages, although not by as significant a decline as experienced in construction (i.e., $0.67/hr. less in real income in 2014 than in 1974). Given that the real value of wages in the construction industry has fallen significantly over this period, it is tempting to infer that construction craft workers are rarely satisfied with their work. However, this paper demonstrates that construction craft workers have continued to express greater job satisfaction than workers in other industries across multiple recession-expansion cycles. This research directly examined craft worker satisfaction in construction and compared it to all other industries over all of the economic recession-expansion cycles that occurred from 1974 to 2014, because the author believe that each cycle represents a comparable case. Each cycle starts with a recession period characterized by few job openings and high unemployment. The economy then goes through an expansionary period highlighted by an increase in job openings along with craft worker shortages in certain trades. The paper also examines how job preferences among craft workers have changed over time with each new construction industry-wide recruiting initiative brought about by a new economic expansion cycle. Finally, realizing that the construction workforce is an assemblage of different occupations that require different workplace experiences and skill sets, the paper also investigates how job satisfaction and job preferences vary by construction trades.



SOURCE: Current Employment Statistics (CES), U.S. Bureau of Labor Statistics.
NOTE: Shaded regions represent recessionary periods.

Figure 8: Real Average Hourly Income for Total Private and Construction Workers (2014 Dollar Amount, Inflation Adjusted)

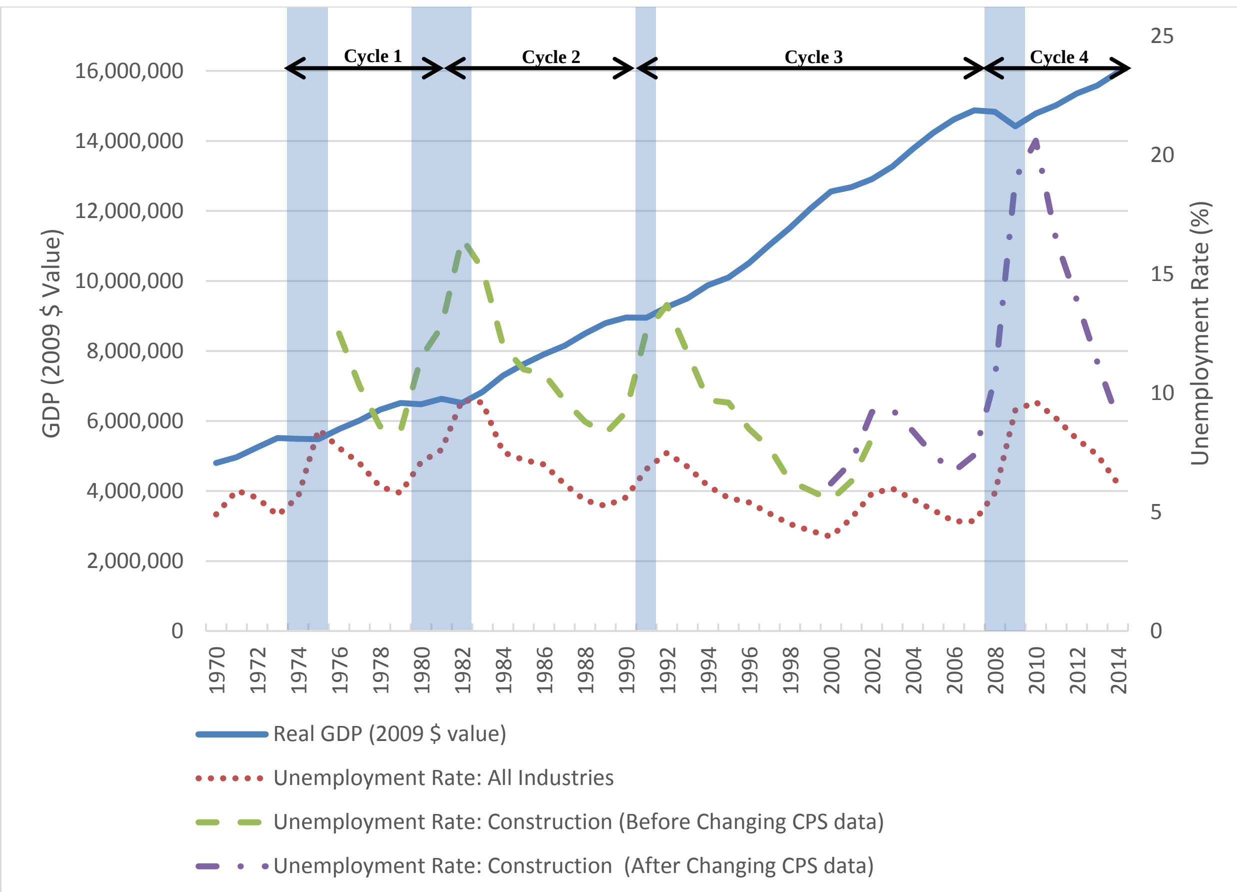
Construction workforce shortages are a worldwide issue existing in the United States, Canada, the United Kingdom, and Australia (Wilder 2013; Komarnicki 2012; Dainty et. al. 2004;

Shah and Burke 2005). Understanding the construction workers' job satisfaction and preferences is important to the industry's workforce retention. Since there are few studies that have addressed job satisfaction and preferences among construction workers in North America (Dabke et al. 2008; Smith 2007; Borcherding and Oglesby 1974), this study specifically focuses on the construction workers' satisfaction and preferences in the United States.

To examine job satisfaction in the construction industry, this paper explores how satisfied and dissatisfied construction craft workers view the importance of their job traits such as income, job security, work-hours, chance for advancement, and the physical accomplishment of the work itself over recession-expansion cycles from 1974 to 2014. The paper also compares job satisfaction among construction craft workers and their counterparts in other industries.

3.4 RESEARCH METHODOLOGY

Analysis of U.S. Bureau of Economic Analysis (BEA) Real Gross Domestic Product (GDP) 2005 Dollar Value data revealed four major recessions between 1970 and 2014 (2015): 1974–1975, 1980–1982, 1991, and the Great Recession, 2008–2009 (shaded regions, Figure 8 and Figure 9). Although some (Kliesen 2003; Stock and Watson 2003) have argued the U.S. experienced a recession in 2001, other researchers disagree because they define a recession as two or more quarters of negative real GDP growth, and in 2001 real GDP experienced negative growth only during the third quarter (Abberger and Nierhaus 2008). The author divided the study period into four economic cycles (recession-expansion periods) based on the BEA data. These are Cycle 1 (1974–1981); Cycle 2 (1982–1990); Cycle 3 (1991–2007); and Cycle 4 (2008–2014) (Figure 9). The General Social Survey (GSS) dataset underpins this paper's analysis. The National Opinion Research Center has administered the GSS since 1972 to monitor social change amid growing social complexity in the U.S. (NORC 2015). Currently, GSS data are available from 1972 to 2014, except the years when the GSS was not administered (1979, 1981, 1992, 1995, 1997, 1999, 2001, 2003, 2005, 2007, 2009, 2011, and 2013). GSS data, which is available to the public, document how individuals respond to questions on topics such as demography, behavior, attitudes, and other special interests. From 1972 to 2014, the GSS included responses from 59,599 respondents to 5,603 questions. Many of the questions in the GSS have remained unchanged since 1972, although other questions have been added, which makes the GSS an ideal data source for examining trends in a population's characteristics over time.



Resource for GDP: Bureau of Economic Analysis (Value Added from NAICS Data).
Resource for Unemployment rate: Bureau of Labor Statistics (Current Population Survey (CPS)).
NOTE: Shaded regions represent recessionary periods.

Figure 9: Economic Recession-Expansion Cycles (Real GDP, 2009 Dollars) and Unemployment in Construction and All Other Industries

Based on occupation codes from the GSS, only craftsman kindred workers and operatives (referred to here as craft workers) were included in this study. Based on GSS respondents' indication of their current industry of employment, respondents were grouped into construction and non-construction industry groups. A total of 2,507 (16.1%) responses from the construction industry and 13,089 (83.9%) responses from all other industries were included in the analysis. The GSS measures job satisfaction on an ordinal scale: very satisfied, moderately satisfied, a little dissatisfied, and very dissatisfied. This study's analysis collapsed these ratings into two categories: satisfied (encompassing very satisfied and moderately satisfied) and dissatisfied (a little dissatisfied and very dissatisfied). This study's analysis also went further and studied job satisfaction and job preferences among construction trades, but excluded trades with less than 2% of the total sampled respondents.

The dataset used for analysis included categorical and numerical data. For categorical data, a chi-square test was used to test the overall difference; the test of difference between two proportions was used throughout the analysis as well. For numerical data, analysis of variance (ANOVA) was used to test whether mean scores differed among groups.

3.5 RESULTS

There are three main parts in this section, which present the results on workers' age differences between construction industry and all other industries, differences in job satisfaction and job preferences by industries (construction vs. all other industries), and differences in job satisfaction and job preferences by construction trades.

3.5.1 Workers' Age Difference between Industries

Table 6 lists the average ages of sampled construction respondents during each cycle. In Cycle 1, the average age was 44, and it decreased to 42 in Cycle 2. However, the mean age rose to 43 and 47 in Cycles 3 and 4, respectively. Despite this increase, the average age of sampled construction respondents was consistently younger than the sampled non-construction industry respondents. There was a statistically significant difference in ages across the four cycles (Table 6). The average age of sampled non-construction respondents in Cycle 1 was 46. This then increased to 47, 47, and 51 in Cycles 2, 3, and 4, respectively. This scenario indicates that the workforce (inclusive of construction and non-construction jobs) has trended older in recent years. As such, construction and non-construction trades could experience a large number of retirements in the near future, which could potentially exacerbate the age gap between new and experienced workers.

Table 6: Mean Age of Construction Craft Workers Compared with Other Industries by Economic Cycles (1974–2014)

Age	*Cycle 1 (74 to 81)*	*Cycle 2 (82 to 90)*	*Cycle 3 (91 to 07)*	*Cycle 4 (08 to 14)*
Construction	*(N=338)*	*(N=588)*	*(N=1079)*	*(N=374)*
Mean	44	42	43	47
S.D.	17.3	16.8	15.6	16.2
All other industries	*(N=2589)*	*(N=3533)*	*(N=4678)*	*(N=1402)*
Mean	46	47	47	51
S.D.	17.8	18.2	17.3	17.4
The Differences				
Mean (Sig. of Diff.[a])	2 (.047)	5 (.00)	4 (.00)	4 (.00)

Data Source: GSS 1974-2012; Sample size does not total to the study's total size of 2507 *(Construction)* and 13089 *(Non-Construction)* due to non-responses in the GSS. [a] These values are the result of the application of the T test.

3.5.2 Workers' Satisfaction in Industries

Over the first three economic cycles, sampled construction respondents were more satisfied with their jobs than sampled respondents in other industries, but the differences between the two groups were not statistically different over the fourth cycle (Table 7). The chi-square test demonstrated that sampled non-construction respondents' satisfaction did not significantly change across the four recession periods, X^2 (3, N = 8,664) = 6.815, p = .08 (Table 7). This confirms that sampled respondents in the construction industry were more satisfied than the sampled respondents employed in other industries. During Cycles 1, 2, and 3 there was a statistically significant difference between construction and non-construction respondents' satisfaction at the 95% confidence level. The 95% confidence level's significant difference for Cycle 1 is (p = 0.03), Cycle 2 is (p = 0.02), and Cycle 3 is (p = 0.00). However, there was not a significant difference in Cycle 4 (p = 0.50) when construction unemployment peaked.

Table 7: Job Satisfaction of Construction Craft Workers Compared with Other Industries by Economic Cycles (1974–2014)

Satisfaction	*Cycle 1 (74 to 81)*	*Cycle 2 (82 to 90)*	*Cycle 3 (91 to 07)*	*Cycle 4 (08 to 14)*
Construction	*(N=240)*	*(N=477)*	*(N=705)*	*(N=275)*
Dissatisfied	10.4%	13.6%	10.4%	13.5%
Satisfied	89.6%	86.4%	89.6%	86.5%
TOTAL	100.0%	100.0%	100.0%	100.0%
Pearson Chi-square = 4.113, d.f.=3, P-value=.25 was performed to test the difference between the columns.				
All other industries	*(N=1986)*	*(N=2680)*	*(N=2977)*	*(N=1021)*
Dissatisfied	15.7%	18.0%	16.4%	15.1%
Satisfied	84.3%	82.0%	83.6%	84.9%
TOTAL	100.0%	100.0%	100.0%	100.0%
Pearson Chi-square = 6.815, d.f.=3, P-value=.08 was performed to test the difference between the columns.				
The Differences				
Dissatisfied (Sig. of Diff.[a])	-5.3% [b] (.03) [c]	-4.4% [b] (.02) [c]	-6.0% [b] (.00) [c]	-1.6% [b] (.50) [c]
Satisfied (Sig. of Diff.[a])	5.3% [b] (.03) [c]	4.4% [b] (.02) [c]	6.0% [b] (.00) [c]	1.6% [b] (.50) [c]

Data Source: GSS 1974-2012; Sample size does not total to the study's total size of 2507 *(Construction)* and 13089 *(Non-Construction)* due to non-responses in the GSS. [a] These values are the result of the application of the test of significance of the difference between two proportions. [b] The difference percentage between two proportions percentages. [c] The P-value from the Z score.

3.5.3 Job Preference

A limitation of the study is that the job preferences question was only asked 17 of the 28 years (GSS study years) between 1974 and 2014. The years in each cycle are: Cycle 1 includes 1974, 1976, 1977, and 1980; Cycle 2 includes 1982, 1984, 1985, 1987, 1988, 1989, and 1990; Cycle 3 includes 1991, 1993, 1994, and 2006; and Cycle 4 includes 2012, and 2014.

3.5.3.1 Job Preferences based on Satisfaction Levels

The differences in job preferences among satisfied and dissatisfied groups were examined, with construction compared to all other industries. The GSS measures this by asking respondents to examine five job characteristics and rate them from most to least important. The five characteristics are: (1) high income; (2) no danger of being fired [job security]; (3) short working hours and significant free time; (4) chances for professional advancement; and (5) the physical accomplishment of the work itself [work accomplishment]. The first three characteristics are classified as extrinsic, and the last two intrinsic (Hurlbert 1991, and Kashefi 2014). Due to the small sample size, this analysis did not partition results based on economic cycles according to a satisfaction category. Analysis revealed satisfied and dissatisfied sampled construction respondents did not significantly differ in their job preferences after the test of significance of the difference between two proportions indicated in parentheses in Table 8, except for high income preference that showed a difference between the groups ($p=0.05$). The majority of respondents in the satisfied group of the construction industry viewed work accomplishment as the most important job characteristic, while the majority of respondents in the dissatisfied group of the construction industry viewed high income as the most important job characteristic. However, the second most important job preference for each group was the first most important job preference for the other group followed by chances for advancement, job security, and short working hours.

Conversely, for non-construction workers, there were statistically significant differences in some job preferences between the respective satisfied and dissatisfied respondents (Table 8). However, the overall ranking of the job preferences among the dissatisfied respondents from both industries was similar. For the satisfied group, the ranking of job preferences among the construction industry respondents mirrors that among the non-construction industry respondents. (Table 8).

Table 8: Workers' Job Preferences in Construction Compared with All Other Industries based on Job Satisfaction (from 1974 to 2014)

	Preferences				
Satisfaction	High income	Job security	Short working hours	Chances for advancement	Work accomplishment
Construction					
Dissatisfied (N=84)	35.7%	8.3%	1.2%	21.4%	33.3%
Satisfied (N=537)	25.5%	9.5%	5.6%	18.2%	41.2%
(Sig. of Diff.[a])	10.2% [b] (.05) [c]	-1.2% [b] (.72) [c]	-4.4% [b] (.08) [c]	3.2% [b] (.48) [c]	-7.9% [b] (.17) [c]
Pearson Chi-square = 7.230, d.f.=4, P-value=.12 was performed to test the difference between the columns.					
All other industries					
Dissatisfied (N=615)	32.5%	9.4%	3.7%	22.8%	31.5%
Satisfied (N=2917)	27.8%	11.3%	4.5%	18.3%	38.1%
(Sig. of Diff.[a])	4.7% [b] (.02) [c]	-1.9% [b] (.17) [c]	-0.8% [b] (.38) [c]	4.5% [b] (.01) [c]	-6.6% [b] (.00) [c]
Pearson Chi-square = 17.299, d.f.=4, P-value=.00 was performed to test the difference between the columns.					
The Differences between Construction and All Other Industries					
Dissatisfied(Sig. of Diff.[a])	3.2% [b] (.56) [c]	-1.1% [b] (.74) [c]	-2.5% [b] (.23) [c]	-1.4% [b] (.77) [c]	1.8% [b] (.74) [c]
Satisfied (Sig. of Diff.[a])	-2.3% [b] (.27) [c]	-1.8% [b] (.22) [c]	1.1% [b] (.27) [c]	-0.1% [b] (.95) [c]	3.1% [b] (.17) [c]

Data Source: GSS 1974-2012; Sample size does not total to the study's total size of 2507 *(Construction)* and 13089 *(Non-Construction)* due to non-responses in the GSS. [a] These values are the result of the application of the test of significance of the difference between two proportions. [b] The difference percentage between two proportions percentages. [c] The P-value from the Z score.

3.5.3.2 Job Preferences based on Economic Cycles

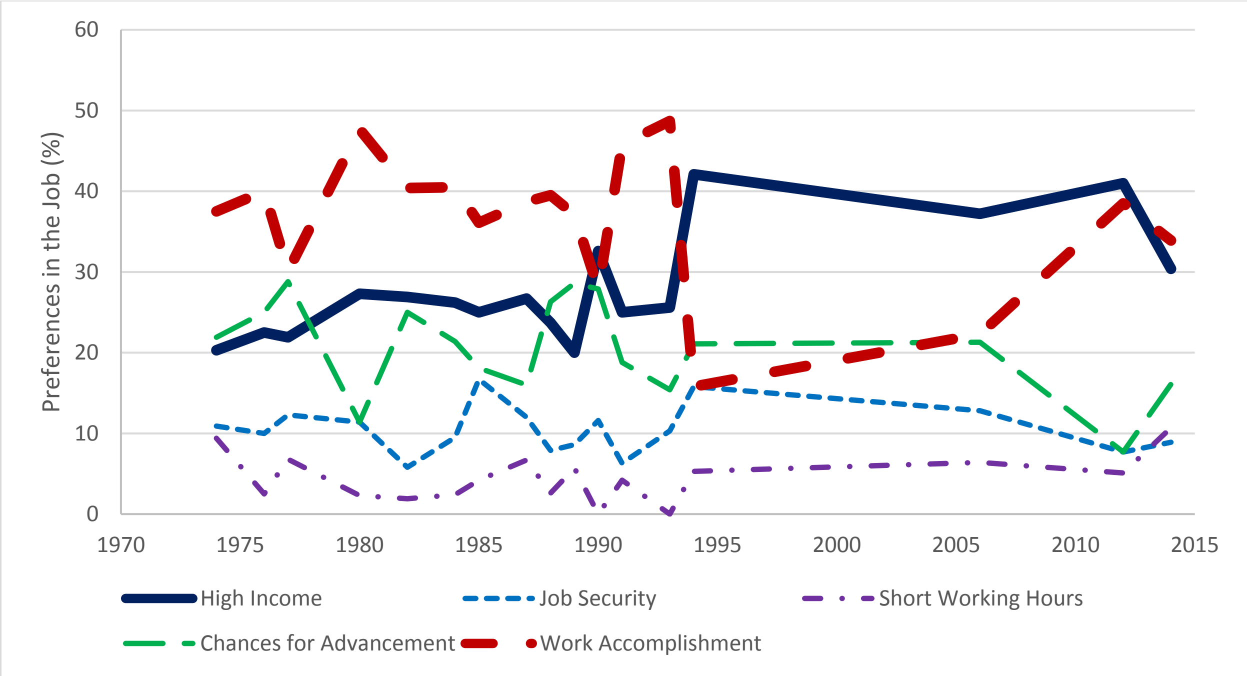
Differences in job preferences within the construction industry were studied for each economic cycle. Work accomplishment was the most important preference during the four cycles, but its trend decreased from cycles 1 to 4. High income was ranked as the second preference during the four cycles, but its trend increased from cycles 1 to 4. Chance for advancement, Job security, and short working hours were the third, fourth, and fifth preferences respectively during the four cycles (Table 9). However, by combining the preferences into extrinsic and intrinsic job characteristics, clearer results emerged. Intrinsic characteristics were prioritized during cycles 1, 2, and 3, with preference rates of 63%, 63.2%, and 54.7%, respectively. However, this rate declined in Cycle 4 when extrinsic characteristics became the most highly ranked preference with a rate of 52%. A consistent trend across the economic cycles was stagnation or decline in the construction industry’s real wages (Figure 8). In addition, the construction industry experienced significant spikes in construction unemployment (Figure 9). The data suggest that the overall decline in real wages, along with the spikes in unemployment, may have influenced the stated job preferences among construction craft workers. Their preferences have shifted from intrinsic job characteristics (i.e., the work itself) to extrinsic job characteristics (i.e., salary and job security). As job conditions in the industry have undergone changes over the past four decades, the author observed that the sampled construction respondents reacted by modifying their job preferences.

Table 9: Workers' Job Preferences in Construction: Comparison across the Four Economic Recessionary/Expansion Cycles

Construction	Preferences				
	High income	Job security	Short working hours	Chances for advancement	Work accomplishment
Cycle 1 [74 – 81] (N=281)	21.3%	9.3%	6.4%	19.9%	43.1%
Cycle 2 [82 – 90] (N=489)	25.4%	8.8%	2.6%	20.9%	42.3%
Cycle 3 [91 – 07] (N=243)	31.3%	9.5%	4.5%	18.5%	36.2%
Cycle 4 [08 – 14] (N=127)	35.4%	8.7%	7.9%	11.0%	37.0%
The Differences between Four Periods					
(Sig. of Diff.[a])					
Cycle 1 and Cycle 2	-4.1% [b] (.19) [c]	0.5% [b] (.81) [c]	3.8% [b] (.01) [c]	-1.0% [b] (.74) [c]	0.8% [b] (.82) [c]
Cycle 1 and Cycle 3	-10.0% [b] (.01) [c]	-0.2% [b] (.93) [c]	1.9% [b] (.34) [c]	1.4% [b] (.68) [c]	6.9% [b] (.10) [c]
Cycle 1 and Cycle 4	-14.1% [b] (.00) [c]	0.6% [b] (.84) [c]	-1.5% [b] (.57) [c]	8.9% [b] (.02) [c]	6.1% [b] (.24) [c]

Data Source: GSS 1974-2012; Sample size does not total to the study's total size of 2507 *(Construction)* and 13089 *(Non-Construction)* due to non-responses in the GSS. Pearson Chi-square = 25.625, d.f.=12, P-value=.012 was performed to test the difference between the columns. [a] These values are the result of the application of the test of significance of the difference between two proportions. [b] The difference percentage between two proportions percentages. [c] The P-value from the Z score.

To interrogate the data further, the author scrutinized annually reported job preferences for each cycle (Figure 10). Over the entire study period, job security and short working hours were routinely ranked by construction respondents as the least important preference. Until the mid-1990s, the first job preference among sampled respondents was work accomplishment. Up until then, high income and chances for advancement tied for being the second most important job preference. This changed in later years and right before 2014 when high income became the highest ranked job preference among the sampled construction respondents.



Resource: General Social Survey (GSS).

Figure 10: Job Preferences Ranking in Construction by Year from 1974 to 2014

3.5.4 Differences in Job Satisfaction and Job Preferences by Construction Trades

Although the GSS dataset covers 20 construction trades, 11 construction trades with less than 2% of the total sampled respondents were excluded from this analysis. The author ranked the nine remaining trades based on their satisfaction percentage (Table 10). The sampled carpenters reported the greatest job satisfaction, with a 90.5% satisfaction rate. By comparison, the sampled roofers were the least satisfied, reporting an 80.0% satisfaction rate, which echoes Smith's (2007) findings.

In terms of job preferences, a dichotomy emerges among respondents in construction trades in terms of how they ranked the first job preference, with the first preference either work accomplishment or high income (Table 11). Respondents in six trades (i.e., electricians; carpenters; pipe-layers, plumbers, pipefitters, and steamfitters; painters, construction and maintenance; roofers; and construction laborers and helpers, denoted in italics) indicated on average that work accomplishment was the most important job preference. Meanwhile, respondents in the remaining three trades (i.e., block-masons, and stonemasons; drywall installers, concrete and terrazzo finishers, and plasterers; and construction equipment operators and related workers) indicated on average that high income was the most important job preference. For the three trades that rated high income as their highest preference, work accomplishment was their second most important job preference. Conversely, for the six trades that reported work accomplishment as the first choice, high income was their second preference. Respondents in all of the trades viewed job security and short working hours as the least important preferences.

Table 10: Average Ranking of Construction Trades' Satisfaction from 1974 to 2014

Rank	Craft	Number	Satisfaction
1	Carpenters	398	90.5%
2	Brickmasons, blockmasons, and stonemasons	73	90.4%
3	Electricians	268	90.3%
4	Construction Equipment Operators, and related workers	129	89.1%
5	Painters, construction and maintenance	131	88.5%
6	Pipelayers, plumbers, pipefitters, and steamfitters	160	87.5%
7	Drywall installers, concrete and terrazzo finishers, and plasterers	61	83.6%
8	Construction laborers and helpers	384	82.6%
9	Roofers	55	80.0%

Table 11: Construction Trades' Job Preferences from 1974 to 2014

Trade	No.	High Income	Job Security	Short Working Hours	Chances For Advancement	Work Accomplishment
Electricians	134	30.6%	8.2%	2.3%	13.4%	45.5%
Carpenters	207	25.1%	6.8%	3.4%	19.8%	44.9%
Pipe-layers, plumbers, pipefitters, and steamfitters	74	25.7%	10.8%	4.0%	23.0%	36.5%
Painters, construction and maintenance	72	27.8%	12.5%	2.8%	22.2%	34.7%
Roofers	25	24.0%	16.0%	8.0%	20.0%	32.0%
Construction laborers and helpers	197	29.4%	12.7%	4.1%	22.8%	31.0%
Brick-masons, block-masons, and stone masons	41	29.3%	12.2%	9.8%	19.5%	29.2%
Construction equipment operators, and related workers	98	36.7%	10.2%	3.1%	16.3%	33.7%
Drywall installers, concrete and terrazzo finishers, and plasterers.	34	35.3%	5.9%	8.8%	17.6%	32.4%

3.6 DISCUSSION

On average, construction respondents were younger than respondents in all other industries. Construction jobs place more physical demands on workers than most of other occupations, which results in construction craft workers retiring at an earlier age. However, construction and non-construction workers' mean age increased slightly from Cycle 1 to Cycle 4.

Across the last four recession-expansion cycles, 90% of sampled construction respondents reported being satisfied with their jobs. The level of job satisfaction among sampled respondents remained unchanged over the study period. A larger percentage of construction respondents reported being satisfied with their job compared to sampled respondents from other industries. This finding bodes well for the construction industry. Unfortunately, the public often perceives employment in the construction industry as offering only low-esteemed and low-skilled jobs, which certainly has an adverse effect on industry recruitment efforts. However, as indicated by GSS data, the reality is that this population of construction workers consistently indicated greater job satisfaction compared to workers in other industries across all four recession-expansion cycles.

Understanding what motivates construction craft workers could lead to industry improvements that could potentially improve already high job satisfaction rates among construction craft workers and improve industry recruitment efforts for the next generation of workers. Improved worker satisfaction decreases worker absenteeism, stress, and turnover, and workers who are satisfied with their jobs tend to be more productive than those who are not (Aletraris 2010; Borcherding and Oglesby 1974; Gazioglu and Tansel 2006; Maloney and J. 1984; Rowings et al. 1996). This study demonstrated that extrinsic rewards became the top job preference in cycle 4 among construction respondents, whereas they consistently ranked it lower during earlier economic cycles. These analyses also revealed that construction respondents rated work accomplishment above high income until the mid-1990s. This should be a source of concern for the industry given that the shift to a focus on high income coincided with a period during which real construction wages fell (Figure 8). The preference for high income suggests that on-site management strategies should focus more on extrinsic rather intrinsic job characteristics in attempts to improve worker satisfaction and bolster motivation.

3.7 CONCLUSION

Using the GSS dataset, this paper examined construction craft workers' job satisfaction and preferences and compared the construction industry with non-construction industries over four recession-expansion cycles spanning four decades from 1974 to 2014. The author also studied job satisfaction and preferences among specific construction trades over the same period. The current work contributes to the overall body of knowledge by finding that the job preference for high income has become more desired during recent years compared to the job preferences for work accomplishment, which has traditionally been the primary job preference among construction workers in general. The study yielded the following findings:

- Among the sampled construction respondents, there was no statistically significant change in overall worker satisfaction across the four recession-expansion cycles from 1974 to 2014. The vast majority (90%) of the sampled construction respondents reported being satisfied with their job. This satisfaction level held steady during cycle 4, which included the Great Recession. A larger percentage of the sampled construction respondents reported job satisfaction than their sampled counterparts in other industries.
- Extrinsic job preferences attained the greatest importance during Cycle 4. In previous cycles, extrinsic job preferences were not rated as highly. More specifically, the

preference for high incomes increased from Cycle 1 to Cycle 4, while the importance respondents placed on chances for advancement and work accomplishment declined.

- Carpenters were the most satisfied trade among the sampled construction respondents, and the sampled construction respondents in the roofing trade expressed the least job satisfaction among the sampled trades.
- Looking at respondents' first preference over the entire study period, 60% of sampled construction trades respondents preferred intrinsic rewards while 40% prefer extrinsic rewards.
- Among all trades and in other industries, the most infrequently chosen preferences were job security and short working hours.

Like most other U.S. industries, construction has experienced long-term declines in real wages, which has likely played a primary role in the structural change in job preference among the sampled population. Obviously, multiple issues influence declines in construction's real wages that are outside the scope of this paper, but it would appear that these declines are having a significant impact on worker motivation. Further, despite negative public perceptions about careers in construction that have traditionally plagued the industry (Coia 1997, and Reid 1997), the study found that construction respondents consistently reported greater job satisfaction in their work than respondents in other industries. Once again, the industry finds itself in a period of significant craft worker shortage, so the fact that construction craft workers experience greater job satisfaction than kindred workers in other industries deserves greater attention in the industry and should drive recruiting and retention efforts.

3.8 AMENDMENT

Based on committee recommendation, the author conducted an analysis for job satisfaction and job preference among age groups. The respondents' ages were divided into three groups (Baby Boomer, Generation X, and Generation Y). The Baby Boomers are the generation of workers who were born between 1946 and 1964; the Generation X workers were born between 1965 and 1980; and the Generation Y workers were born between 1981 and 2000 (UNJSPF 2015).

3.8.1 Workers' Satisfaction within Industries among the Three Generations

Among Baby Boomers and Generation Xers, sampled construction respondents were more satisfied with their jobs than sampled respondents in other industries (Table 12). The 95% confidence level's significant difference for Baby Boomers was (p = 0.00), and for Generation Xers it was (p = 0.01). However, there was not a significant difference in satisfaction level between sampled construction and non-construction respondents in the Generation Y group (p = 0.36). On the other hand, the sampled construction respondents' satisfaction did not significantly change across the three generations, X^2 (2, N = 1,647) = 1.107, p = .57, while the sampled non-construction respondents' satisfaction did significantly change across the three generations, X^2 (2, N = 24,850) = 7.936, p = .019. In fact, Generation Y respondents from the non-construction industries were the ones who differ from the other two generations of respondents (Table 12).

Table 12: Job Satisfaction of Construction Craft Workers Compared with Other Industries by Generations (1974–2014)

Satisfaction	*Baby Boomer*	*Generation X*	*Generation Y*
Construction	*(N=1064)*	*(N=467)*	*(N=116)*
Dissatisfied	12%	11.1%	14.7%
Satisfied	88%	88.9%	85.3%
TOTAL	100.0%	100.0%	100.0%
Pearson Chi-square = 1.107, d.f.=2, P-value=.57 was performed to test the difference between the columns.			
The Difference Between Generations (Sig. of Diff.[a])			
Baby Boomer	N/A	0.9%[b] (.61)[c]	-2.7%[b] (.39)[c]
Generation X	-0.9%[b] (.61)[c]	N/A	-3.6%[b] (.28)[c]
Generation Y	2.7%[b] (.39)[c]	3.6%[b] (.28)[c]	N/A
All other industries	*(N=16535)*	*(N=6752)*	*(N=1563)*
Dissatisfied	15.5%	15.3%	18%
Satisfied	84.5%	84.7%	82%
TOTAL	100.0%	100.0%	100.0%
Pearson Chi-square = 7.936, d.f.=2, P-value=.019 was performed to test the difference between the columns.			
The Difference Between Generations (Sig. of Diff.[a])			
Baby Boomer	N/A	0.2%[b] (.70)[c]	-2.5%[b] (.00)[c]
Generation X	-0.2%[b] (.70)[c]	N/A	-2.7%[b] (.00)[c]
Generation Y	2.5%[b] (.00)[c]	2.7%[b] (.00)[c]	N/A
The Differences Between Industries			
Dissatisfied (Sig. of Diff.[a])	-3.5%[b] (.00)[c]	-4.2%[b] (.01)[c]	-3.3%[b] (.36)[c]
Satisfied (Sig. of Diff.[a])	3.5%[b] (.00)[c]	4.2%[b] (.01)[c]	3.3%[b] (.36)[c]

Data Source: GSS 1974-2012; Sample size does not total to the study's total size of 2507 *(Construction)* and 13089 *(Non-Construction)* due to non-responses in the GSS. [a] These values are the result of the application of the test of significance of the difference between two proportions. [b] The difference percentage between two proportions percentages. [c] The P-value from the Z score.

3.8.2 Job Preferences in the Construction Industry among the Three Generations

Differences in job preferences within the construction industry were studied for each generation. Work accomplishment was the most important preference among Baby Boomers, while it was the second preference among the Generation X and Generation Y groups. High income was ranked as the second preference among Baby Boomers, while it was the most important preference among Generation X and Generation Y. Chance for advancement, Job security, and short working hours were the third, fourth, and fifth preferences, respectively, among all generations (Table 13). By combining the preferences into extrinsic and intrinsic job characteristics, clearer results emerged. Intrinsic characteristics were prioritized by Baby Boomers, with a preference rate of 62.8%, while extrinsic characteristics were prioritized by Generation X and Generation Y, with preference rates of 53% and 56.3%, respectively. The data suggest that the overall decline in real wages (Figure 8), along with the spikes in unemployment (Figure 9), may have influenced the stated job preferences of the younger generations *(Generation X and Generation Y)* in the construction industry. Their preferences have shifted from intrinsic job characteristics (i.e., the work itself) to extrinsic job characteristics (i.e., salary and job security).

Table 13: Workers' Job Preferences in Construction: Comparison across the Three Generations (1974–2014)

	Preferences				
Construction	High income	Job security	Short working hours	Chances for advancement	Work accomplishment
Baby Boomer (N=462)	29%	5.2%	2.6%	18.6%	44.2%
Generation X (N=134)	31.3%	14.9%	6.7%	23.1%	23.9%
Generation Y (N=32)	40.6%	12.5%	3.1%	15.6%	28.1%
The Differences between Generations					
(Sig. of Diff.[a])					
Baby Boomer and Generation X	-2.3% [b] (.60) [c]	-9.7% [b] (.00) [c]	-4.1% [b] (.02) [c]	-4.5% [b] (.24) [c]	20.3% [b] (.00) [c]
Baby Boomer and Generation Y	-11.6% [b] (.16) [c]	-7.3% [b] (.08) [c]	-0.5% [b] (.86) [c]	3.0% [b] (.67) [c]	16.1% [b] (.07) [c]
Generation X and Generation Y	-9.3% [b] (.31) [c]	2.4% [b] (.72) [c]	3.6% [b] (.44) [c]	7.5% [b] (.35) [c]	-4.2% [b] (.62) [c]

Data Source: GSS 1974-2012; Sample size does not total to the study's total size of 2507 *(Construction)* and 13089 *(Non-Construction)* due to non-responses in the GSS. Pearson Chi-square = 33.545, d.f.=8, P-value=.00 was performed to test the difference between the columns. [a] These values are the result of the application of the test of significance of the difference between two proportions. [b] The difference percentage between two proportions percentages. [c] The P-value from the Z score.

In conclusion, sampled construction respondents were more satisfied with their jobs than sampled respondents in other industries among Baby Boomers and Generation Xers. However, there was not a significant difference between sampled construction and non-construction respondents from Generation Y; they have a similar satisfaction level. The author believes that the Generation Y respondents in all industries have less experience than the respondents of the other two generations. Therefore, when the construction unemployment peaked, they were affected the most, which impacted their job satisfaction. Among sampled construction respondents, intrinsic characteristics were prioritized by Baby Boomers, while extrinsic characteristics were prioritized by Generation X and Generation Y. Specifically, work accomplishment was the most important preference among Baby Boomers, while high income was the most important preference among Generation X and Generation Y respondents.

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4. A COMPARATIVE ANALYSIS OF THE UTILIZATION OF MULTISKILLING AMONG U.S. HISPANIC AND NON-HISPANIC CONSTRUCTION CRAFT WORKERS

4.1 ABSTRACT

Since the 2008 economic recession, the U.S. construction industry has faced a shortage of craft workers, mainly among highly skilled trades, such as pipefitters and electricians. Current skilled workers are leaving the industry for other industries, often to manufacturing. Multiskilling—in which workers possess a range of skills appropriate for multiple uses—is one strategy that improves current worker retention by increasing wages and job duration for workers. This study sought to understand the changes in multiskilling among Hispanic compared with non-Hispanic craft workers in the construction industry. This study applied two datasets, the U.S. Bureau of Labor Statistics' Current Population Survey (CPS) and the National Craft Assessment and Certification Program (NCACP) for the multiskilling analysis, using the Categorical Principal Component Analysis (CATPCA). Analysis revealed that the Hispanic craft worker population increased sharply in the construction industry but mainly among lower skilled construction trades. However, there was no difference between Hispanic and non-Hispanic patterns among craft workers with dual-skills, but differences were found in multiskilling combinations between craft workers with more than two skills.

4.2 INTRODUCTION

The construction industry currently faces a shortage of skilled craft workers as the U.S. economy recovers after the 2008 recession. Two main reasons for this shortage are the high demand for construction projects and the low number of skilled craft workers (Komarnicki 2012; Glavin 2013; Wilder 2013; Shelar 2013). Increased demand for construction projects is due to two main factors: economic recovery and low energy prices. Several factors have contributed to the recovery of the U.S. economy, notably continued low interest rates, technological innovations, and a focus on domestic rather than international trade deals after the 2008 economic downturn (Schoen 2014; Clinch 2014). Economic recovery, technically defined as a significant increase in the Gross Domestic Product (GDP), means that both government and private investors have more money to spend on construction.

The shortage of skilled craft workers is due to increasing numbers of seasoned workers retiring or leaving the construction industry for jobs in other sectors, and fewer new workers entering the construction industry (Druker and White 1996; Makhene and Thwala 2009; Belman 2013). There is no single solution to resolve the shortage problem. Multiple approaches are needed to minimize the shortage (Komarnicki 2012; Healy et al. 2011). Some solutions focus on retaining current craft workers (e.g., increasing workers job satisfaction). Others focus on attracting new craft workers to the industry (e.g., enhancing vocational program at high schools), and some solutions are based on creating different management approaches (e.g., prefabrication, modularization, and worker relocation). Because retaining current craft workers is one common strategy for mitigating the labor shortage, this study was conducted to understand how multiskilling contributes to worker retention. A previous study by Albattah et al. (2016) found that recruiting and retention efforts in the construction industry should emphasize extrinsic motivation, primarily in the form of satisfactory wages. Other studies have also found that multiskilling is a strategy that not only increases craft workers' wages, but also affords longer employment times. Further, multiskilling reduces workforce shortages because it increases the number of skills in the labor market pool even if the number of workers remains constant (Burleson 1997; Gomar et al 2002; Carley et al 2003; Ejohwomu et al. 2008; Wang et al. 2009).

Burleson et al. (1998) define multiskilling as "a labor utilization strategy in which workers possess a range of skills that are appropriate for more than one work process and that are used flexibly on a project or within an organization." Multiskilling gives craft workers longer contracts and higher wages which increase job satisfaction (Wang et al. 2009; Carley et al. 2003; Haas et al. 1999a; Gomar et al. 2002). Hispanics are the most rapidly growing population in the U.S. construction industry, while other populations have been shrinking (Goodrum 2004). Therefore, this study specifically explored the multiskilling patterns among Hispanic craft workers in the U.S. construction industry.

4.2.1 Research Objective

The main objective of this study was to understand the changes in multiskilling and the influence of race (Hispanic versus non-Hispanic) on multiskilling patterns. The Hispanic population has increased sharply in the construction industry in recent decades. Thus, this study examined the types of trades most common among Hispanic craft workers and compared single, dual, and multi-skill trends between Hispanic and non-Hispanic craft workers. Furthermore, the effect of formal training was investigated among both Hispanic and non-Hispanic craft workers.

4.2.2 Scope

The U.S. Bureau of Labor Statistics (BLS) Current Population Survey (CPS) dataset was used to study Hispanic versus non-Hispanic craft workers' demographics and distribution in the construction industry. In addition, the National Craft Assessment and Certification Program (NCACP) from the National Center for Construction Education and Research (NCCER) dataset was used to study the multiskilling patterns among Hispanic and non-Hispanic craft workers.

The analysis only included craft trades and excluded managers, superintendents, foremen, inspectors, office staff, and engineers.

4.3 LITERATURE REVIEW

Shah and Burke (2005) defined a skill as “an ability to perform a productive task at a certain level of competence,” and an Australian Business Characteristics Survey (BCS) defined a skills shortage as “an insufficient supply of appropriately qualified workers available or willing to work under existing market conditions” (Healy et al. 2011). Skills requirements are qualitative and can be met by formal education or informal training through jobsite experience. Vereen (2013) defined highly skilled trades as ones that require specialized education or several years of training (e.g., carpenters, electricians, pipefitters) and low skilled trades as ones that require minimal or no training (e.g., general helpers and roofers). Highly skilled trades in construction are experiencing greater shortages than low skilled trades. After the Great Recession (2008-2009), electricians, pipefitters, welders, boilermakers, millwrights, and ironworkers were among the skilled crafts with the greatest demands in construction industry trades in the U.S. (Wilder 2013; Shelar 2013; Gonzales 2013). All these trades are most often related to industrial projects.

4.3.1 Multiskilling Strategy

Decades ago, the multiskilling strategy was known and applied in the manufacturing industry (Nonaka 1990; Ettlie and Rezo 1992; Carmichael and McLeod 1993; Burleson 1997). This multiskilling strategy was developed by manufacturing companies for labor cost savings because of technical changes and market demand shifts that decreased worker demand in current jobs and increased demand in other jobs. Therefore, multi-skilled workers were transferred between work groups based on the job demand (Carmichael and McLeod 1993). The multiskilling strategy in the manufacturing companies revealed the following benefits: 1) reduction in indirect manning; 2) lower job turnover; 3) greater job security when demand dropped; 4) improved process innovation and/or technology implementation; 5) increased earning potential of workers; 6) increased productivity; and 8) significant restructuring of recruitment, selection and training practices (Carmichael and McLeod 1993; Burleson 1997).

Burleson (1997) was one of the first researchers to explore multiskilling specifically in the construction industry. Burleson used the Construction Industry Institute (CII) Model Plant, developed in 1985, to create a basis for analyzing a hypothetical petrochemical facility project. In addition, she used a scheduling program (Primavera P3) and applied a cost analysis for a traditional single-skill workforce as a baseline, and then compared it with four multiskilling strategies, Table 14. Skill combinations were driven by the phase nature of a construction project, skill complexity, and trade similarities.

According to Burleson (1997), the main motivation for using the multiskilling strategy was to reduce the workforce size in favor of productivity improvements and unit cost savings, achieving both an increase in workers' wages and a decrease in the total project costs. The petrochemical project hypothetically cost $70 million (including direct and indirect costs) when using the single-skill strategy. Burleson analyzed multiskilling strategies with zero productivity improvement and with 20% productivity improvement. She believed that the 20% productivity improvement using multiskilling was a result of a reduction of supervision and supporting workers, a reduction of absenteeism, a reduction of idle time, and an increase of output per hour. Among the four multiskilling strategies, Four-Skill Strategy B was the most successful (Table 14), in which each worker had all skills under one of the main four groups (Civil/Structure, General Support, Mechanical, and Electrical). With zero productivity improvements, Four-Skill

Strategy B reduced labor costs by 4.6% and total construction costs by 1.4%; with 20% productivity improvements, Four-Skill Strategy B reduced labor costs by 23.6% and total construction costs by about 7%. Moreover, Four-Skill Strategy B reduced indirect labor costs by 33% over the baseline dataset, and increased the direct wages to workers by 75.5%. To clarify, these cost savings were estimated changes based on a hypothetical project and not changes actually experienced on construction jobsites.

Table 14: The Multiskilling Strategy – the Four Types (Burleson 1997)

Dual-skill strategy	**Four-skill strategy (A)**	**Four-skill strategy (B)**	**Theoretical optimum strategy**
Welder/General Laborer Electrician/Insulator Rigger/Equipment Operator Carpenter/Pipefitter Surveyor/Instrumentation Worker Iron Worker/Structural Steel Erector Crane Operator/Painter Concrete Finisher/Millwright	**Civil/Structural:** carpenter, iron worker, concrete finisher, structural steel erector. **General Support:** general laborer, equipment operator, truck driver, crane operator, rigger, surveyor, painter. **Mechanical:** insulator, millwright, pipefitter, welder. **Electrical:** electrician, instrumentation worker.	**Civil/Structural:** carpenter, iron worker, concrete finisher, structural steel erector. **General Support:** all helper, general laborer, equipment operator, truck driver, crane operator, rigger, surveyor, painter. **Mechanical:** insulator, millwright, pipefitter, welder. **Electrical:** electrician, instrumentation worker.	**Construction worker:** carpenter, iron worker, concrete finisher, structural steel erector, laborer, equipment operator, truck driver, crane operator, rigger, surveyor, painter, insulator, millwright, pipefitter, welder, electrician, instrumentation worker.

Wang et al. (2009) applied secondary raw data to study the multiskilling strategy in the construction industry. They used two data sources: the NCACP from NCCER and previous research data (RT-182) from the Construction Industry Institute (CII). They employed Pearson's analysis to identify the correlation between two skills obtained by workers and ranked the top combination of skills, Table 15. They also used cluster analysis to find the relationships between three or more skills, Table 16. The NCACP data included 66,410 participants between 2000 and 2006. Among these participants, 1,579 craft workers were considered multi-skilled. Of 17 different trades in the dataset, pipefitter, electrician, and boilermaker trades were the three largest trades.

Table 15: Top Dual Skills from the NCACP Data (Wang et al. 2009)

Rank	Craft skill (1)	Craft skill (2)	Pearson correlation coefficient
1	Electrician	Instrument technician	0.794
2	Reinforcing ironworker	Concrete finisher	0.475
3	Scaffold builder	Insulation	0.425
4	Scaffold builder	Carpenter	0.329
5	Boilermaker	Pipefitter	0.218
6	Carpenter	Concrete finisher	0.190
7	Electrician	Instrument fitter	0.181
8	Instrument technician	Instrument fitter	0.145
9	Carpenter	Reinforcing ironworker	0.139
10	Crane operator	Structural ironworker	0.100

Table 16: Multiskilling Groups based on Cluster Analysis, using the NCACP Data (Wang et al. 2009)

Multiskilling Groups	
1	**Mechanical Work:** pipefitter, boilermaker, mechanical, and millwright
2	**Civil Work:** insulation, scaffold builder, carpenter, concrete finisher, reinforcing rodman, and painter
3	**Electrical Work:** electrician, instrument fitter, instrument technician, and HVAC
4	**General Support:** crane operator, ironworker, and rigger

Wang et al. (2009) found that a higher percentage of non-Hispanic craft workers (83.6%) obtained multiskilling certificates compared to Hispanic craft workers (16.4%). They also found that multi-skilled workers have more years of experience when compared to single skill workers. However, one of the main findings in the Wang et al. (2009) study was that the workers' primary motivation for becoming multi-skilled was to increase functionality rather than length of employment. That finding was based on fact that the most common skills combinations were those most likely to be performed concurrently rather than consecutively on a jobsite. Concurrent skills may be more functional and consecutive skill combinations increase employment duration.

Other researchers have conducted survey-based studies on the multiskilling strategy in the construction industry (Haas et al. 1999a; Haas et al. 1999b; Carley et al. 2003). Haas et al.

(1999a) conducted a survey of 1,100 craft workers and found that 70% of the workers were working on trades other than their main trades, which made them multi-skilled workers. In addition, 57% of workers were interested in learning new skills and cited “higher hourly wages” and “interested in the trade” as the top reasons for doing so. Haas et al. (1999b) conducted 51 personal interviews and 15 telephone interviews in 12 different companies. The interviewees were managers, superintendents, and foremen. The main reason companies implemented the multiskilling strategy was to reduce labor costs, which was most effective when multiskilling was considered during all phases of the project (Haas et al. 1999b).

Carley et al. (2003) surveyed 721 craft workers from 10 construction companies. Most respondents were from Texas and primarily pipefitters/plumbers, followed by electricians. Participants wished to work in trades with higher wages, which were necessarily highly skilled trades such as welders and electricians (Carley et al. 2003). However, other researchers applied a different model to study the multiskilling strategy using a “Multiskilling Optimization Model for Allocation” that was tested and validated by the CII Model Plant data and commercial linear programming software (Gomar et al. 2002). Gomar et al. (2002) addressed the benefits of the multiskilling strategy on the planning and scheduling of the construction projects, and found that multiskilling increases the participation and job employment duration for workers and reduces idle time.

In general, multiskilling has benefits at the project, worker, and industry level. At the project level, the multiskilling strategy significantly reduces total costs (Burleson 1997; Haas et al. 1999b; Gomar et al. 2002). At the worker level, multi-skilled workers have longer employment, higher wages, and higher productivity with fewer construction accidents (Burleson 1997; Haas et al. 1999a; Gomar et al. 2002; Carley et al. 2003; Wang et al. 2009). At the industry level, multiskilling increases worker retention, reduces the demand for new entrants and the number of the workers at the jobsite, and develops career-path opportunities in the construction industry (Burleson 1997).

4.3.2 Hispanic Construction Workers in the US

According to the U.S. Management and Budget Office (1997), the Hispanic demographic category includes individuals from Cuba, Mexico, Puerto Rico, South or Central America, or other Spanish culture or origin, regardless of race. The number of Hispanic workers in the U.S. construction industry increased from 705,000 to 2.2 million between 1990 and 2010 (BLS 2012). In 2010, Hispanic workers accounted for over 25% of the U.S. construction workforce (CPWR, 2013). While the number of Hispanic workers in the construction industry increased, the percentage of Hispanics in construction compared to Hispanic workers in other trades decreased after the Great Recession. In 2007, 14.2% of the total number of Hispanic workers in all trades were employed in construction and declined to 10.8% by 2011 (PHC 2012).

The percentage of Hispanic U.S. citizens is expected to increase to 128 million by 2060 (U.S. Census Bureau 2011). The majority of foreign-born workers in construction (82%) were born in Latin American countries, and those who identify their origin as Latin American are categorized as ethnically Hispanic (CPWR 2013). Most Hispanic workers' region of origin is Mexico (66%), followed by Central America (20%), and South America (16%) (BLS, 2011). Further, Hispanic workers account for 69% of the construction workforce in Texas, 56% in New Mexico, and 30% in Colorado (PHC 2012). Hispanic workers are generally younger than non-Hispanic workers in construction. In 2010, the median age for Hispanic workers was 35 years compared to 44 years for non-Hispanic workers (CPWR 2013).

In 2010, the Center to Protect Worker's Rights (CPWR) (2013) found that about 90% of Hispanic workers had a job in either low or highly skilled trades, as compared to 68% of non-Hispanic workers. On the other hand, only 7% of Hispanic workers had managerial or professional occupations. Figure 11 shows a breakdown of different construction trades in which Hispanic construction workers are employed.

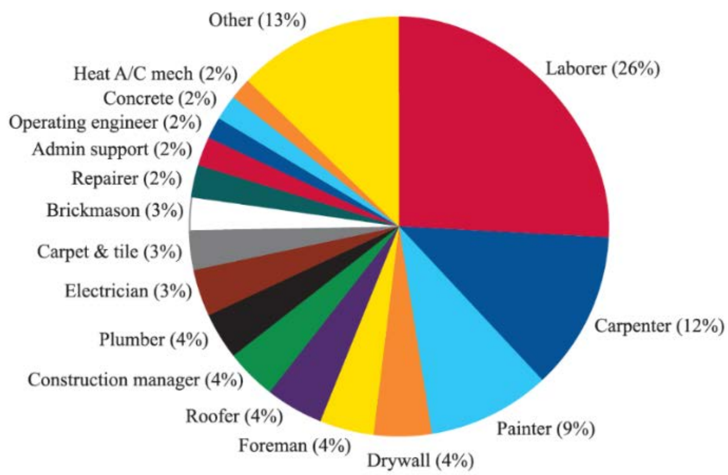


Figure 11: Hispanic Construction Distribution by Trade, Average from 2008 to 2010 (CPWR 2013)

In 2010, non-union Hispanic workers made about 20% less than non-Hispanic non-union workers per hour ($14.33 vs. $17.94). In the union sector, the hourly wage difference between the two ethnicities was only 3% ($25.31 vs. $25.98). On average, Hispanic construction workers earned 25% less per hour than their non-Hispanic counterparts ($15.19 vs. $19.99), Figure 12 (CPWR, 2013).

The wage differences are due to several factors. The cultural background of the Hispanic workers contributes to the language barrier, career choices pushed by parents, and the need to financially support one's family at an early age (Hallowell and Yugar-Arias 2016). All these factors also contribute to lack of a high school degree and a lack of equivalent training, which are the main requirements for the highly skilled trades.

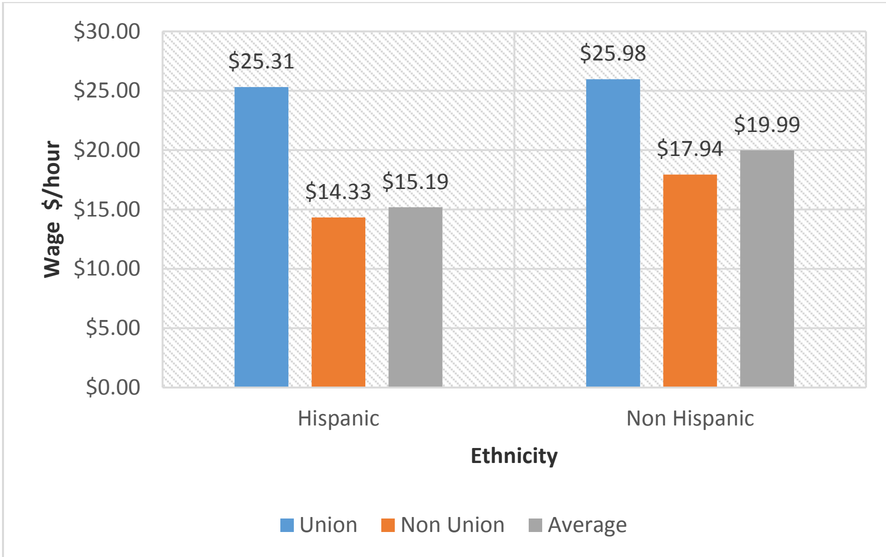


Figure 12: Average Hourly Wage in Construction, for Hispanic and Non-Hispanic Workers, and Union Status, 2010 (CPWR 2013)

Education completion statistics also show differences between the two demographic groups. About 50% of Hispanic construction workers had less than a high school diploma, one third earned a high school diploma, and the rest (18%) had some post-secondary education, Figure 13. On the other hand, nearly 47% of non-Hispanic workers went to college and earned some college degree or higher, and about 53% had a high school diploma or less (CPWR 2013).

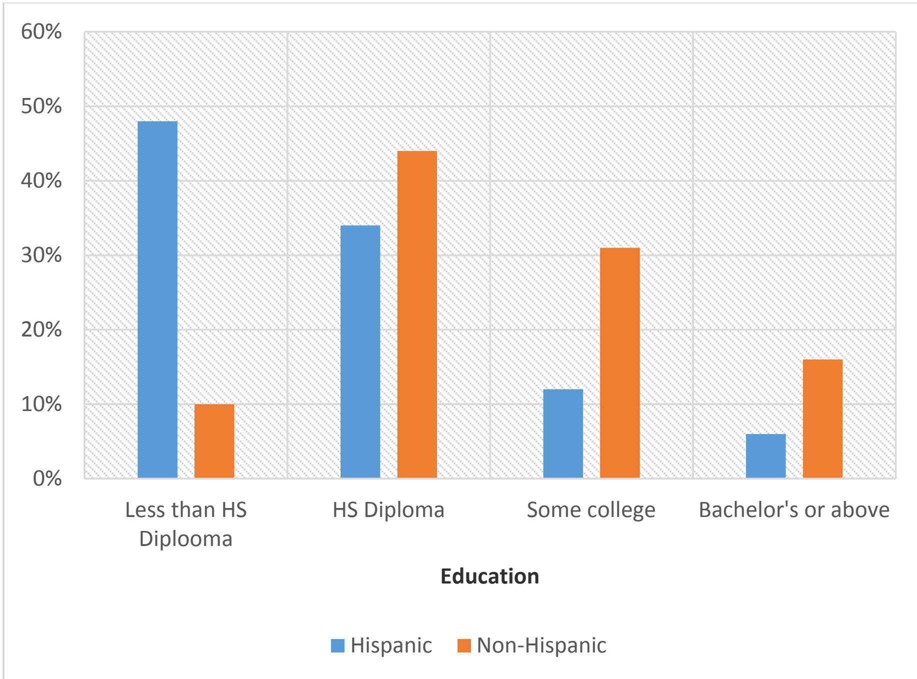
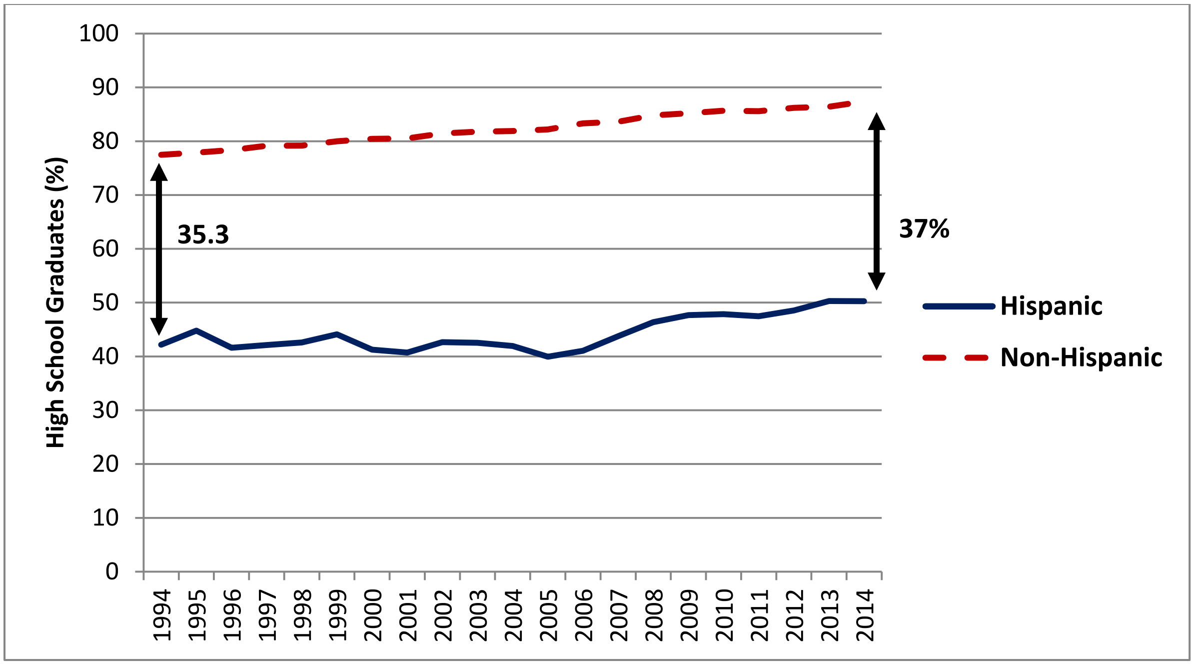


Figure 13: Distribution of Educational Accomplishment among Construction Workers, for Hispanic and Non-Hispanic Workers, 2010 (CPWR 2013)

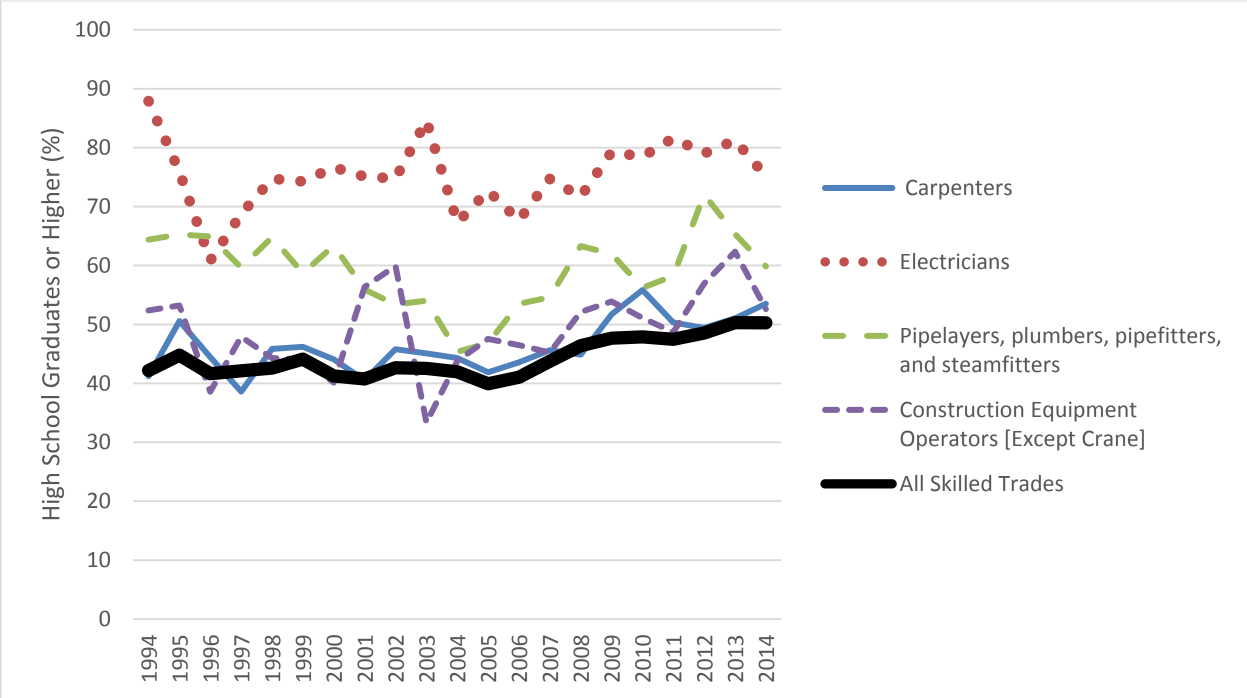
According to CPS data, in 1994, 42.1% of Hispanic craft workers had a high school diploma compared to 77.4% of non-Hispanic craft workers. In 2014, the rate of Hispanic craft workers with a high school diploma increased to 50.2%, and the rate of non-Hispanic craft workers with a high school diploma increased to 87.3%. Thus, the high school education gap between Hispanic and non-Hispanic craft workers was approximately 37% in 2014, Figure 14.



SOURCE: DataFerret – Current Population Survey, U.S. Bureau of Labor Statistics.

Figure 14: High School Diploma or Higher (Hispanic vs. Non-Hispanic workers)

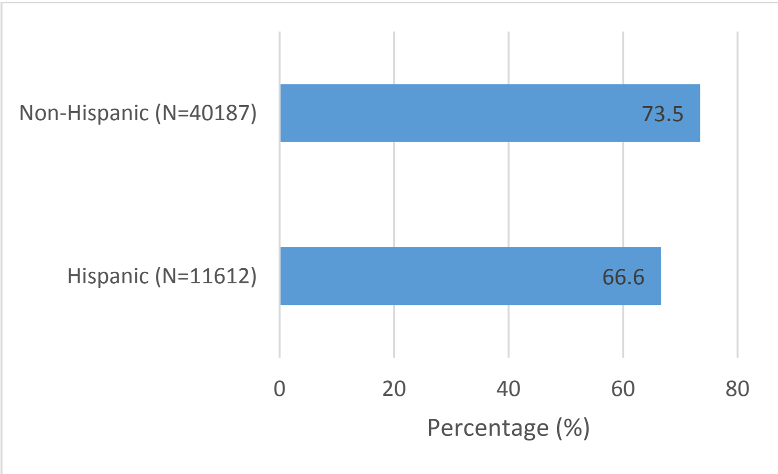
More high school graduates are employed in highly skilled construction trades than in skilled trades in general, Figure 15. In 2014, the average rate of high school graduation among all Hispanic craft workers in the construction industry was 50.2%. However, the average rate of high school graduation among Hispanic electricians was 75.1%, Hispanic pipefitters was 59.8%, Hispanic carpenters was 53.5%, and Hispanic construction equipment operators [except crane] was 52.5%. Therefore, one strategy to address the skilled workforce shortages is improving high school graduation rates or obtainment of an equivalent degree through General Education Development (GED).



SOURCE: DataFerret – Current Population Survey, U.S. Bureau of Labor Statistics.

Figure 15: Hispanic High School Diploma or Higher by Trade

In addition to the educational level, there was also a difference between Hispanic and non-Hispanic craft workers in their formal training rates. The formal training rate was calculated using NCACP data from 2005-2014. Fewer Hispanic craft workers (66.6%) had formal training than non-Hispanic craft workers (73.5%), as shown in Figure 16.



Chi-square test was performed to test the difference between the columns. The P-value = 0.00.

SOURCE: National Craft Assessment and Certification Program (NCACP).

Figure 16: Formal Training Rate among All Participants (Hispanic vs. Non-Hispanic)

4.4 RESEARCH METHODOLOGY

Data was collected from two datasets to study the differences between Hispanic and non-Hispanic craft workers in the construction industry and their influence on multiskilling. The U.S. Bureau of Labor Statistics' Current Population Survey (CPS) was used for applying trend analyses to Hispanic and non-Hispanic craft worker demographics. The National Craft Assessment and Certification Program (NCACP) was used for analyzing the multiskilling patterns among Hispanic and non-Hispanic craft workers using a Skill Matrix method and Categorical Principal Component Analysis (CATPCA).

4.4.1 U.S. Bureau of Labor Statistics' Current Population Survey (CPS)

The CPS raw data was obtained from the DataFerrett website, which is publicly accessible and updated monthly. The author used monthly microdata from 1994 to 2014. The CPS identifies the occupation of respondents with 3- and 4-digit occupation classification codes defined by the U.S. Census Bureau. The author used these code numbers to identify and include only construction craft workers (hourly paid) in the analysis. Supervisor, managerial, engineering, and administrative workers were not included in the analysis. In total, there were 705,321 construction craft workers, and 3,151,229 craft workers in non-construction industries in the dataset.

4.4.2 National Craft Assessment and Certification Program (NCACP)

The National Center for Construction Education and Research (NCCER) developed the NCACP to evaluate journey-level knowledge and the skills of experienced craft workers. The worker who achieves a score above a cut-off point is classified as passing their written certification exam, otherwise training is recommended. Besides the workers' test results (pass/training needed), the NCACP data includes codes identifying each participant's assessment location, gender, race, training curriculum, training provider, and years of experience in construction. A total of 402,899 exams or cases (number of exams taken by different individuals) with 174 different certificates were included in the dataset from 2005 to 2014. This study included only 14 trades—a total of 134 certificates—related to the construction industry, excluding trades relevant to operation and maintenance and management sectors. Some certificates are related to specific tasks under a certain trade, require more experience (advanced certificates), or are in a different language (e.g., Spanish). Only those who took exams for two or more different certificates were included in this study, a total of 20,789 participants.

4.4.3 Construction Trades Education and Training Requirements

The BLS (2015) defines the education and training requirements for each trade in the construction industry. Some trades require a high school degree or equivalent while others do not. For a worker to become a journeyman, some trades require short-term training (1-2 years), moderate-term training (3-4 years), or apprenticeship (3-5 years). According to Vereen (2013), highly skilled trades require longer and more specialized education (e.g., carpenters, electricians, pipefitters) and low skilled trades require minimal or no training (e.g., general helpers, roofers). For the purposes of this study, trades requiring a high school degree or equivalent, as well as moderate-term training or apprenticeship were considered "highly skilled." Otherwise, a trade was considered "low skilled" if it did not require a high school degree but involved moderate-term training, or required a high school degree or equivalent and short-term training. See Table 17 for the CPS data trades and Table 18 for the NCACP data trades.

Table 17: Trades' Education and Training Requirements from the CPS Data

Trade	High School Requirement	Training Years	Training level	Trade level
Electricians	yes	4 to 5 years	Apprenticeship	Highly Skilled
Pipelayers, plumbers, pipefitters, and steamfitters	yes	4 to 5 years	Apprenticeship	Highly Skilled
Carpenters	yes	3 to 4 years	Apprenticeship	Highly Skilled
Brickmasons, blockmasons, and stonemasons	yes	3 to 4 years	Apprenticeship	Highly Skilled
Construction Equipment Operators	yes	3 to 4 years	Moderate-term	Highly Skilled
Painters, construction and maintenance	no	3 to 4 years	Moderate-term	Low Skilled
Roofers	no	Up to 3 years	Moderate-term	Low Skilled
Carpet, floor, and tile installers and finishers	no	2 to 4 years	Moderate-term	Low Skilled
Drywall installers, concrete and terrazzo finishers*, and plasterers	no	within a year or 2	Short-term	Low Skilled
Construction laborers and helpers	no	within a year or 2	Short-term	Low Skilled

* Most terrazzo workers learn their trade through a 3-year apprenticeship.

Table 18: Trades' Education and Training Requirements from the NCACP Data

Trade	High School Requirement	Training Years	Training level	Trade level
Pipefitter	yes	4 to 5 years	Apprenticeship	Highly Skilled
Electricians & Instrumentation	yes	4 to 5 years	Apprenticeship	Highly Skilled
Boilermaker	yes	4 to 5 years	Apprenticeship	Highly Skilled
Industrial Insulation* (Mechanical)	yes	4 to 5 years	Apprenticeship	Highly Skilled
Reinforcing Iron and Rebar	yes	3 to 4 years	Apprenticeship	Highly Skilled
Ironworker	yes	3 to 4 years	Apprenticeship	Highly Skilled
Carpenters	yes	3 to 4 years	Apprenticeship	Highly Skilled
Millwright	yes	3 to 4 years	Apprenticeship	Highly Skilled
Heavy Equipment Operator	yes	3 to 4 years	Moderate-term	Highly Skilled
Crane Operator	yes	3 to 4 years	Moderate-term	Highly Skilled
Painter	no	3 to 4 years	Moderate-term	Low Skilled
Riggers	yes	within a year or 2	Short-term	Low Skilled
Scaffold Builder**	no	within a year or 2	Short-term	Low Skilled
Concrete Finisher**	no	within a year or 2	Short-term	Low Skilled

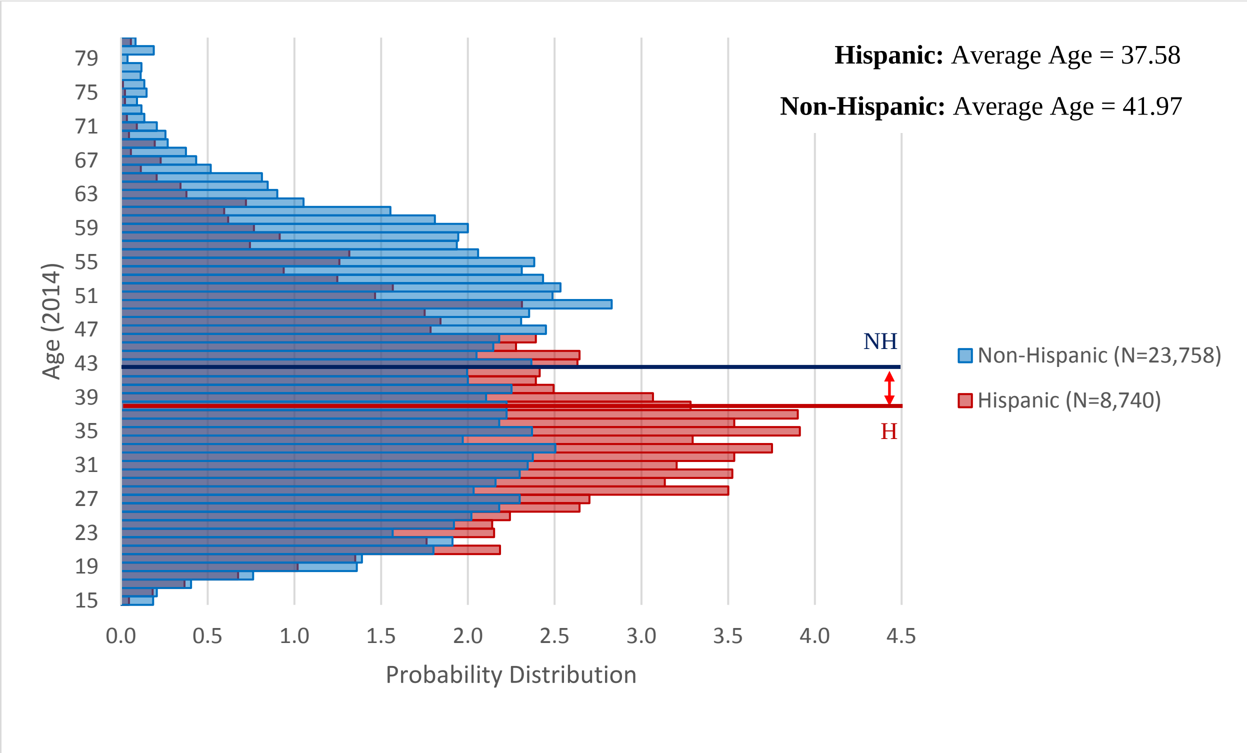
* There is no specific education requirements for floor, ceiling, and wall insulation workers, and their training will be within a year or 2.
** Start as a helper.

4.5 RESULTS

4.5.1 CPS Data Results

4.5.1.1 Age Distribution [Hispanic vs. Non-Hispanic]

The age distribution for Hispanic and non-Hispanic craft workers was compared for the year 2014. For all trades, the average age of Hispanic craft workers was around 38 years and the average age among non-Hispanics was around 42 years. In other words, the average Hispanic craft worker was around four years younger than the average non-Hispanic craft worker, Figure 17.

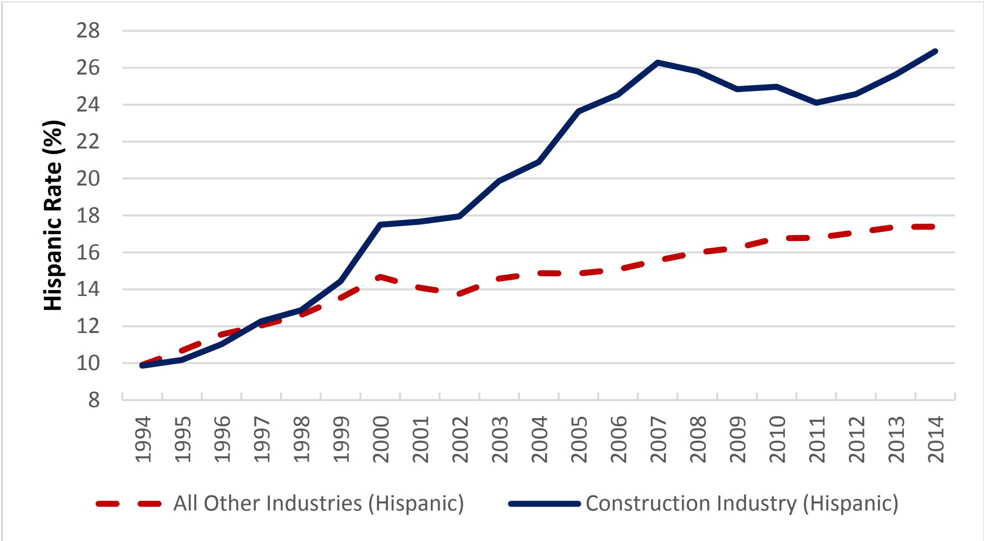


SOURCE: DataFerret – Current Population Survey, U.S. Bureau of Labor Statistics. T test (p-value) = 0.00

Figure 17: Age Distribution in 2014 (Hispanic vs. Non-Hispanic Workers)

4.5.1.2 The Hispanic Workforce in Construction versus Other Industries

The participation rate of Hispanic craft workers in the construction industry versus Hispanic craft workers in all other industries was analyzed using the CPS dataset. The participation rate was growing over time for construction and all other industries, Figure 18. However, the Hispanic participation rate in construction was especially low in the mid-1990's and grew quickly after the early 2000's. In 2014, the Hispanic craft workers' population rate was 26.9% for the construction industry and 17.4% for all other industries, while it was 9.9% in 1994 for both construction and other industries.

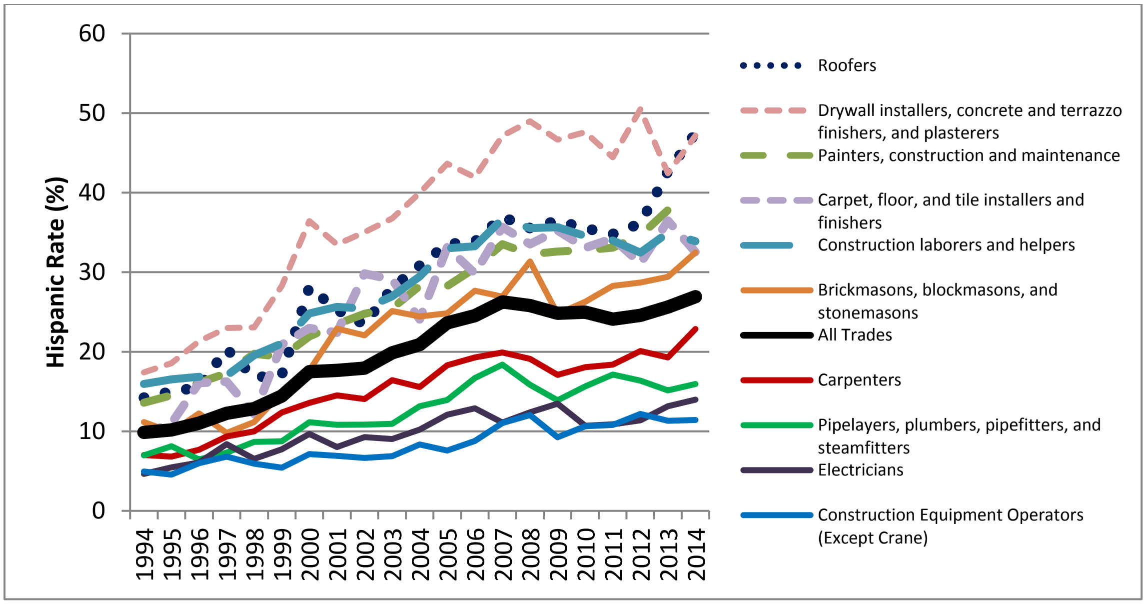


SOURCE: DataFerret – Current Population Survey, U.S. Bureau of Labor Statistics.

Figure 18: The Hispanic Workforce (Construction vs. All Other Industries)

4.5.1.3 Hispanic Construction Workers at Trades Level

There are high percentages of Hispanic craft workers in the residential-sector construction trades and the participation rate is higher for these trades than the average of all skilled trades, Figure 19. In fact, most of these residential-sector construction trades do not require a high school diploma, Table 17 and Table 18. In 2014, Hispanic construction craft workers constitute around 20% of the total craft workers among highly skilled trades that require unique training or certification, Figure 19.

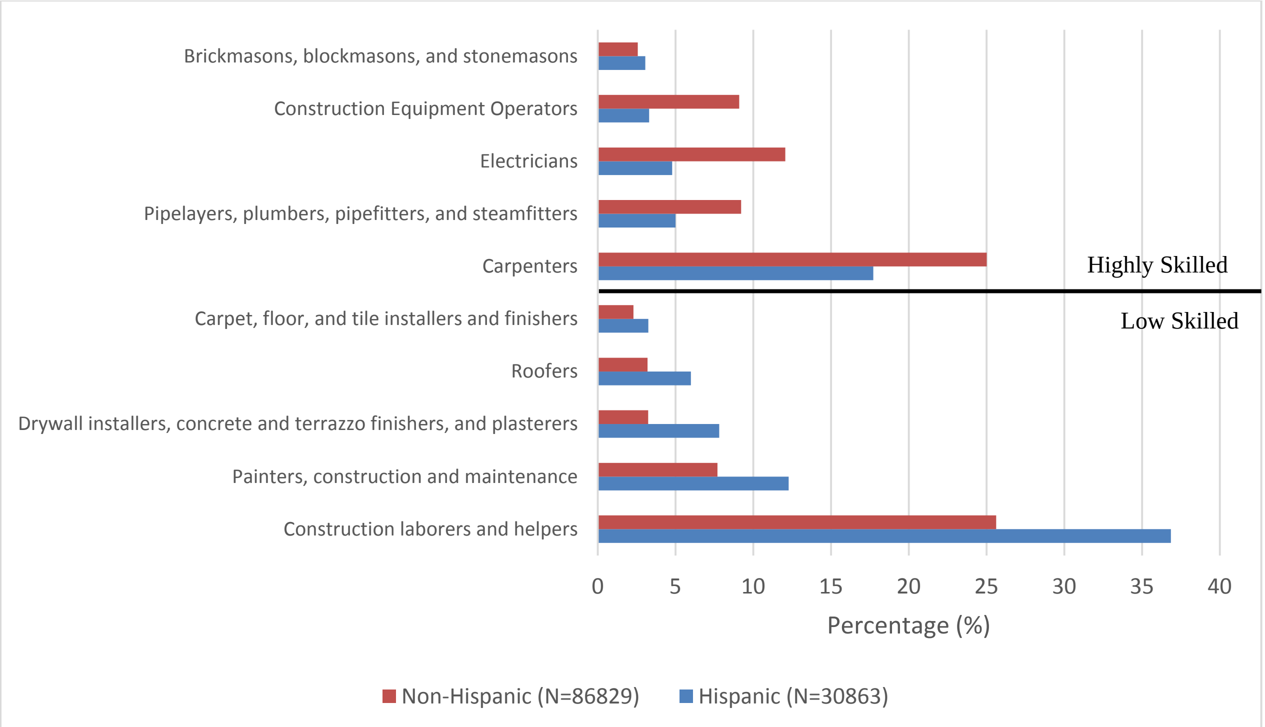


SOURCE: DataFerret – Current Population Survey, U.S. Bureau of Labor Statistics.

Figure 19: Hispanic Construction Workers' Distribution among Trades

4.5.1.4 Hispanic versus Non-Hispanic Population Distribution among Construction Trades for 2011- 2014

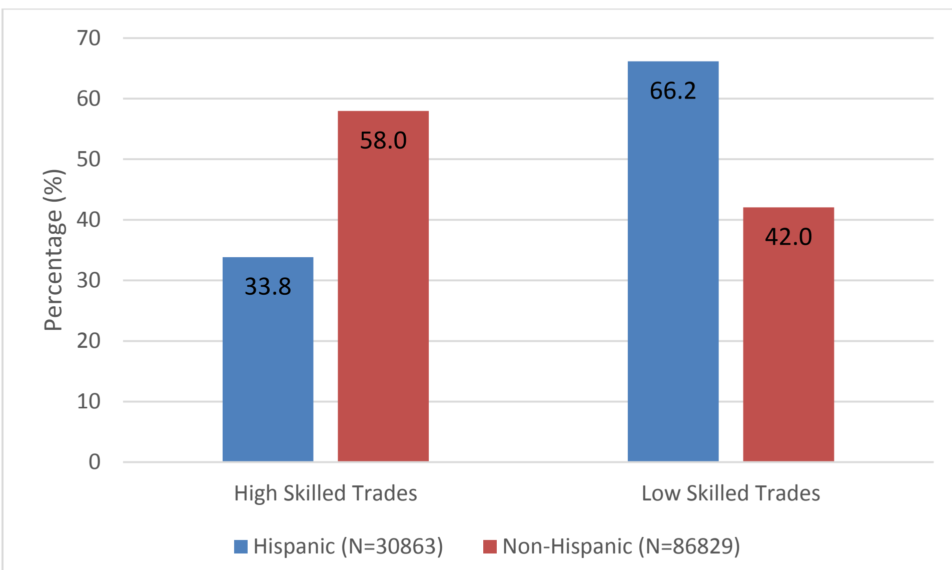
Using CPS data from 2011 to 2014, the distribution of Hispanic and non-Hispanic craft workers among construction trades was analyzed, Figure 20. The percentage of Hispanic workers was higher (36.8%) than non-Hispanic workers (25.6%) among the construction laborers and helpers—the entry level to the construction industry. Hispanics (3.0%) and non-Hispanics (2.6%) were evenly represented among brick-masons, block-masons, and stonemasons. Among carpet, floor, and tile installers and finishers, Hispanics are slightly more numerous (3.3%) than non-Hispanics (2.3%). However, only 33.8% of Hispanic craft workers were in highly skilled trades compared to 58% of non-Hispanic craft workers, Figure 21.



Chi-square test was performed to test the difference between the columns. The P-value = 0.00.

SOURCE: DataFerret – Current Population Survey, U.S. Bureau of Labor Statistics.

Figure 20: Hispanic vs. Non-Hispanic Workers' Distribution among Construction Trades from 2011 to 2014



Chi-square test was performed to test the difference between the columns. The P-value = 0.00.

SOURCE: DataFerret – Current Population Survey, U.S. Bureau of Labor Statistics.

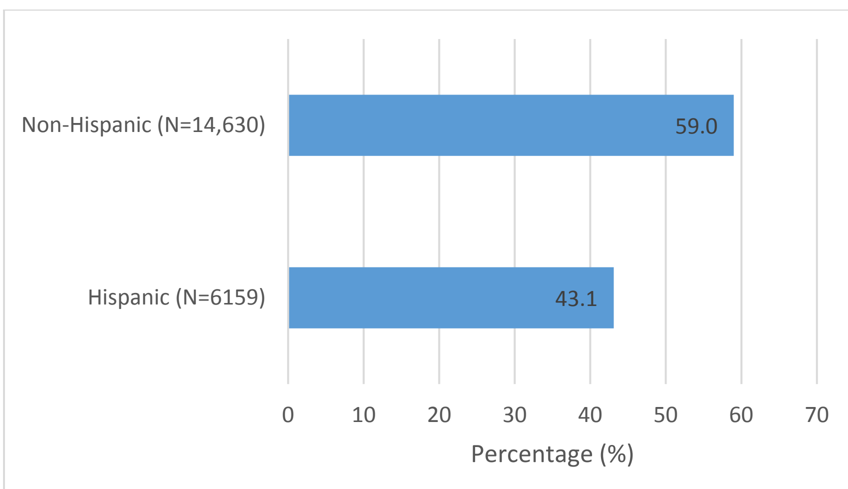
Figure 21: Hispanic and Non-Hispanic Workers in Highly Skilled Trades vs. Low Skilled Trades from 2011-2014 (based on data from Figure 20)

4.5.2 NCACP Data Results

In this section, comparisons of Hispanic and non-Hispanic multi-skilled craft workers' participation rates and formal training rates are presented. Hispanic and non-Hispanic multi-skilled craft workers' distribution among construction trades and their multiskilling patterns by construction trades were also analyzed.

4.5.2.1 Percentage of Multi-Skilled Workers by Race

NCACP data was used to compare the participation percentages of Hispanic and non-Hispanic multi-skilled craft workers. Among all multi-exam takers in the dataset, 29.6% were Hispanic and 70.4% were non-Hispanic. These percentages included all exam takers—regardless of whether or not they passed the exam—between 2005 and 2014. However, the percentage of Hispanic craft workers who passed at least two exams was lower (43.1%) than the percentage of non-Hispanics (59%), Figure 22.

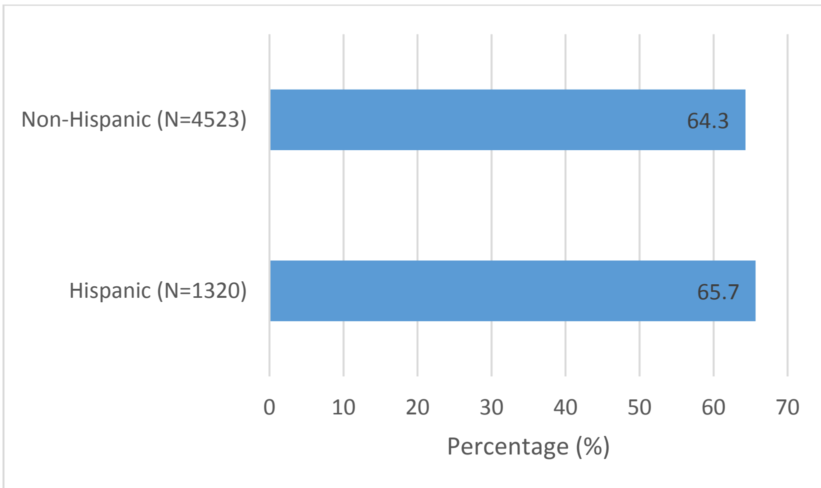


Chi-square test was performed to test the difference between the columns. The P-value = 0.00.
SOURCE: National Craft Assessment and Certification Program (NCACP).

Figure 22: Percentage of Multi-skilled Workers by Race (Hispanic vs. Non-Hispanic)

4.5.2.2 Percentage of Formal Training among Multi-Skilled Workers

There was no statistical difference between ***multi-skilled*** Hispanic (65.7%) and non-Hispanic (64.3%) craft workers in the percentage of formal training, as demonstrated using chi-square test (p = 0.36) (Figure 23). Therefore, formal training could be a driver for Hispanic craft workers to become multi-skilled. Workers who did not specify their training type were not included in the analysis.

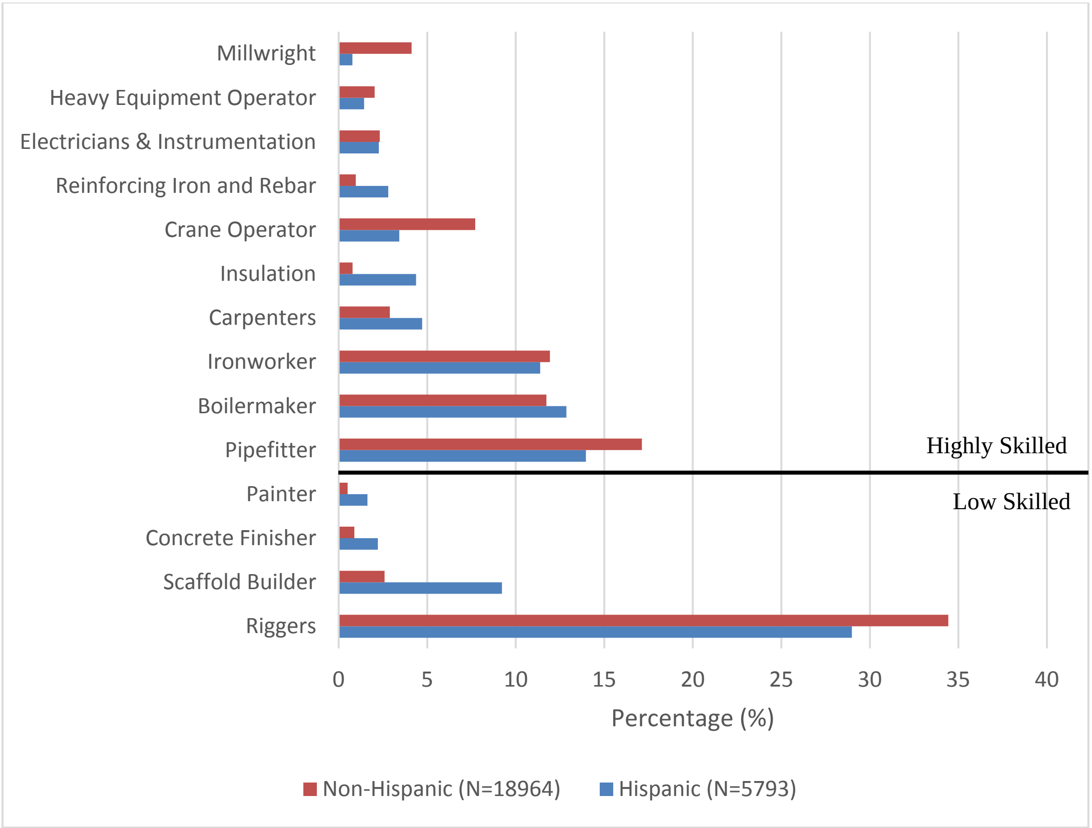


Chi-square test was performed to test the difference between the columns. The P-value = 0.36.
SOURCE: National Craft Assessment and Certification Program (NCACP).

Figure 23: Formal Training's Rate among Multi-Skilled Workers (Hispanic vs. Non-Hispanic)

4.5.2.3 Multi-Skilled Workers' Distribution among Construction Trades

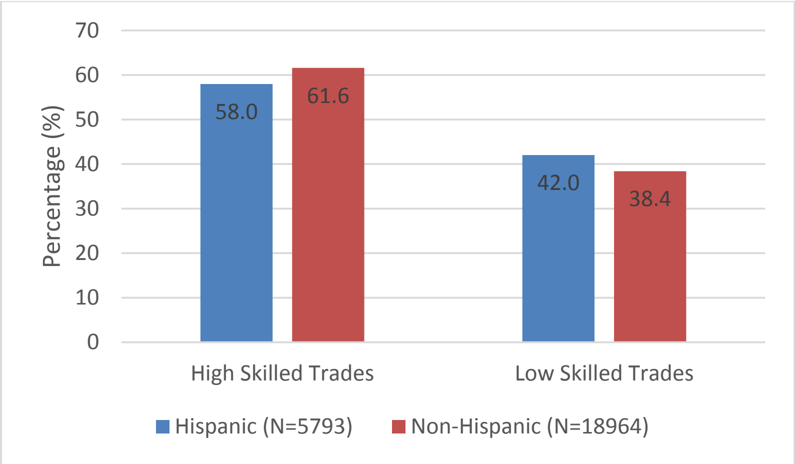
Twenty-nine percent of Hispanic and 34.4% of non-Hispanic multi-skilled workers were riggers, the most common construction trade among both groups, Figure 24. The least common construction trade among Hispanic workers was millwright (0.8%), compared with 4.1% among non-Hispanics. The least common construction trade among non-Hispanic workers was painter (0.5%), compared to 1.6% among Hispanics. The distribution of Hispanic craft workers (58%) was about equal to non-Hispanics (61.6%) among highly skilled trades, Figure 25.



Chi-square test was performed to test the difference between the columns. The P-value = 0.00.

SOURCE: National Craft Assessment and Certification Program (NCACP).

Figure 24: Hispanic vs. Non-Hispanic Workers' Distribution among Construction Trades from 2005-2014 (Multi-Skilled Workers Skills Only)



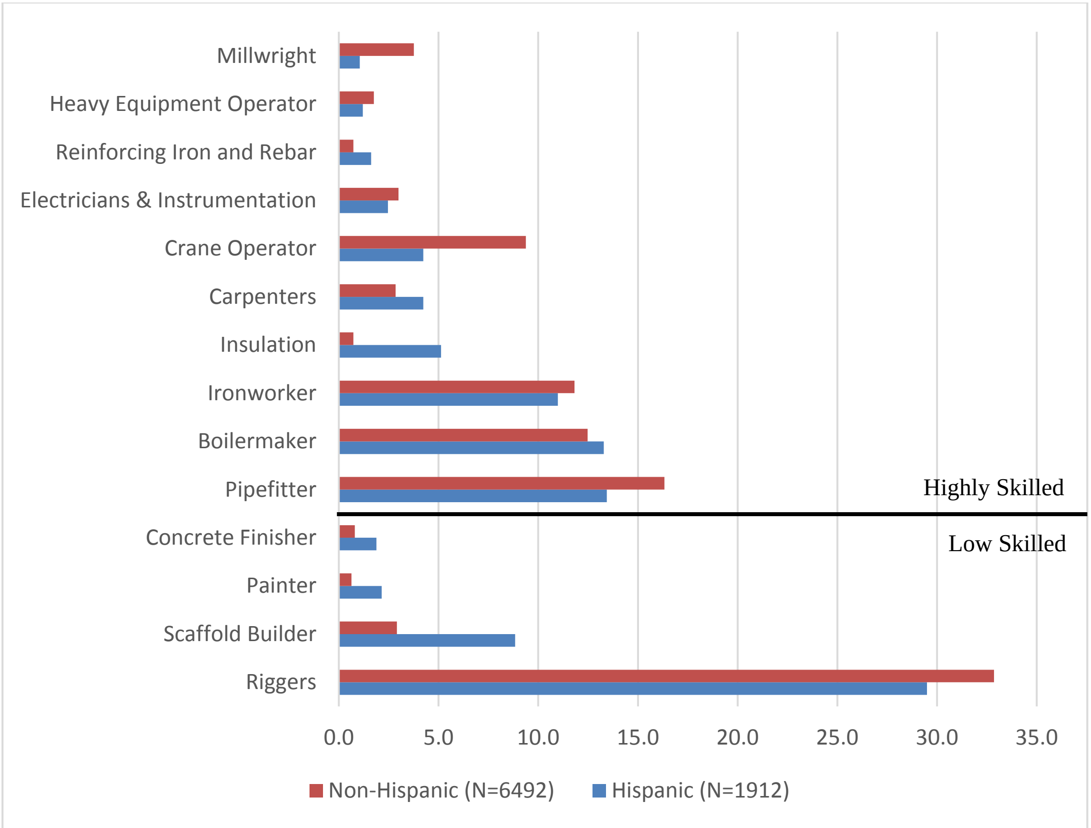
Chi-square test was performed to test the difference between the columns. The P-value = 0.00.

SOURCE: National Craft Assessment and Certification Program (NCACP).

Figure 25: Hispanic and Non-Hispanic Workers in Highly Skilled Trades vs. Low Skilled Trades from 2005-2014 (based on data from Figure 24)

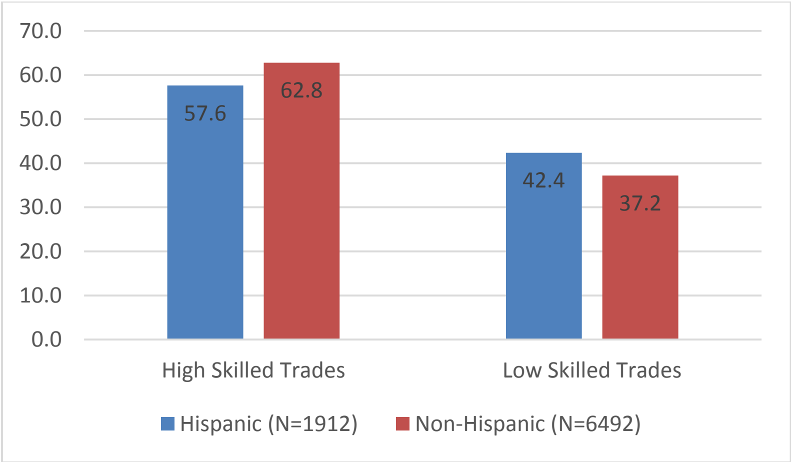
4.5.2.3.1 Workers' Distribution among Construction Trade by Formal Training

In addition to the distribution of workers engaged in various construction trades, formal training was also compared between Hispanic and non-Hispanic craft workers. Among both groups, the most common type of formal training was rigger training; 29.5% of Hispanic and 32.9% of non-Hispanic craft workers received rigger training. The least common formal training type among Hispanic workers was millwright (1%), compared with 3.8% among non-Hispanics. The least common formal training type among non-Hispanic workers was painter (0.6%), compared with 2.1% among Hispanics, Figure 26. However, nearly as many Hispanic craft workers (57.6%) received formal training in highly skilled trades as non-Hispanic craft workers (62.8%), Figure 27.



Chi-square test was performed to test the difference between the columns. The P-value = 0.00.
SOURCE: National Craft Assessment and Certification Program (NCACP).

Figure 26: Hispanic vs. Non-Hispanic Workers' Distribution among Construction Trades from 2005-2014 (Formal Training)



Chi-square test was performed to test the difference between the columns. The P-value = 0.00.
SOURCE: National Craft Assessment and Certification Program (NCACP).

Figure 27: Hispanic and Non-Hispanic Workers in Highly Skilled Trades vs. Low Skilled Trades from 2005-2014 (based on data from Figure 26)

4.5.2.4 Multiskilling Patterns
4.5.2.4.1 Dual-Skill Sets

To define the dual-skill sets, two skill matrices were applied, one for Hispanics (n = 6,159) and the other one for non-Hispanics (n = 14,630). Fourteen trade skills were included in this study for a total of 91 dual-skill sets. To avoid bias in the ranked results due to the high distribution of some skills, dual-skill sets were normalized, using Equation 2.

Equation 2. Normalized dual-skill sets

$$NDS = \frac{\#BS(x,y)}{[\#S(x) + \#S(y)] - \#BS(x,y)} \times 100$$

NDS = the normalized dual-skill by percentage, *#BS (x, y)* = the number of workers who have the both skills, *#S(x)* = the number of workers who have the skill in the *x*-axis, and *#S(y)* = the number of workers who have the skill in the *y*-axis

The top 10 dual-skill sets were ranked among Hispanics and compared with the top 10 dual-skill sets among non-Hispanic. Carpenter/concrete finisher was the top dual skill-set among all Hispanic multi-skilled craft workers and fourth among non-Hispanics. Reinforcing iron and rebar/concrete finisher was the top dual skill-set among non-Hispanic craft workers and second among Hispanics, Table 19. Among the 91 dual-skills, the top 9 dual-skills for Hispanic craft workers were in the top 9 dual-skills for non-Hispanic craft workers but with different rankings. However, the 10^{th} dual-skill of both Hispanic and non-Hispanic craft workers were not the same. In general Hispanic and non-Hispanic construction craft workers had similar multiskilling patterns, Figure 28.

Table 19: Top 10 Dual-Skills for All Hispanic Multi-Skilled Workers Compared with Non-Hispanics

#	Dual-Skill			Hispanic		Non-Hispanic	
				Rank (#)	%	Rank (#)	%
1	Carpenters	&	Concrete Finisher	1	29.77	4	23.06
2	Reinforcing Iron and Rebar	&	Concrete Finisher	2	28.89	1	32.7
3	Ironworker	&	Riggers	3	27.62	3	26.59
4	Reinforcing Iron and Rebar	&	Carpenters	4	27.19	7	16.61
5	Pipefitter	&	Riggers	5	24.4	2	28.41
6	Boilermaker	&	Riggers	6	20.96	5	20.48
7	Pipefitter	&	Boilermaker	7	20.09	6	18.73
8	Scaffold Builder	&	Insulation	8	19.79	9	15.32
9	Crane Operator	&	Riggers	9	10.09	8	16.29
10	Scaffold Builder	&	Boilermaker	10	9.97	31	2.69
11	Scaffold Builder	&	Carpenters	16	6.04	10	9.95

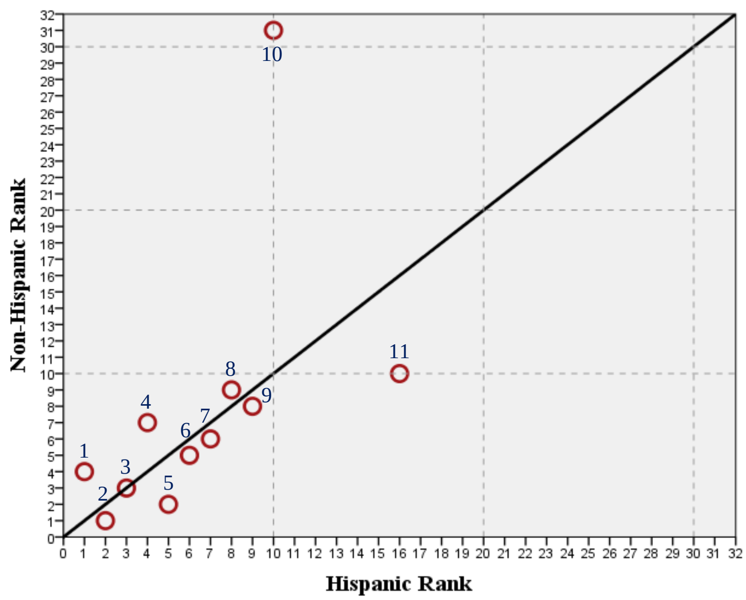


Figure 28: A Scatter Plot Showing the Relationship between Hispanic and non-Hispanic Dual-Skills Ranking (All Workers)

The author created two additional skill matrices that included only Hispanics (*n* =1,320) and non-Hispanics (*n* = 4,523) with formal training. Carpenter/concrete finisher was the top dual-skill set among Hispanic craft workers with formal training, and fifth among non-Hispanics with formal training. Reinforcing iron and rebar/concrete finisher was also ranked first among non-Hispanic craft workers with formal training, and seventh among Hispanics with formal training, Table 20. The top 10 dual-skills for both Hispanics and non-Hispanics were the same as the top 10 dual-skills for all workers when controlling for formal training, but the ranking of the dual-skills changed. The top 9 dual-skills for Hispanic craft workers were in the top 9 dual-skills for non-Hispanic craft workers but with different rankings. In addition, the 10th dual-skill of both Hispanic and non-Hispanic craft workers were not the same. Overall, however, formally trained Hispanic and non-Hispanic construction craft workers had similar multiskilling patterns, Figure 29.

Table 20: Top 10 Dual-Skills for Hispanic Workers with Formal Training Compared with Non-Hispanics

#	Dual-Skill			Hispanic		Non-Hispanic	
				Rank (#)	%	Rank (#)	%
1	Carpenters	&	Concrete Finisher	1	31.46	5	20.3
2	Ironworker	&	Riggers	2	27.51	3	25.43
3	Pipefitter	&	Riggers	3	23.46	2	27.47
4	Pipefitter	&	Boilermaker	4	23.13	7	18.81
5	Reinforcing Iron and Rebar	&	Carpenters	5	23.08	9	13.17
6	Scaffold Builder	&	Insulation	6	21.92	10	9.77
7	Reinforcing Iron and Rebar	&	Concrete Finisher	7	21.82	1	30.26
8	Boilermaker	&	Riggers	8	21.01	4	23.45
9	Crane Operator	&	Riggers	9	12.96	6	19.48
10	Scaffold Builder	&	Boilermaker	10	9.87	27	3.2
11	Scaffold Builder	&	Carpenters	15	6.38	8	13.33

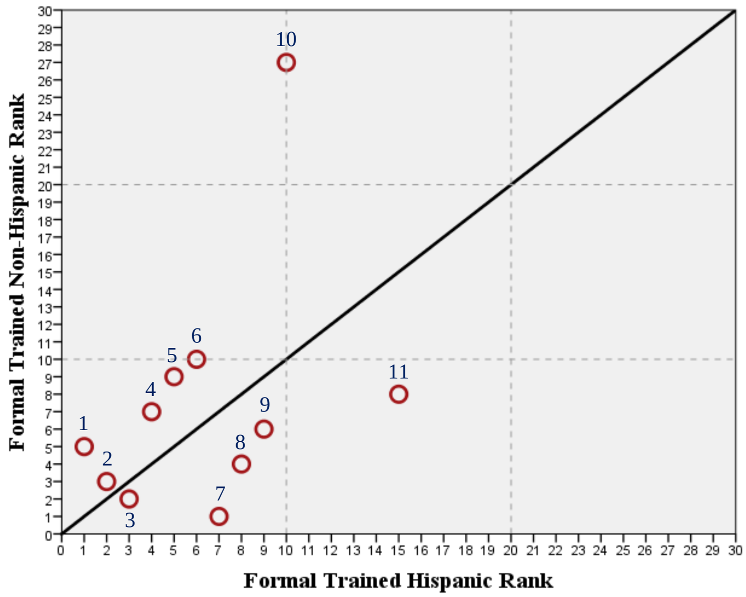


Figure 29: A Scatter Plot Showing the Relationship between Hispanic and non-Hispanic Dual-Skills Ranking (Workers with Formal Training)

4.5.2.4.2 Multi-Skill Groups

CATPCA was used to examine if workers sought certifications in more than two skills. CATPCA reduces the number of variables into lower numbers of uncorrelated components (Linting et al. 2007; Linting and Kooij 2012; Song et al. 2013). Principal Component Analysis (PCA), the original version of CATPCA, is the most popular tool for dimensionality reduction in science and engineering studies (Shen et al. 2015; Song et al. 2013). PCA only works with continuous data or data that can be treated as continuous, like ordered categorical variables (e.g., Likert scale) (Tixier et al. 2014). In addition, PCA assumes linear relationships between variables and normality is required (Linting et al. 2007; Linting and Kooij 2012). However, CATPCA can be used to transform data from qualitative scales to quantitative values by applying an optimal scaling technique (Linting et al. 2007; Song et al. 2013; Linting and Kooij 2012). Also, CATPCA does not assume linear relationships between variables and normality is not required (Linting et al. 2007; Linting and Kooij 2012). PCA could not be used in this study because it requires continuous data, and a value in each cell. Although the data in this study is continuous, almost 85% of the total data had missing values representing exams not taken. Other studies (Parreira et al. 2015; Chen et al. 2013; McIntosh et al. 2016; Awai et al. 2016; Ojiako et al. 2015; Wulffaert et al. 2009; Slingerland et al. 2011; Vilela et al. 2015; de Sousa Mendes and Miller Devos Ganga 2013) in engineering and in different science fields used the CATPCA tool because they needed to transform at least one nominal or ordinal variable into a quantitative value. Figure 30 shows the CATPCA steps.

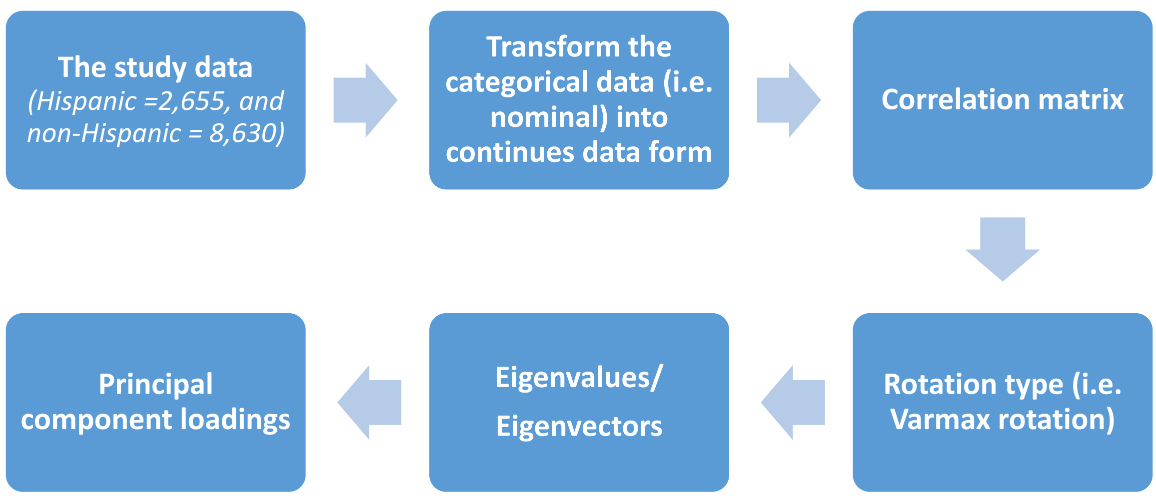


Figure 30: CATPCA Steps

Based on Linting et al. (2007) and Linting and Kooij (2012), the following CATPCA assumptions were considered: 1) variables should be independent and not be associated with one or more dependent variables; 2) forced classification/grouping specifies the number of the components before analysis; 3) the number of the variables is reduced into fewer components; 4) optimal scaling transforms the qualitative scales to quantitative values, and uses multiple levels of measurements (continuous, ordinal, nominal) at the same time in the same analysis; 5) linear relationships are not assumed among numeric data; 6) multivariate normal data are not assumed; 7) missing values are excluded from the calculation process, without the need for pairwise or list-wise deletion, but missing values can also be included as an extra category; 8) negative values are excluded from the calculation process, and the category number coded by “0” is considered as missing value; and 9) for nominal data, a minimum of three categories is required.

To study the multiskilling strategy using NCACP data, matrices were created for Hispanics with all training types, non-Hispanics with all training types, Hispanics with formal training, and non-Hispanics with formal training. Only multi-skilled craft workers were included. The *y*-axis included the participant IDs and the *x*-axis included 14 construction trades. These matrices had three nominal groups: passing a skill exam was coded “1” under that skill column, failure to pass the exam was coded “2,” and exams not taken were coded “3.”

Based on Linting and Kooij (2012), the following steps were taken to enhance and stabilize the results. With optimal scaling, the eigenvalues of the principal components (PCs) are maximized and differ by the number of PCs. For example, if two PCs were chosen for the solution, the eigenvalues of these two PCs will be different from the first two PCs of the three PC solutions, and so on (the solutions are not nested), unlike the linear PCA, in which the eigenvalues do not change by the number of PCs. Therefore, analysis began with the two PCs solution and stopped at the PCs solution that included all variables with loadings of ±0.4 or higher at any PC. This loading cutoff was chosen based on prior research by Linting and Kooij (2012). For the comparison between Hispanic and non-Hispanic craft workers, the best PC numbers that could be applied to both were determined. Furthermore, outliers were defined and excluded by examining the object scores in the CATPCA analysis results. In the analysis, scores that exceeded ±4 were excluded.

4.5.2.4.2.1 CATPCA Results

By using the conditions above, five PCs were determined as the best dimension numbers to compare Hispanic and non-Hispanic construction craft workers. At each PC, if more than two skills loaded ±0.4, they were considered as a multiskilling group. The ±0.4 loading among certain skill variables means that a 16% variance was found at that PC. The loadings that have +0.4 or higher are shaded dark gray and the loadings that have -0.4 or lower are shaded light gray, Table 21 and Table 23. Because only 14 skill variables were analyzed to find the multiskilling pattern, those without the required loading are unshaded and were excluded from the multiskilling groups but included in the analysis.

4.5.2.4.2.1.1 Hispanic Results

From the Hispanic CATPCA results, out of five PCs only four multiskilling groups met the loading requirement. Among 2,655 craft workers, 42 outliers were excluded. The Variance Account For (VAF) across the five PCs together was 54%, which is considered reasonable in studies such as this (Linting and Kooij 2012). The first PC, Civil/Concrete, included carpenter, concrete finisher, and reinforcing iron & rebar skills. The second PC, Support Finishing, included scaffold builder, insulation, and painter skills; the rigger skill loaded high in this PC but in the negative direction, and was considered quite different from this group of skills. The third PC, Mechanical, included pipefitter and boilermaker skills. The ironworker skill loaded high in this PC but in the positive direction, and was considered quite different from this group of skills. The fourth PC, Equipment Operators, includes heavy equipment operator and crane operator skills. The fifth PC included only electricians & instrumentation skill, and therefore was not a multiskilling group, Table 21.

Table 21: Rotated Component Loadings from a Five-Dimensional CATPCA on 14 Variables among Hispanic Workers (All Multi-Skilled Workers)

Trade	Dimension (principal component)				
	1	2	3	4	5
Carpenters	**.809**	**.063**	**.005**	**.124**	**.056**
Concrete Finisher	**.736**	**-.087**	**.085**	**-.088**	**-.032**
Reinforcing Iron and Rebar	**.725**	**-.019**	**.119**	**-.095**	**.014**
Scaffold Builder	**-.046**	**.741**	**.008**	**-.006**	**-.029**
Riggers	**-.342**	**-.713**	**.163**	**.028**	**.047**
Insulation	**-.125**	**.659**	**.126**	**-.045**	**-.108**
Painter	**-.105**	**.468**	**.124**	**.050**	**.334**
Pipefitter	**-.129**	**-.176**	**-.671**	**-.175**	**.024**
Boilermaker	**-.139**	**-.050**	**-.664**	**-.132**	**.141**
Ironworker	**-.111**	**-.282**	**.659**	**-.388**	**.253**
Heavy Equipment Operator	**.160**	**.000**	**-.064**	**.681**	**.167**
Crane Operator	**-.160**	**-.225**	**.243**	**.635**	**-.029**
Millwright	**.073**	**-.050**	**-.041**	**-.194**	**.105**
Electricians & Instrumentation	**-.040**	**.055**	**.079**	**.013**	**-.908**

Variable Principal Normalization.
Rotation Method: Varimax with Kaiser Normalization. Rotation failed to converge in 6 iterations. (Convergence = .000).
Note. Loadings higher than .40 are highlighted.

The multiskilling patterns among Hispanic craft workers with formal training were analyzed to determine differences. Again, out of five PCs only four multiskilling groups met the loading requirement. Among 867 craft workers, 19 outliers were excluded. The VAF across the five PCs together was 54.3%. The first PC, Support Finishing, included scaffold builder, insulation, and painter skills; the rigger skill loaded high in this PC in the negative direction, and was considered quite different from this group of skills. The second PC, Civil/Concrete, included carpenter, concrete finisher, and reinforcing iron & rebar skills. The third PC, Mechanical, included pipefitter and boilermaker skills; the ironworker skill loaded high in this PC in the positive direction, and was considered quite different from this group of skills. The fourth PC, Support Mechanical, included millwright and crane operator skills. The fifth PC included only electricians & instrumentation skill, and therefore was not a multiskilling group, Table 22.

Table 22: Rotated Component Loadings from a Five-Dimensional CATPCA on 14 Variables among Hispanic Workers (Workers who had Formal Training)

Trade	Dimension (principal component)				
	1	2	3	4	5
Scaffold Builder	**.740**	**-.026**	**.026**	**-.060**	**-.068**
Riggers	**-.704**	**-.292**	**.192**	**.085**	**-.083**
Insulation	**.669**	**-.164**	**.150**	**-.014**	**.179**
Painter	**.481**	**-.093**	**.105**	**-.012**	**-.229**
Carpenters	**.067**	**.829**	**.029**	**.007**	**.020**
Concrete Finisher	**-.062**	**.737**	**.049**	**-.035**	**.029**
Reinforcing Iron and Rebar	**.052**	**.644**	**.097**	**-.067**	**-.034**
Heavy Equipment Operator	**-.052**	**.288**	**-.023**	**.027**	**-.024**
Boilermaker	**-.048**	**-.093**	**-.728**	**-.018**	**-.096**
Pipefitter	**-.189**	**-.099**	**-.696**	**-.209**	**-.065**
Ironworker	**-.300**	**-.159**	**.613**	**-.405**	**-.322**
Millwright	**.004**	**.017**	**-.055**	**.691**	**-.045**
Crane Operator	**-.226**	**-.104**	**.273**	**.639**	**-.041**
Electricians & Instrumentation	**-.051**	**-.075**	**.100**	**-.085**	**.936**

Variable Principal Normalization.
Rotation Method: Varimax with Kaiser Normalization. Rotation failed to converge in 7 iterations. (Convergence = .000).
Note. Loadings higher than .40 are highlighted.

4.5.2.4.2.1.2 Non-Hispanic Results

From the non-Hispanic CATPCA results, five PCs and six multiskilling groups were identified. Among 8,630 craft workers, 176 outliers were excluded and the VAF was 48.2%. The first PC, Support Insulation, included scaffold builder and insulation skills; rigger skill loaded high in this PC but in the negative direction, and was considered quite different from this group of skills. The second PC had two multiskilling groups: Support Structural and Mechanical. Support Structural included rigger and ironworker skills, and Mechanical included pipefitter and boilermaker skills. The third PC, Formwork, included carpenter and reinforcing iron & rebar skills. The fourth PC, Equipment Operators, included heavy equipment operator and crane operator. The fifth PC, Mechanical/Electrical, included millwright and electrician & instrumentation skills; the boilermaker skill loaded high in this PC but in the negative direction, and was considered quite different from this group of skills, Table 23.

Table 23: Rotated Component Loadings from a Five-Dimensional CATPCA on 14 Variables among Non-Hispanic Workers (All Multi-Skilled Workers)

	Dimension (principal component)				
	1	2	3	4	5
Scaffold Builder	**.797**	**.064**	**.033**	**-.004**	**-.044**
Insulation	**.672**	**.098**	**-.165**	**-.081**	**.020**
Riggers	**-.499**	**.401**	**-.251**	**-.016**	**-.328**
Painter	**.319**	**-.054**	**.011**	**.019**	**-.025**
Ironworker	**-.082**	**.753**	**.050**	**-.289**	**-.099**
Pipefitter	**-.131**	**-.656**	**-.086**	**-.377**	**.039**
Carpenters	**.227**	**-.024**	**.722**	**.100**	**-.010**
Reinforcing Iron and Rebar	**-.075**	**.065**	**.638**	**-.056**	**-.010**
Concrete Finisher	**-.068**	**.029**	**.348**	**.017**	**.000**
Crane Operator	**-.075**	**.083**	**-.190**	**.805**	**.041**
Heavy Equipment Operator	**.013**	**-.069**	**.256**	**.532**	**-.028**
Millwright	**-.035**	**-.025**	**-.161**	**.135**	**.656**
Electricians & Instrumentation	**.010**	**-.119**	**.080**	**-.194**	**.638**
Boilermaker	**.017**	**-.489**	**-.107**	**-.130**	**-.516**

Variable Principal Normalization.
Rotation Method: Varimax with Kaiser Normalization. Rotation failed to converge in 6 iterations. (Convergence = .000).
Note. Loadings higher than .40 are highlighted.

The multiskilling patterns among non-Hispanic craft workers with formal training were analyzed to determine differences. From the CATPCA results, five PCs and four multiskilling groups were identified, because the first PC loaded one skill in the positive direction and one skill in the negative direction. Among 2,909 craft workers, 63 outliers were excluded. The VAF across the five PCs together was 47.8%. The first PC included only crane operator skill in the positive direction and pipefitter skill in the negative direction, therefore no multiskilling group was in this PC. The second PC, Support Finishing, included scaffold builder, insulation, and painter skills; the rigger skill loaded high in this PC but in the negative direction, and was considered quite different from this group of skills. The third PC, Mechanical/Electrical, included millwright and electrician & instrumentation skills; the rigger skill loaded high in this PC but in the negative direction, and was considered quite different from this group of skills. The fourth PC, Structural, included ironworker and reinforcing iron & rebar skills. The fifth PC, Support Civil, included carpenter, concrete finisher, and heavy equipment operator skills, Table 24.

Table 24: Rotated Component Loadings from a Five-Dimensional CATPCA on 14 Variables among Non-Hispanic Workers (Workers who had Formal Training)

Trade	Dimension (principal component)				
	1	2	3	4	5
Crane Operator	**.788**	**-.125**	**.039**	**-.207**	**-.075**
Pipefitter	**-.604**	**-.215**	**.125**	**-.478**	**.045**
Scaffold Builder	**.025**	**.710**	**-.077**	**-.027**	**.289**
Insulation	**-.063**	**.502**	**.063**	**.010**	**-.045**
Painter	**.026**	**.477**	**-.016**	**-.008**	**-.222**
Electricians & Instrumentation	**-.204**	**-.031**	**.706**	**.029**	**-.028**
Millwright	**.272**	**.015**	**.585**	**-.041**	**-.133**
Riggers	**.106**	**-.476**	**-.552**	**.179**	**-.156**
Boilermaker	**-.355**	**.141**	**-.396**	**-.262**	**-.292**
Ironworker	**.052**	**-.062**	**-.102**	**.795**	**-.031**
Reinforcing Iron and Rebar	**-.139**	**-.015**	**.069**	**.494**	**.068**
Carpenters	**-.024**	**.243**	**-.036**	**.072**	**.732**
Concrete Finisher	**-.081**	**-.194**	**-.006**	**.052**	**.503**
Heavy Equipment Operator	**.368**	**-.039**	**-.013**	**-.198**	**.424**

Variable Principal Normalization.
Rotation Method: Varimax with Kaiser Normalization. Rotation failed to converge in 6 iterations. (Convergence = .000).
Note. Loadings higher than .40 are highlighted.

4.6 DISCUSSION

There are some limitations when the NCACP dataset is used. The participants were mainly from the industrial sector and from Gulf Coast region. In addition, there were no variables for participants' age and education background, which would enrich this paper results.

On average, Hispanic construction craft workers were approximately four years younger than non-Hispanics. In addition, the Hispanic craft workers' population growth rate in the construction industry was faster than the growth rate in all other industries. There were high percentages of Hispanic craft workers among residential-sector construction trades, most of which do not require a high school diploma. Overall, most Hispanic construction craft workers were employed in low skilled trades that require short-term or moderate-term training and do not require a high school diploma. Conversely, most non-Hispanic construction craft workers were employed in highly skilled trades that require moderate-term training or years-long apprenticeships as well as at least a high school diploma.

Nearly 30% of multi-exam takers were Hispanic craft workers, and this percentage was close to the overall percentage of Hispanics in the construction industry. However, the percentage of the Hispanic multi-skilled craft workers was 43.1%, far less than the percentage among non-Hispanics (59%). To examine the reason for this disparity, formal training percentages among Hispanics and non-Hispanic craft workers were analyzed. When controlling for formal training, no statistical differences were found between the Hispanic and non-Hispanic multi-skilled percentage—both populations had a percentage of about 65%. These findings may help the construction industry design effective retention strategies for Hispanic craft employees, such as long-term training plans for highly skilled trades, because the number of Hispanics in the construction industry is growing quickly (Goodrum 2004).

Investigating trade distribution among multi-skilled Hispanic and non-Hispanic craft workers, rigger trade was the most common skill among both populations. Also, over half of Hispanic and non-Hispanic construction craft workers were employed in highly skilled trades. These results were the same when controlling for formal training.

Among the 91 dual-skills, nine of the top 10 dual-skills for Hispanic craft workers were in the top 10 dual-skills for non-Hispanic craft workers but with different rankings. Further, the top 10 dual-skills for both Hispanics and non-Hispanics were the same when controlling for formal training, but the ranking of the dual-skills changed. Thus, Hispanic and non-Hispanic construction craft workers had similar multiskilling patterns. These findings are similar to the findings of Wang et al. (2009), Table 15. Six of the top 10 dual-skills found by Wang et al. (2009) were in the top 10 dual-skills found in the present study. However, three of the top 10 dual-skills found by Wang et al. (2009) were not applicable in this study because they treated electrician, instrument technician, and instrument fitters as separate trades, whereas this study combined them as one trade, electricians & instrumentation.

From the CATPCA results, Hispanic and non-Hispanic construction craft workers had the same number of dimensions (PCs), but a different number of multiskilling groups. In the ranking system used, the first PC represents the most important group because this had the highest eigenvalue, while the last PC represents the least important group with the lowest eigenvalue. In descending order of importance, the four multiskilling groups among Hispanics were Civil/Concrete, Support Finishing, Mechanical, and Equipment Operators, Table 21 and Table 25. In descending order of importance, the six multiskilling groups among non-Hispanics were Support Insulation, Mechanical and Support Structural, Formwork, Equipment Operators, and Mechanical/Electrical, Table 22 and Table 25. Notably, Mechanical and Support Structural were two skills combined into a single PC. Among Hispanics with formal training, the four multiskilling groups were Support Finishing, Civil/Concrete, Mechanical, and Support Mechanical, Table 23 and Table 25. Among non-Hispanics with formal training, the four multiskilling groups were Support Finishing, Mechanical/Electrical, Structural, and Support Civil, Table 24 and Table 25. For Hispanics, the difference in the fourth multiskilling group was the only difference between all training types and formal training type. For non-Hispanics, there were major differences between all training types and formal training type. Specifically, the number of multiskilling groups was reduced from six to four groups for those with formal training, and these skills focused on civil/structural and general support skills. Unlike the dual-skills results, Hispanic and non-Hispanic construction craft workers had different multiskilling patterns when they pursued more than two skills.

Table 25: A Comparison between Hispanic and Non-Hispanic, with All Multi-Skilled Workers vs. Workers Who Had Formal Training, among Multiskilling Groups

Multiskilling Groups	**Hispanic** All Multi-Skilled Workers	**Non-Hispanic** All Multi-Skilled Workers	**Hispanic** Workers who had Formal Training	**Non-Hispanic** Workers who had Formal Training
1	**Civil/Concrete:** carpenter, concrete finisher, and reinforcing iron & rebar	**Support Insulation:** scaffold builder and insulation	**Support Finishing:** scaffold builder, insulation, and painter	**N/A**
2	**Support Finishing:** scaffold builder, insulation, and painter	**Support Structural:** rigger and ironworker **Mechanical:** pipefitter and boilermaker	**Civil/Concrete:** carpenter, concrete finisher, and reinforcing iron & rebar	**Support Finishing:** scaffold builder, insulation, and painter
3	**Mechanical:** pipefitter and boilermaker	**Formwork:** carpenter and reinforcing iron & rebar	**Mechanical:** pipefitter and boilermaker	**Mechanical/Electrical:** millwright and electrician & instrumentation
4	**Equipment Operators:** heavy equipment operator and crane operator	**Equipment Operators:** heavy equipment operator and crane operator	**Support Mechanical:** millwright and crane operator	**Structural:** ironworker and reinforcing iron & rebar
5	**N/A**	**Mechanical/Electrical:** millwright and electrician & instrumentation	**N/A**	**Support Civil:** carpenter, concrete finisher, and heavy equipment operator

4.7 CONCLUSION

Using the CPS data from 1994 to 2014 and the NCACP data from 2005 to 2014, this study examined and compared the number and type of construction craft skills among Hispanic and non-Hispanic workers. The most valuable contribution of this study was the discovery that the difference between Hispanic and non-Hispanic craft workers almost disappeared when they were multi-skilled, especially when they had formal training. This contribution suggests that greater educational and training attainment create equal career pathways for Hispanic and non-Hispanic construction craft workers. The study also revealed differences between Hispanic and non-Hispanic craft workers among single skilled and multi-skilled workers who seek more than two skills, while it revealed no differences among dual-skilled Hispanic and non-Hispanic craft workers. The study yielded the following findings:

- Among multi-exam takers, only 43% of Hispanic craft workers passed at least two exams in two different skills to be considered multi-skilled. Nearly 60% of non-Hispanic multi-exam takers passed exams in two different skills, suggesting that non-Hispanics were better able to pass the exams.

- Both Hispanic and non-Hispanic multi-skilled craft workers with formal training were employed in construction trades at the same percentage, about 65%.
- More than half of the trade distribution among multi-skilled Hispanic and non-Hispanic craft workers was toward highly skilled trades.
- Among dual-skilled workers, Hispanic and non-Hispanic craft workers had similar multiskilling patterns. Nine of the top 10 dual-skills for Hispanic craft workers were in the top 10 dual-skills for non-Hispanic craft workers but ranked differently.
- Unlike the dual-skills results, Hispanic and non-Hispanic craft workers who pursued more than two skills had different multiskilling patterns.

The findings of this study will guide the construction industry’s future retention strategies by improving long-term training plans for Hispanic craft workers in highly skilled trades. Also, it will help researchers in the construction industry and other industries to study the multiskilling patterns among craft workers using the same or different datasets, and eventually contribute to the industry’s body of knowledge.

4.8 REFERENCES

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5. CONCLUSION

The construction industry plays a major role in the United States' economy. Currently, and during economic expansion periods, the U.S construction industry faces a workforce shortage, primarily among highly skilled trades, for two reasons: 1) strong construction demand across multiple industry sectors; and 2) low supply levels of skilled craft workers (Komarnicki 2012; Glavin 2013; Wilder 2013; Shelar 2013). By definition, highly skilled trades are those requiring specialized education or training, which can take years to complete (e.g. carpenters, electricians, and pipefitters), and low skilled trades are those requiring minimal to no training and instruction (e.g. general helpers) (Vereen 2013). A primary factor for the low supply of craft workers is current workers leaving the construction industry, either for other industries or retirement (Belman 2013). The shortage of skilled labor in the construction industry is not a recent issue, but rather a cyclical problem (Dainty et. al. 2004; Castaneda et. al. 2005). The U.S. Bureau of Labor Statistics (BLS) predicted that the U.S. construction industry will be the fastest growing industry in the nation over the next decade with an estimated 1.6 million new jobs (Glavin 2013; Gonzales 2013). Because of such rapid growth, 76% of construction companies in the U.S. are having difficulty finding qualified workers to fill job openings (AGC 2015). The main objective of this dissertation was to understand construction workforce shortages and how to mitigate these shortages.

5.1 Contributions

The three papers (chapters) contained in the body of this dissertation contribute to an understanding of the construction labor market in the U.S., focusing on the demographics that are currently influencing craft supply and demand. The first paper employed a new metric of workforce availability, using a public data set, among construction trades and regions in the U.S.; the second paper applied a longitudinal analysis of the changes in U.S. craft workers' satisfaction and job preferences; and the third paper applied a comparative analysis of the utilization of multiskilling among U.S. Hispanic and non-Hispanic construction craft workers. Figure 31 presents a revised conceptual overview from the introduction that adds the general results.

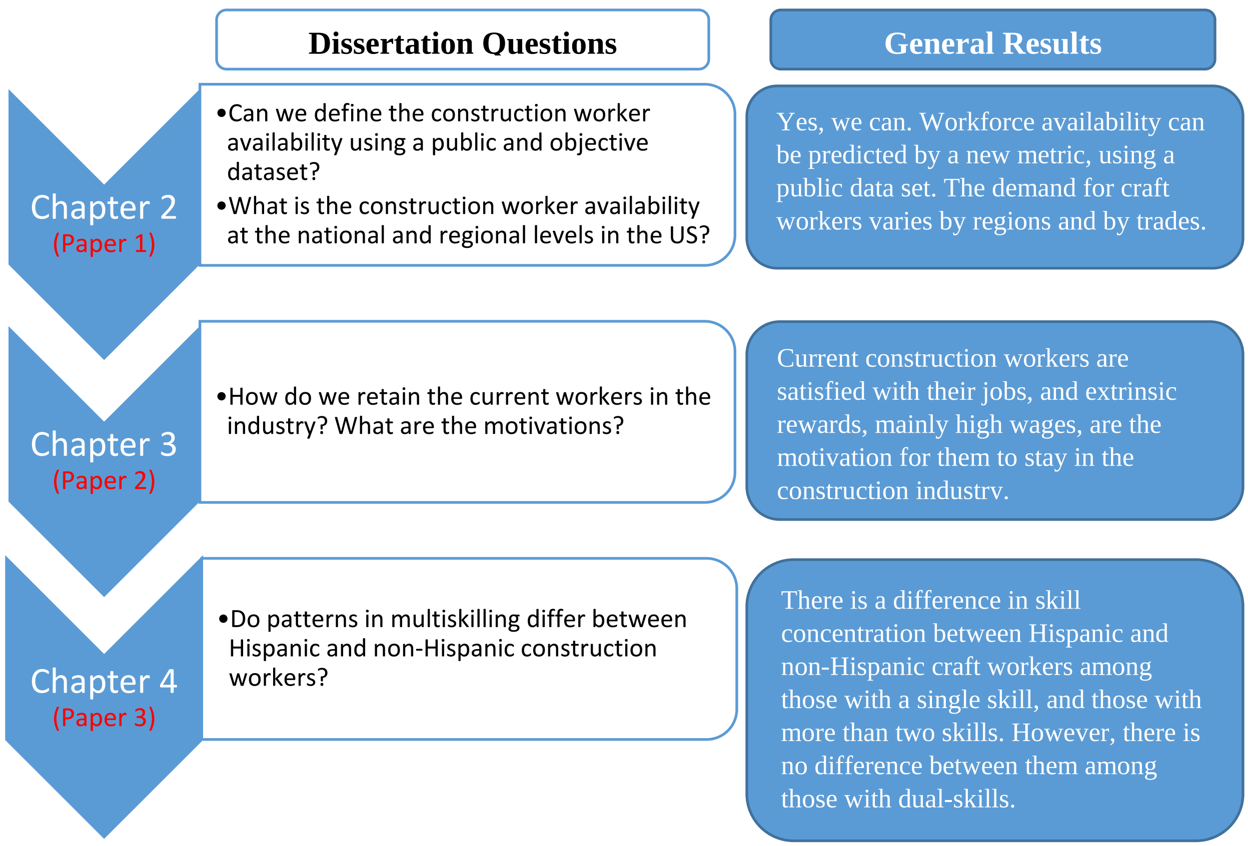

Figure 31: Conceptual Overview of Research Questions and General Results

The metric of paper 1 has the potential to define the trades in demand nationally and regionally. Therefore, owners and industry leaders may use this metric in early stages of projects to mitigate the craft shortages by applying alternative management approaches. Furthermore, the construction community, and educators within vocational programs, may reference this metric to direct future workers to trades in high demand. Additionally, this metric helps the construction industry leaders and community to focus on retaining the current workers in the trades in demand.

The findings of paper 2 show that construction workers were satisfied with their job, suggesting to industry leaders that they should resolve the issues that make the existing workers leave the industry, such as poor wages, poor career path, poor industry image, lack of job security, and poor working conditions. Further, extrinsic rewards were the motivation for current craft workers to stay in the construction industry. This suggests that the industry's future retention strategies should emphasize extrinsic rewards, and specifically, workers indicated their main preference was higher wages. Other studies have also found that multiskilling is a strategy that not only increases craft workers' wages, but also affords longer employment times (Burleson 1997; Haas et al 1999; Gomar et al 2002; Carley et al 2003). Further, multiskilling reduces workforce shortages because even though there may be a constant number of workers, there are more skills in the labor market pool (Burleson 1997).

Among the results in paper 3, the author focused on Hispanic craft workers because the percentage of Hispanic workers increased sharply in the construction industry, although most of them work in low skilled trades. Therefore, we could increase the supply in the demanded trades by encouraging Hispanic workers to have another skill among highly skilled trades, which are in demand. Among multi-skilled workers who had formal training, there was no statistical difference between the number of Hispanic and non-Hispanic craft workers, suggesting that long-term training plans for Hispanic craft workers is a potential retention strategy for the industry. In addition, Hispanic and non-Hispanic craft workers had similar multiskilling patterns among those with a dual-skills, while they did not have similar multiskilling patterns among those who had more than two skills. Therefore, additional studies need to be conducted exploring these findings.

5.2 Suggestions for Future Research

As a result of this dissertation findings, I have three suggestions for future research: 1) use different datasets on the same dissertation questions because there were limitations to the current datasets; 2) define future research based on the findings of the previous questions; and 3) define future research that helps to mitigate the craft supply and demand issues.

5.2.1 Limitations of Current Datasets

The results of this study were limited in a number of ways by the use of the CPS, GSS, and NCACP datasets. For future research, I suggest applying different data sources to answer the dissertation's research questions, using the same or different methods, to increase the body of industry knowledge. In the CPS dataset, there is a small sample size for a number of occupations that prevents the author from applying the workface availability analysis on them nationally and regionally. In addition, the CPS dataset used to have a variable that the author could use to breakdown and analyze the dataset by state; this gave the author the flexibility to define regions on the U.S. map that would give the author more accurate results for the workforce availability, but this variable was suspended in March 2014. Moreover, some variables in the CPS dataset have combined skills and treat it as one occupation, like "pipe-layers, plumbers, pipefitters, and steamfitters," that the author cannot differentiate between; it is better to treat each skill as one occupation. Among the GSS dataset, few participants answered the job preferences question. In addition, the job preferences question was only asked 17 of the 28 GSS study years, between 1974 and 2014. Therefore, if the data is controlled by cycle periods and age groups, for example, the author would have a small sample size. Among NCACP dataset, the participants were mainly from the industrial sector and from Gulf Coast region. In addition, there were no variables for participants' age and education background, which would enrich this dissertation results.

5.2.2 Future Research based on the Findings

Paper 1 provides a metric for workforce availability, using CPS, a public data set. For future work, I suggest defining other metrics that can be applied to the construction industry, by using a public or private dataset. Further, I suggest using the same metric on the same or different dataset, to the construction or different industries. Paper 2 measures the construction workers' satisfaction and job preferences. For future work, I suggest applying the same study to a different dataset, which includes more preference choices. Further, I suggest defining the race (Hispanic vs. non-Hispanic) influence on the construction workers' satisfaction and job preferences. Paper 3 explores the multiskilling strategies and compares patterns between Hispanic and non-Hispanic craft workers. For future work, I suggest defining the reasons construction craft workers became multi-skilled, and the demographic influence on these reasons.

5.2.3 Future Research among Craft Supply and Demand Issues

The shortage of skilled labor in the construction industry is not a recent issue, but rather a cyclical problem (Dainty et. al. 2004; Castaneda et. al. 2005). Therefore, the construction industry will have the same issue in the future. Each economic cycle has a recessionary period characterized by rising unemployment rates and followed by an expansionary period characterized by craft shortages. At the same time many skilled workers reached retirement age, especially during the Great Recession, many existing workers left the construction industry for other industries. One research idea is to focus on training strategies during the economic recession periods as a solution to retain the current workers instead of losing them to other industries. Therefore, the industry should train unemployed workers to improve their skills or learn other skills that are in demand, and make them ready for growth period jobs. This leads the author to another idea, which is to create a prediction model during the recession period to define the skills that will be in demand during the growth period. These previous ideas will not only help to mitigate the skills shortages during the economic growth periods, but also will create a career path for construction workers. Another future research idea is to find innovative ways to transfer the knowledge and experience from retired workers to the new workers.

Further, retention of existing workers is not enough to recover the skills shortages for the construction industry during the current economic expansion period because it’s estimated to add 1.6 million new jobs (Glavin 2013; Gonzales 2013). Decades ago, there was a lack of new workers entering the construction industry (Druker and White, 1996). Therefore, future research should also focus on attracting new craft workers to the industry. Training strategies during the recession periods is one factor that could attract new workers. Another factor is understanding and enhancing vocational programs in high schools, and providing a clear path for high schoolers into the construction industry.

This dissertation and future work suggestions are mainly focused on the construction craft workers in the U.S. The author does recommend applying these studies and suggestions to construction craft workers or construction workers in general in the other countries.

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6. APPENDICES

6.1 APPENDIX 1: Trades Census Codes for CPS and GSS Datasets

#	Trade	1970	1980	2010
1	Brickmasons, blockmasons, and stonemasons	410	563	6220
		411	564	
2	Carpet, floor, and tile installers and finishers	420	565	6240
		440		
		560	566	
3	Carpenters	415	567	6230
		416	569	
4	Electricians	430	575	6350
		431	576	6355
		433	577	6540
5	Painters, construction and maintenance	510	579	6420
6	Paperhangers	512	583	6430
7	Pipelayers, plumbers, pipefitters, and steamfitters	522	585	6440
		523	587	
8	Drywall installers, concrete and terrazzo finishers, and plasterers.	615	573	6330
		421	588	6250
		520	584	6460
9	Glaziers	445	589	6360
10	Insulation Workers, and hazardous materials removal workers	601	593	6720
				6400
11	Construction Equipment Operators, and related workers	412	594	6300
		424	855	6310
		436	848	6320
			849	7560
			853	
12	Roofers	534	595	6510
				6515
13	Structural Metal, Reinforcing iron, and Rebar Workers	550	597	6530
				6500
14	Earth drillers	614	598	6820
15	Boilermakers	404	643	6210
16	Millwrights	502	544	7360
			543	6700
17	Sheet metal workers	535	596	6520
		536	653	
			654	
18	Construction laborers and helpers	750	865	6600
		751	869	6260
19	Air cond., heating, and refrigeration	470	534	7315
20	Miscellaneous construction and related workers	575	599	6760
				6765
21	Explosives workers, Blasters and Powdermen	603		6830

1970 codes = 1974 to 1990 (GSS)
1980 codes = 1988 to 2010 (GSS) **1980 codes = 1994 to 2002 (CPS)**
2010 codes = 2012 & 2014 (GSS) **2010 codes = 2003 to 2015 (CPS)**

6.2 APPENDIX 2: Trades Codes for NCACP Data

Certificate Type	SPSS Code	Frequency	Trade
Academic Heavy Equipment Operator Level One	98	1	Heavy Equipment Operator
Heavy Equipment Operator: Dump Trucks	64	115	
Heavy Equipment Operator: Forklift V2	65	1124	
Heavy Equipment Operator: Roller	66	55	
Heavy Equipment Operator: Scraper	168	207	
Heavy Equipment Operator: Backhoe	7	971	
Heavy Equipment Operator: Dozer	8	582	
Heavy Equipment Operator: Excavator	9	1061	
Heavy Equipment Operator: Forklift	10	259	
Heavy Equipment Operator: Level One	67	900	
Heavy Equipment Operator: Loader	11	735	
Heavy Equipment Operator: Motor Grader	12	101	
Drywall Mechanic	166	520	Carpenters
Drywall Mechanic Spanish Version	6	7	
Academic Carpentry	49	2	
Academic Carpentry Level One V2	94	225	
Carpenter Level One V2	52	271	
Carpentry Level One	53	100	
Commercial Carpenter	3	396	
Commercial Carpenter V2	140	334	
Finish Carpenter	32	116	
Form Carpenter	160	781	
Frame Carpenter	161	162	
Industrial Carpenter V3	15	4697	
Industrial Carpenter V4	71	532	
Industrial Carpentry V2	149	3757	
Industrial Carpentry V3 (Spanish Version)	72	245	
Academic Electrical Level One	97	27	Electricians & Instrumentation
Commercial Electrician V2	141	579	
Electrical & Instrumentation Pipeline Technician V3	30	433	
Electrical & Instrumentation Pipeline Technician V4	145	2175	
Electrical Level One	61	141	
Electrician Level One V2	108	318	
Electronic Systems Technician V2	146	402	
Industrial Electrician Performance Verification	170	2	
Industrial Electrician V2	36	13181	
Industrial Electrician V3	73	10712	
Industrial Electrician V3 Spanish	111	95	

Industrial Electrician V4	74	1621	
Industrial Maintenance Electrical & Instrumentation Technician	114	498	
Industrial Maintenance: Electrical V2	151	811	
Instrument Technician V2	41	693	
Instrument Technician V3	19	6634	
Instrument Technician V3 (Spanish Version)	77	2	
Instrumentation Fitter V2	42	617	
Instrumentation Fitter V3	20	2641	
Power Generation Maintenance Electrician	129	66	
EST Installer	147	146	
Power Generation Maintenance Mechanic	130	103	
Power Line Worker Distribution	131	29	
Power Line Worker Substation	132	21	
Power Line Worker Transmission	133	15	
Advanced Rigger	101	2150	
Advanced Rigger Practical	138	608	
Basic Rigger	102	5090	
Basic Rigger Practical	139	2393	
Intermediate Rigger	122	1485	**Riggers**
Intermediate Rigger Practical	155	566	
Rigger	85	10943	
Rigger Fundamentals	22	21231	
Rigger Fundamentals (Spanish Version)	23	78	
Boiler Technician	1	227	
Boilermaker V2	2	14228	
Industrial Boilermaker V3	162	9887	**Boilermaker**
Petrochemical Boilermaker V3	126	3119	
Power Boilermaker V2	128	12	
Rough Terrain / All Terrain Practical	86	916	
Rough Terrain / All Terrain Practical V2	24	1661	
Boom Truck - Telescopic Boom Practical	50	51	
Boom Truck Crane	51	181	
Boom Truck Crane V2	165	693	
Industrial / All Purpose Crane	69	472	
Industrial / All Purpose Crane V2	169	757	
Lattice Boom Crane	78	343	**Crane Operator**
Lattice Boom Crane - Crawler Mount Practical	79	70	
Lattice Boom Crane V2	171	611	
Math for Crane Operators	125	24	
Mobile Crane Operation V2	82	3284	
Telescopic Boom Crane	90	1427	
Telescopic Boom Crane - Truck Mount - AT Multiple Control Station Practical	91	48	

Telescopic Boom Crane V2	173	3426	
Telescopic Crawler Practical	92	5	
Tower Crane Operator	159	9	
Tower Crane Operator Practical	174	10	
Crawler Mount Crane - Practical	107	91	
Crawler Mount Crane - Practical V2	5	379	
Rubber Tire Mount Crane Practical	87	303	
Rubber Tire Mount Crane Practical V2	25	1108	
Concrete Finisher	142	1655	
Concrete Finisher (Spanish Version)	103	127	**Concrete Finisher**
Concrete Finisher Performance Verification	54	2	
Corrosion Prevention Field Technician 1 - Installation V3	27	350	
Corrosion Prevention Field Technician 1 - Installation V4	143	7387	
Corrosion Prevention Field Technician 1 - Measurement V3	28	132	
Corrosion Prevention Field Technician 1 - Measurement V4	144	3657	
Corrosion Prevention Field Technician 2 V3	4	2493	
Corrosion Prevention Field Technician 3 V3	29	1186	
Gas Maintenance Specialty Technician	33	393	
Custom - Pipeline Maintenance Technician	56	1	
Custom Pipeline Maintenance Technician Inspector	57	59	
Custom Pipeline Maintenance Technician Level 1	58	382	
Custom Pipeline Maintenance Technician Level 2	59	186	
CustomPMT - Tex Clark	60	1	
Mechanical Pipeline Technician V4	43	3805	
Pipeline Maintenance Technician V3	163	32691	**Pipefitter**
Plumber	127	427	
Industrial Coating And LIning Application Specialist Level 2	16	13	
Industrial Coating and Lining Application Specialist Level One	17	18	
Academic HVAC	99	25	
HVAC Technician	35	440	
HVAC Technician V2	13	473	
Industrial Pipefitter Performance Verification	76	1	
Industrial Pipefitter V2	40	17327	
Industrial Pipefitter V3	120	18716	
Industrial Pipefitter V3 (Spanish Version)	154	405	
Industrial Pipefitter V4	121	2135	
NDT: Radiographic Film Interpretation of Pipeline Welds	83	674	
Industrial Insulation (Spanish Version)	150	616	
Industrial Insulation V2	37	6160	**Insulation**
Industrial Insulator V3	112	506	
Industrial Ironworker V2	38	11780	**Ironworker**

Industrial Ironworker V3	113	1110	
Industrial Millwright V2	39	6191	**Millwrighter**
Industrial Millwright V3	18	3589	
Industrial Millwright V4	118	513	
Industrial Painter V2	153	5762	**Painter**
Industrial Painter V3	119	1	
Industrial Painter V3 (Spanish Version)	75	7	
Reinforcing Iron and Rebar - Spanish	84	107	**Reinforcing Iron and Rebar**
Reinforcing Iron and Rebar (Spanish Version)	157	78	
Reinforcing Iron and Rebar Worker	21	2111	
Scaffold Builder	164	18331	**Scaffold Builder**
Scaffold Builder (Spanish Version)	134	1011	
Scaffold Builder Performance Verification	88	1	
Total	**134**	**301139**	