Predictive Modeling of U.S. Transportation Workforce Diversity Trends: A Study of Human Capital Recruitment and Retention in Complex Environments

Sharareh Kermanshachi, Ph.D., P.E., M.ASCE, and Hessam Sadatsafavi, Ph.D.

1 (Corresponding author) Assistant Professor, Department of Civil Engineering, University of Texas at Arlington, 425 Nedderman Hall, 416 Yates Street, Box 19308, Arlington, TX 76019. E-mail: sharareh.kermanshachi@uta.edu

2 Postdoctoral Associate, Department of Design and Environmental Analysis, Cornell University, 3422 Martha Van Rensselaer Hall Ithaca, New York. E-mail: hs825@cornell.edu

ABSTRACT

Successful delivery of transportation projects requires extensive level of effort spent by Departments’ of Transportation skilled employees. Although these human resources are very valuable assets for transportation projects, most state agencies face numerous challenges in recruitment and retention of motivated and diverse employees. Earlier studies concluded that recent college graduates are less attracted to be hired by state agencies as the salary range would be less competitive compared to the same positions in private companies. Therefore, the aim of this study is to investigate and assess the recruitment and retention trends of transportation workforce across different U.S. regions. For this reason, this research project utilized US transportation workforce demographic information which has been nationally collected and published. The used databased includes several demographical aspects of transportation workforce including: region, gender, age, disability status, ethnicity/race, years of experience, and supervisory role. In this study, the association of transportation workforce age with the transportation organization responsibilities across various regions were studied and analyzed. Furthermore, gender-based distribution of transportation workforce controlling for other variables was investigated and presented. It was concluded that the proportion of male to female employees in engineering positions is only associated with their race/ethnicity and year of service. It was also found that the gender disparity in engineering positions is higher in the White group than the African/American group controlling for region, year of service, disability status, and role (supervisory versus non-supervisory). The outcome of this study helps transportation decision makers to incorporate appropriate policies into their human capital development strategic plans. The findings of this study will also enable state transportation agencies to diversify their active workforce through implementation of recruitment and retention practical approaches.

INTRODUCTION

The definition of “diversity” is unclear, as reflected in the multiplicity of meanings in the literature. For some, the term provokes intense emotional reactions, bringing to mind such politically charged ideas as “affirmative action” and “quotas.” These reactions stem, in part, from a narrow focus on protected groups covered under affirmative action policies, where differences such as race and gender are the focal
point. Some alternative definitions of diversity extend beyond race and gender to include all types of individual differences, such as ethnicity, age, religion, disability status, geographic location, personality, sexual preferences, and a myriad of other personal, demographic, and organizational characteristics. Diversity can thus be an all-inclusive term that incorporates people from many different classifications. Generally, “diversity” refers to policies and practices that seek to include people who are considered, in some way, different from traditional members. More centrally, diversity aims to create an inclusive culture that values and uses the talents of all would-be members.

Although a diverse nation would have more paved paths to sharp economic growths, less attention has been paid to the education level of minorities. In this regard, many studies have been conducted to assess the impact of more diverse working environments on overall success of the projects and/or organizations, and it has been observed that diversity offers better communication networks and applicability of more input varieties into the organizations’ decision-making process (Kamalirad et al., 2017). However, less governmental agencies analyze the diversity trend of their recruitment over an extended duration. Therefore, the aim of this study is to analyze the hiring diversity of state transportation agencies based on following criteria: Gender, Disability Status, Age, Race/Ethnicity, and other factors. Also, this study performs a quantitative analysis of significant contributors to gender-based recruitments in state transportation agencies. In other words, this paper will identify and analyze the predictors of male-to-female hiring ratio in engineering positions. Moreover, this study determines and analyzes significant predictors of the age of new employees in transportation engineering positions. The outcome of this study helps transportation agencies to have a more holistic view of their recruitment trends. Furthermore, the findings of this research project helps transportation organizations take necessary actions to create a more diverse environments leading to successful completion of their on-going projects.

LITERATURE REVIEW

Diversity, a term with a lot of different definitions in the literature, is the originator of some very interesting controversial concepts like affirmative action and quotas. Affirmative actions or quotas are the laws or regulations that are practiced to protect the oppressed group based on race or gender. Diversity not only considers race and gender, it is the study of practicing laws that create a habit of including all the prospective member from all the comprehensive classifications of humankind irrespective of their personality traits, geographical location, sexual orientation, religion etc. Harish et al. (1996) found out that only recently the diversity of the gender is noticed in the labor force in many countries even though this diversity was present in the population all the time. There is also a term called occupational gender segregation, it is the division of works based on person gender and this phenomenon is quite common in the global market. There are some statistics that suggest some job types are ‘women’s work’ like health, education etc. and some are ‘man’s job’ like construction, transport, industry agriculture etc. (Eurofound, 2013). With the change of time, politics related to diversity also changed and Berry (2007) found out that the change was significant over the last 50 years. Even though various programs of
diversity training and mentoring was established to reduce bias in managerial level in the timeline of 1972 to 2002, Kaley et al (2006) found out that they were only effective to make an environment so that white women, black women, and black men get a chance to work in management.

Diversity has its own benefit. For example, whenever a group of diverse people will be added into a group so that they can work together then the final result that this group comes up with will be much more superior than the outcome of the group made of only same level of thinkers (Page, 2007). This is because, diverse people can add more creative ideas to the group (Williams and O’Reilly, 1998; DiTomaso et al. 2007) and if they have a little functional experience then they can appreciate the necessity of the diversity in the group which helps them to overcome the communication barrier created by the diversity behavior (Bunderson and Sutcliffe, 2002). Thus, the diversity increases the quality of the group work (Williams and O’Reilly, 1998; DiTomaso et al. 2007) and professional practitioner and other concerned of human resources also believes in this positive side of managing diversity in the workplace.

In the decade of 1980, varieties of human resource programs called “managing diversity” or “valuing diversity” were conducted in USA and Canada. When a number of people from different groups like racial minorities, women or immigrants start participating in the working or consumer population, then the response of the traditional group changes and that is called managing diversity (Abella, 1984; Towers Perrin and The Hudson Institute, 1990).

Diversity in environments consisting complex projects requires more attention as it can be an organizational strategy to overcome the undesired challenges associated with complexity (Kermanshachi et al., 2016a and 2016b). In this regard, Dao et al, (2016a, 2016b, and 2017) conducted several studies to quantify various elements of project and organizational complexity and identify managerial best practices. He found out that allocation of the resources play a significant role in managing complexity. In addition, Safapour et al. (2017) investigated the challenges associated with complex environments and concluded that human capital and their interactions could lead to successful outcomes.

When there is diversity, another term comes with it naturally, which is inequality. US and Canadian population also suffering from the mutual effect of these two terms: diversity and inequality as both the countries have wide range of diverse people as employee or customer in the international and domestic market. In addition, it is difficult to converge all the working force of diverse background into a single decision-making force (Agocs and Burr, 1996). As a result, there is a necessity of a new business entity that will manage this diversity. Based on the fact that diversity increases productivity, many countries welcomed diversity and ignored the fact that diversity comes with discrimination and discrimination reduces potential. United States overcame this risk by providing more opportunity to the oppressed group of the diversity (Alon and Tienda, 2007).

**METHODOLOGY**

To successfully accomplish the objectives of this study, a multi-step methodology process was designed. As shown in Figure 1, we initially conducted a comprehensive review of the existing literature to identify the major indictors of age
and gender of new employees within state transportation agencies. Then, the team collected diversity-based U.S. transportation hiring data consisting information regarding age, gender, race/ethnicity, disability, region, supervisory role, and experience level. Initially, preliminary data analysis was conducted to identify the distribution of the recruitments based on various diversity-based factors. Then, the data was used to identify significant determinants of gender and age of new transportation employees and develop two logistic regression predictive models anticipating the age and gender trends of future recruitment.

**Figure 1. Research Methodology**

**DATA COLLECTION AND ANALYSIS**

The data used for this study was obtained from U.S. Department of Transportation (DOT) providing demographic information of all the new transportation skilled workforce hires across the nation. The collected data for the diversity analysis contained age, gender, years of service, region, supervisory role, ethnicity/race, and disability status information of the new departments’ of Transportation (DOTs’) employees. In this study, we assessed the engineering roles of 3,623 new hires in regions with more than 200 engineers, which included Aeronautical Center, Headquarters, and the Technical Center. Regions with less than 200 engineers were excluded in this study as investigating their interactions does not yield accurate results.

Table 1 presents the results of descriptive analysis for 3,623 new transportation employees in engineering positions. As it is shown in this Table, more than 92 percent of engineering positions were filled by male employees while the rest was assigned to female workforce. With regard to the age of employees, it is observed that most of engineering positions were granted to the senior human resources. In addition, it has been observed that around 11 percent of new positions were based on supervisory roles,
while the rest belonged to no-supervisory positions. It was also observed that most of the positions were filled by white ethnicity while African-American and Hispanic engineers filled less than 17 percent of the jobs collectively. Although part of this issue could be based on the ratio of the ethnicities pursuing engineering majors (Kermanshachi and Safapour, 2017). We also analyzed the number and distribution of engineering positions filled by disabled employees and found that close to eight percent of the these positions were given to staff with one or more types of disability.

Table 1. Descriptive Analysis of 2017 Recruitments in State Transportation Agencies

<table>
<thead>
<tr>
<th>Demographic Characteristics</th>
<th>Number (Percentage) in the Sample</th>
<th>Demographic Characteristics</th>
<th>Number (Percentage) in the Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td>Region</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>3,351 (92.4%)</td>
<td>Headquarters</td>
<td>2,670 (73.6%)</td>
</tr>
<tr>
<td>Female</td>
<td>275 (7.6%)</td>
<td>Aeronautical Center</td>
<td>713 (19.7%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Technical Center</td>
<td>243 (6.7%)</td>
</tr>
<tr>
<td>Age Range</td>
<td></td>
<td>Supervisor Status</td>
<td></td>
</tr>
<tr>
<td>Under 25 years old</td>
<td>66 (1.8%)</td>
<td>Supervisory role</td>
<td>394 (10.9%)</td>
</tr>
<tr>
<td>Between 25 and 29 years old</td>
<td>218 (6.0%)</td>
<td>Non-supervisory role</td>
<td>3,232 (89.1%)</td>
</tr>
<tr>
<td>Between 30 and 34 years old</td>
<td>265 (7.3%)</td>
<td>Person without disability</td>
<td>3,351 (92.4%)</td>
</tr>
<tr>
<td>Between 35 and 39 years old</td>
<td>326 (9.0%)</td>
<td>Person with disability</td>
<td>275 (7.6%)</td>
</tr>
<tr>
<td>Between 40 and 44 years old</td>
<td>242 (6.7%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between 45 and 49 years old</td>
<td>401 (11.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between 50 and 54 years old</td>
<td>693 (19.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between 55 and 59 years old</td>
<td>774 (21.3%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over 60 years old</td>
<td>641 (17.7%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years in Service Range</td>
<td></td>
<td>Ethnicity/Race</td>
<td></td>
</tr>
<tr>
<td>Under 5 years</td>
<td>605 (16.7%)</td>
<td>White</td>
<td>2,503 (69.0%)</td>
</tr>
<tr>
<td>Between 5 and 9 years</td>
<td>609 (16.8%)</td>
<td>Asian</td>
<td>534 (14.7%)</td>
</tr>
<tr>
<td>Between 10 and 14 years</td>
<td>507 (14.0%)</td>
<td>African-American</td>
<td>321 (8.9%)</td>
</tr>
<tr>
<td>Between 15 and 19 years</td>
<td>437 (12.1%)</td>
<td>Hispanic/Latino</td>
<td>268 (7.4%)</td>
</tr>
<tr>
<td>Between 20 and 24 years</td>
<td>347 (9.6%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between 25 and 29 years</td>
<td>560 (15.4%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between 30 and 34 years</td>
<td>379 (10.5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over 35 years</td>
<td>182 (5.0%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Only regions with more than 200 employees in engineering positions are included in the analysis.

MODEL DEVELOPMENT

Ratio of Male to Female Employees in Engineering Positions

To investigate difference in the proportion of male to female employees in engineering positions, the authors performed a binomial logistic regression analysis with gender as the outcome variable. A generalized linear model (GLM) procedure with binomial distribution on a Logit link was used in Statistical Package for the Social Science (SPSS). To investigate the association between the age of employees in engineering positions and the explanatory variables, age was transformed into a continuous variable. To make this transformation, the midpoint of each age category was used as the age value. For example, if the age level of an employee was indicated to be “25 - 29”, 27 was used as the age value. For the “Under 25” category, 23 was used as the age value, assuming that the minimum entry age to engineering positions is about 21 years old. For the “Over 60” category, 62 was used as the age value, assuming that the maximum retirement age in engineering positions is 64 years old.
After transforming age to a continuous variable, a linear regression analysis with age as the outcome variable was performed using the GLM procedure in SPSS.

In both models, the authors used estimated marginal means for different levels of categorical predictor variables to compare demographic groups. For example, in the model with the gender as the outcome variable, estimated marginal means were used to compare the proportion of male to female employees in those with the supervisory roles versus those in non-supervisory roles. To investigate difference across regions, in interaction term including region and other explanatory variables were also included in both models.

In summary, proportion of males to females in engineering roles was considered as a dependent variable, and Supervisory Status, Region, Ethnicity, Disability Status, Year of Service, Region*Supervisory Status, Region*Ethnicity, Region*Disability Status were considered as potential independent predictors. Table 2 shows the results of the logistic regression analysis for testing the association between explanatory variables and the proportion of male to female employees in engineering positions. The likelihood ratio chi-square test indicated that the models with explanatory variables included was an improvement over the intercept-only model, $\chi^2(18) = 104.28$, $p < 0.05$.

Table 2. Logistic regression results modeling the proportion of male to female employees in engineering positions

<table>
<thead>
<tr>
<th>Explanatory variable</th>
<th>Wald Chi-Square</th>
<th>Degree of freedom</th>
<th>Significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>39.78</td>
<td>1</td>
<td>0.000</td>
</tr>
<tr>
<td>Year of service</td>
<td>15.70 (0.020)*</td>
<td>1</td>
<td>0.000</td>
</tr>
<tr>
<td>Region</td>
<td>0.53</td>
<td>2</td>
<td>0.767</td>
</tr>
<tr>
<td>Supervisory status</td>
<td>0.95</td>
<td>1</td>
<td>0.329</td>
</tr>
<tr>
<td>Ethnicity/Race</td>
<td>25.99</td>
<td>3</td>
<td>0.000</td>
</tr>
<tr>
<td>Disability status</td>
<td>1.32</td>
<td>1</td>
<td>0.250</td>
</tr>
<tr>
<td>Region x Supervisory status</td>
<td>1.92</td>
<td>2</td>
<td>0.383</td>
</tr>
<tr>
<td>Region x Ethnicity/Race</td>
<td>11.12</td>
<td>6</td>
<td>0.085</td>
</tr>
<tr>
<td>Region x Disability status</td>
<td>4.52</td>
<td>2</td>
<td>0.104</td>
</tr>
</tbody>
</table>

* Year of service was transformed to a continuous variable by using the midpoint value of each category as the value for the number of years in service. The value in parentheses shows parameter estimates (log of odds).

The adjusted proportion of male to female employees, after controlling for the effect of ethnicity/race, region, year of service, supervisory status, and disability status was 0.89 with 95% confidence intervals (CI) [0.83, 0.93]. Figure 1 shows the estimated marginal means and 95% CIs for the adjusted proportions of male to female employees in engineering position across regions, after controlling for the effect of the other explanatory variables.

It was observed that the overwhelming majority of engineering positions (89%) are filled with male employees. Overall, the same level of disparity exists across all regions, roles (supervisory versus non-supervisory), and disability status. It was also concluded that the proportion of male to female employees in engineering positions is only associated with their race/ethnicity and year of service. For every one-unit (year) increase in the year of service, a 0.02 increase in the log-odds of having males in engineering positions is expected, holding all other independent variables constant. In
other word, the gender disparity in engineering positions increase by about 2% (the exponent of 0.02).

![Estimated Marginal Means and 95% CIs – Ethnicity by Region](image)

**Figure 2. Adjusted Proportion of Male to Female Employees in Engineering Position across Regions**

It was also found that controlling for region, year of service, disability status, and role (supervisory versus non-supervisory), the gender disparity in engineering positions is higher in the White group than the African/American group. As shown in Figure 2, in the White group, the adjusted proportion of males in engineering positions is 93% (95% CI: 90%-96%), while in the African-American group this proportion is 79% (95% CI: 67%-88%). Moreover, as Figure 2 shows, a similar pattern was observed in the Headquarters, where the gender disparity was lower among African-American groups (83% male [95% CI: 76%-89%]) than white groups (91% male [95% CI: 88%-94%]). Estimated marginal means shown in Figure 2 for the Aeronautical and Technical Centers are not statistically different (i.e., within each center, the proportions of male to female engineers are similar across race/ethnicity groups). In the Headquarters, a higher gender disparity exist in engineering positions based on the disability status of employees. Controlling for ethnicity and year of service, the adjusted proportion of male employees in engineering positions was 92% (95% CI: 86%-96%) for those with disability and 83% (95% CI: 80%-85%) for those without disability. The difference was statistically significant after adjusting the p-values for the number of comparisons (Bonferroni Correction).
Age of Employees in Engineering Positions

In the second part of the analysis, investigating the age of new employees, age of employees in engineering roles was considered as dependent variable while Supervisory Status, Region, Ethnicity, Disability Status, Gender, Year of Service (control variable), Region*Supervisory Status, Region*Ethnicity, Region*Disability Status, and Region*Gender were considered as potential predictors. Table 3 shows the results of the linear regression analysis for testing the association between explanatory variables and the age of employees in engineering positions. The obtained adjusted $R^2$ value of the constructed model was 0.40.

Table 3. Linear regression results modeling the age of employees in engineering positions

<table>
<thead>
<tr>
<th>Explanatory variable</th>
<th>Degree of freedom</th>
<th>F statistics</th>
<th>Significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1</td>
<td>2825.50</td>
<td>0.000</td>
</tr>
<tr>
<td>Gender</td>
<td>1</td>
<td>8.91</td>
<td>0.003</td>
</tr>
<tr>
<td>Region</td>
<td>2</td>
<td>0.78</td>
<td>0.459</td>
</tr>
<tr>
<td>Supervisory status</td>
<td>1</td>
<td>0.52</td>
<td>0.473</td>
</tr>
<tr>
<td>Ethnicity/Race</td>
<td>3</td>
<td>3.06</td>
<td>0.027</td>
</tr>
<tr>
<td>Disability status</td>
<td>1</td>
<td>5.95</td>
<td>0.015</td>
</tr>
<tr>
<td>Region x Supervisory status</td>
<td>2</td>
<td>2.02</td>
<td>0.133</td>
</tr>
<tr>
<td>Region x Ethnicity/Race</td>
<td>6</td>
<td>0.76</td>
<td>0.601</td>
</tr>
<tr>
<td>Region x Disability status</td>
<td>2</td>
<td>0.67</td>
<td>0.510</td>
</tr>
<tr>
<td>Year of service *</td>
<td>1</td>
<td>2197.75</td>
<td>0.000</td>
</tr>
</tbody>
</table>

* Year of service was transformed to a continuous variable and included in the model as the control variable. Results regarding the effect of this variable are not discussed.

After controlling for the effect gender, region, ethnicity/race, disability status, and supervisory status, the adjusted age of employees in engineering positions was 48.03, 95% CI [46.76 - 49.29] years old. Figure 2 shows the estimated marginal means and 95% CIs for the adjusted age of employees in engineering positions by race/ethnicity, gender, and disability status (the explanatory variables statistically significant at $p < 0.05$).

It was discovered that there is no age difference across regions and roles (supervisory versus non-supervisory). None of the interaction terms including the region variable reached statistical significance at $p < 0.05$ level, indicating that across regions, there is no difference in the age of employees in engineering roles after adjusting for supervisory role, ethnicity, gender, and disability status. In summary, it could be concluded that ethnicity, disability status, and gender are associated with the age of engineering employees.

Figure 3 shows that across ethnicity/race groups, engineers in the Hispanic groups had the lowest adjusted age. The adjusted mean age for this group was 46.07 (95% CI = 44.17 - 47.96). However, after correcting the p-value for the number of comparisons, only the difference between Hispanic groups and white groups was statistically significant. Engineers in the Hispanic group are about 2.50 (95% CI: 4.15-0.84) younger than engineers in the white group, adjusting for year of service, region, disability status, gender, and supervisory role. As Figure 3 shows, female engineers are 2.39 (95% CI: 3.96-0.82) years younger than males, after adjusting for year of service, region, disability status, ethnicity, and supervisory role. Figure 3 also shows that
individuals without disability in engineering positions are 2.02 (95% CI: 0.40 - 3.65) years younger than individuals with disability, after adjusting for year of service, region, gender, ethnicity, and supervisory role.

**Estimated Marginal Means and 95% CIs – Age by Ethnicity, gender, and Disability Status**

![Figure 3](image.png)

**Figure 3. Adjusted Age of Employees in Engineering Positions by Race/Ethnicity, Gender, and Disability Status**

**CONCLUSION**

Although many researches pointed out that diverse working environments lead to more successful completion of organizational deliverables, less number of governmental agencies investigated and analyzed the diversity of their recruitment activities over an extended period of time. Therefore, this study focused on the gender and age distribution of new transportation employees across the nation. In this regard, demographic information of 3,623 recent recruited staff in terms of age, gender, years of service, region, supervisory role, ethnicity/race, and disability status were collected and analyzed. It was found that the overwhelming majority of engineering positions are filled with male employees and the proportion of male to female employees in engineering positions is only associated with their race/ethnicity and year of service. It was also found that the gender disparity in engineering positions is higher in the White group than the African/American group. This study also concluded that there is no age difference across regions and roles (supervisory versus non-supervisory). However, female engineers are 2.39 years younger than males, after adjusting for year of service, region, disability status, ethnicity, and supervisory role. It was also concluded that across ethnicity/race groups, engineers in the Hispanic groups had the lowest adjusted age. The outcome of this study provides a roadmap for human resource managers to more diversify transportation agencies through appropriate strategic planning for the future recruitments.
REFERENCES


Towers Perrin and the Hudson Institute (1990), Workforce 2000: Work and Workers for the 21st Century, Hudson Institute, Indianapolis, IN.