Transforming the Role of the Concrete Delivery Professional: A Study on Innovative Solutions for the Ready Mixed Concrete Industry

MIT CONCRETE SUSTAINABILITY HUB

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Executive Summary

Currently, there is a severe shortage of concrete delivery professionals (CDPs) – the individuals who transport concrete from the plant to the construction site. In fact, according to a recent study by the National Ready Mixed Concrete Association (NRMCA), 70% of concrete producers had to turn away business because their CDP workforce was insufficient to satisfy demand.

Strategies to Increase CDP Productivity, Recruitment, and Retention

- Increase the candidate pool and leverage technology to change the perception of the job
- Reduce first year challenges through high-quality training and/or automated technologies
- Develop standardized skill set for CDPs that align with industry standards
- Support case-study demonstrations and simulation models of emerging technologies
- Increase communication with CDPs using digital platforms
- Clarify career pathway potential

This report presents the findings of a research project conducted by the MIT Concrete Sustainability Hub (CSHub), with funding by the Concrete Advancement Foundation, that explores both immediate and long-term innovative strategies to address the national CDP shortage and transform the role of the CDP. These solutions are organized into three categories to reflect the primary way in which each impacts the CDP shortage challenge: productivity, recruitment, and retention.

The CSHub research team used a multi-disciplinary approach to arrive at these solutions. The approach included an analysis of over 36,000 concrete deliveries to identify efficiency opportunities, interviews with various industry stakeholders; the construction of a representative ready mix operational simulation model to estimate the value of improving productivity, recruitment, and retention; a survey of over 500 CDPs across the U.S.; and an industry workshop to recognize key barriers to the adoption of proposed recommendations. The next sections summarize the main findings.

Productivity Gains Required to Eliminate the National CDP Shortage

Improvements in recruitment and retention rates for CDPs are critically needed to mitigate the CDP shortage, but so is bolstering CDP productivity. To explore this area, the team characterized the performance of payload deliveries, using telematics data consisting of over 36,000 deliveries (Figure ES1). The purpose was to explore how firms could overcome the 10.9% national vacancy rate [1]) through increased productivity of the existing workforce.

The analysis showed that, on average, a CDP takes 120 minutes to deliver a load of concrete. (See Figure ES 1.) Reducing this time by only 12 minutes (10%) would significantly

boost productivity and nearly completely alleviate the shortage issue. This gain in productivity would enable each CDP to deliver an average of 3.4 loads of concrete per day, instead of 3.1.

There are significant opportunities to achieve this level of productivity, such as increasing the use of automation for non-value-added tasks (e.g., truck washing). Additionally, the duration of driving and waiting tasks for CDPs depends on various factors, such as traffic and scheduling. At the same time, these tasks can be performed more efficiently with better information and communication. For example, more accurate data on traffic conditions and site readiness can help CDPs plan their routes and reduce their waiting time.

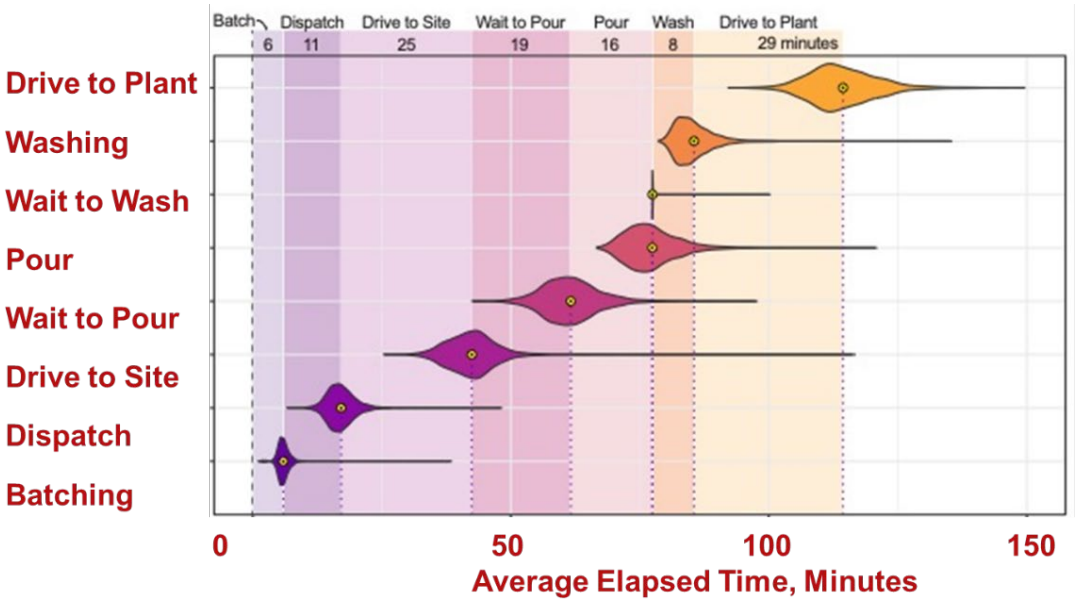

Figure ES 1 The average time (minutes) to complete each task from batching to returning to the plant.

Based on the productivity analysis, the team built a simulation representing a concrete plant in order to quantify the value of improving CDP productivity, recruitment, and retention.

The Estimated Value of Improving Productivity, Recruiting, and Retaining CDPs Using a Ready Mix Operational Simulation

Leveraging feedback from interviews and inputs from the NRMCA 2022 Mixer Driver Recruitment & Retention Survey, the team constructed a Ready Mix Operational Simulation (RMOS). The simulation estimates the value of a concrete plant 1) increasing the number of hirable candidates per truck, 2) increasing the retention rate for new hires, and 3) gains in CDP productivity, due to operational changes or investments in new technologies. The tool computed both direct and indirect costs to a company. The direct costs comprised HR, recruiting, training, and CDP wages. The indirect costs encompassed lost productivity due to shifts in CDP experience and idle trucks. A Monte Carlo simulation

was used to explore the economic impact of changes in productivity, recruitment, and retention across a broad range of scenarios.

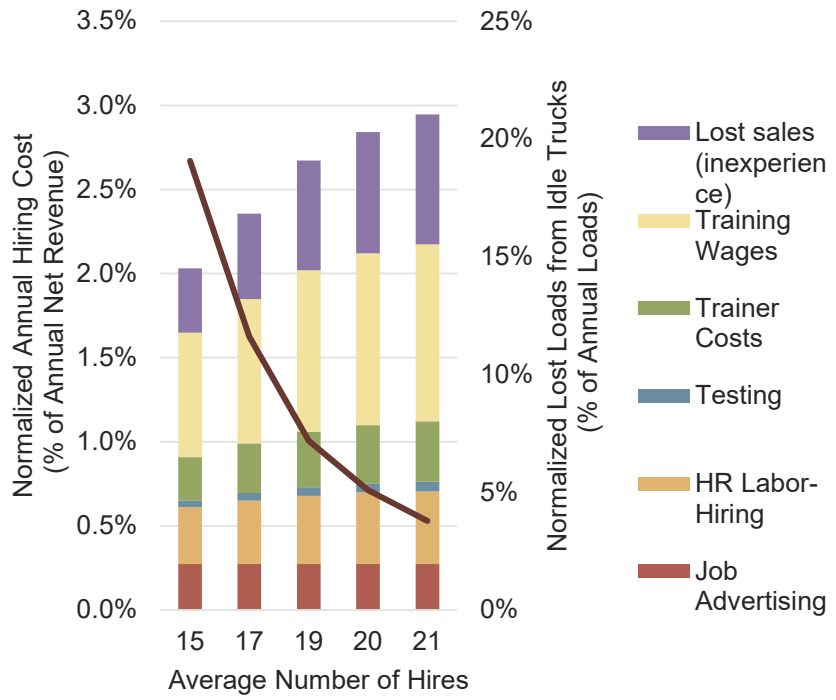

Figure ES 2 A comparison of the changes in direct costs and indirect costs per annual expected revenue. When the hiring rate increases, the hiring cost per expected revenue normalized hiring cost also rises (left axis). However, there is also a reduction in the lost sales as the number of idle trucks declines (right axis).

**Normalized hiring cost represents dollars spent on hiring normalized against the expected net revenue of the facility operating at the baseline hiring rate*

Applying this model, the CSHub research team found that the costs to increase hiring are easily offset by the gains from more available trucks operating (e.g., reductions in lost sales from idle trucks). In Figure ES 2, a 10% increase in hiring rate leads to a 3% increase in trucks operating, a 22% decrease in idle trucks, and a 5% expected total net revenues increase. In fact, a 28% increase in hiring should be sufficient to achieve 95% of nominal capacity. While hiring more CDPs each year increases the direct costs (hiring and wages), there are significant gains in revenue from the improved productivity from an increase in the available fleet operating. Increasing hiring is not the only strategy to reduce the driver shortage. Model results revealed that increasing new hire driver retention (i.e., average driver tenure) would also provide significant productivity gains. As CDPs gain experience, their productivity increases and truck idle time decreases. While the need for better recruitment and retention is not news, the model helps us to understand specific targets and payback periods which enables better decision-making about strategies and investments to boost these areas. The RMOS estimates that every additional week new drivers are retained on average generates about a 1% gain in net revenue per the annual expected revenue (Figure ES 3). Increasing new hire tenure by 35% provides the same value as doubling the hiring rate.

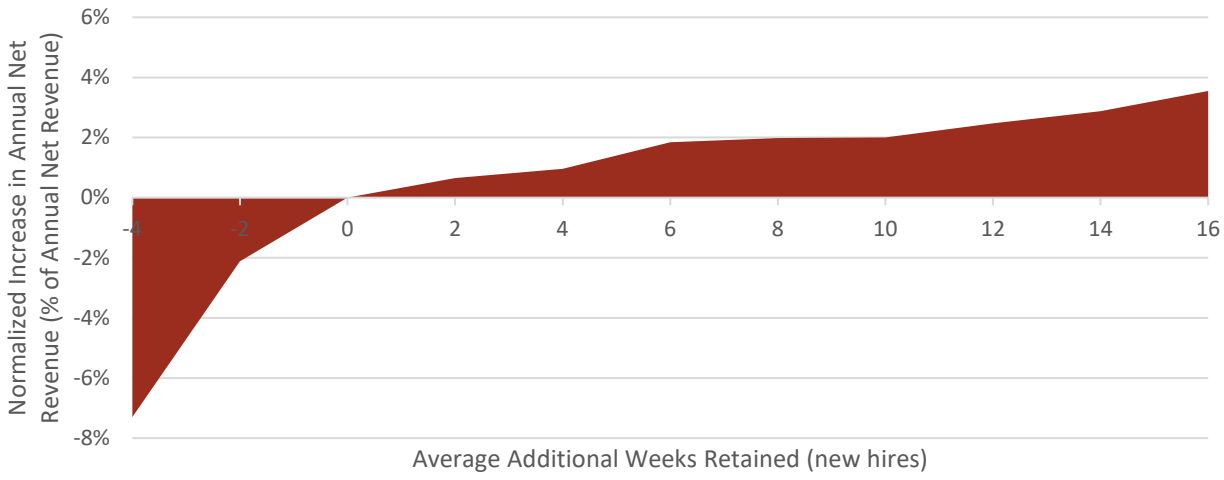

Figure ES 3 Results showing the gains in net revenue per annual expected net revenue for each additional week beyond the first 26 weeks of employment.

Discoveries from RMOS demonstrate that increasing driver productivity, the hiring rate, and/or driver retention are significant in addressing the driver shortage. Based on RMOS, the team created a CDP survey to find out how productivity, recruitment, and retention could be improved by listening to CDPs' opinions on their job satisfaction and work environment.

CDP Responses from National Job Satisfaction Survey

While data and modeling of concrete operations reveal the impact and value of productivity, hiring, and retention, they do not alone provide insight into how those goals might be achieved. To gain those insights, the team designed a nationwide CDP job satisfaction survey.

The survey explored the factors that influence job satisfaction and dissatisfaction of both experienced and novice CDPs to identify strategic solutions that would most effectively impact productivity, recruitment, and retention. Over 500 CDPs from across the nation provided responses.

Most Enjoyable Tasks for Experienced CDPs

- Dealing with contractors
- Operating the truck
- Experiencing the variety of job types
- Income and benefits

The survey revealed that the CDPs who are satisfied with their job appreciate engaging with contractors, the day-to-day variety of the job, the income and benefits, and, most of all, actually operating the ready mixed concrete truck. (Figure ES 4)

The survey also exposed those aspects of the CDP occupation that bring the least satisfaction. These include the irregular schedule, the timing of breaks during shifts, the lack of acknowledgment of their performance, the responsiveness of management, employee monitoring (e.g., cameras), and the physical demands (especially the

handling and assembling of the chutes). Qualitative responses from CDPs made it clear that these aspects of the job are often viewed as unfair, intrusive, or physically demanding.

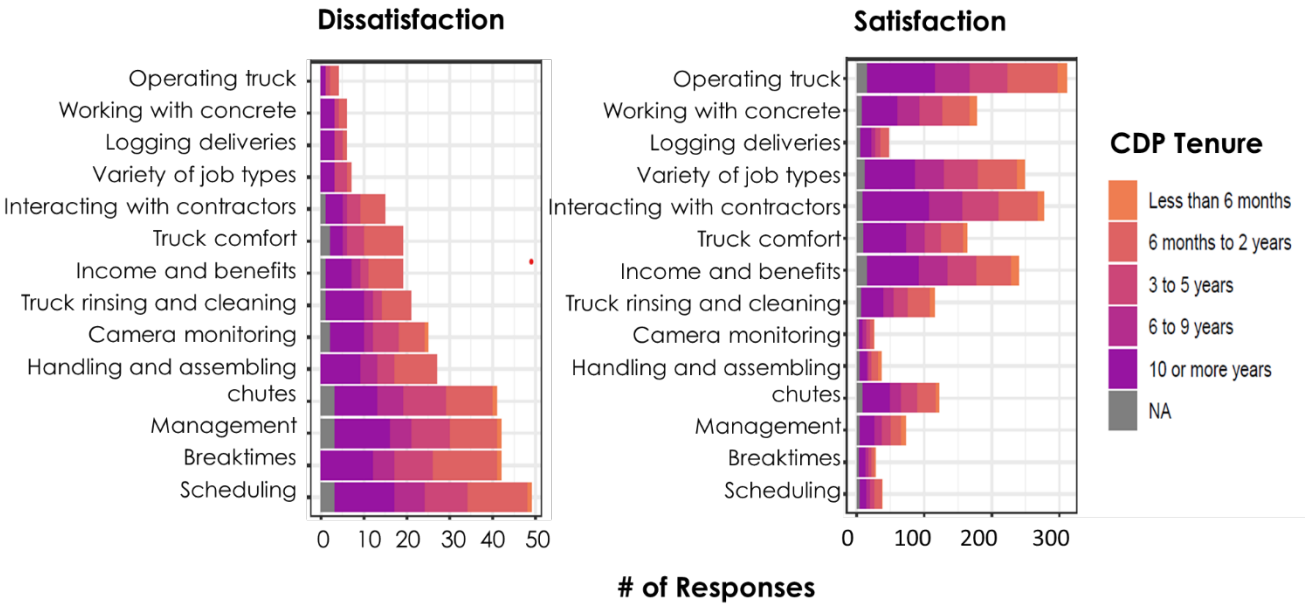

Figure ES 4 CDP survey results (n=378) indicate which factors contribute the most to job satisfaction or dissatisfaction.

To gain insight into how the CDP occupation could be made more appealing to new CDPs, existing CDPs were also asked about the most challenging tasks for first-year CDPs. The results (Figure ES 5) show that the greatest burdens for first-year CDPs are caused by learning the properties of concrete, placing concrete for more challenging pours, dealing with contractors, and driving off-road. Prioritizing and implementing solutions to reduce these frustrations for first-year CDPs will have far-reaching benefits for the ready mixed concrete industry.

Most Challenging Tasks for First Year CDPs

- Learning properties of concrete
- Placing concrete for more challenging pours
- Dealing with contractors
- Driving off-road

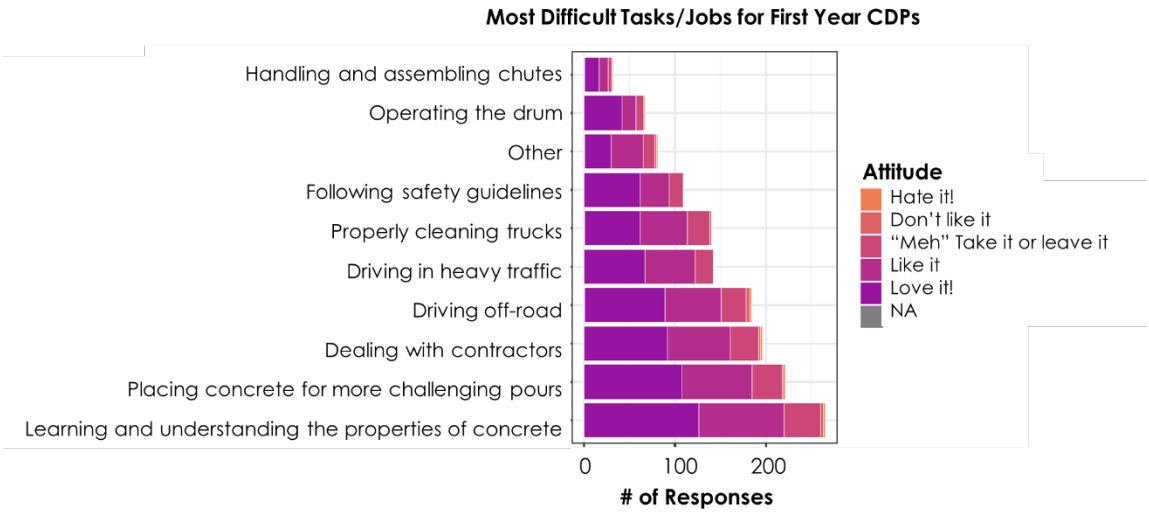

Figure ES 5 Survey results for the main challenges faced by first-year CDPs.

The team used feedback from CDPs, productivity analysis, and RMOS to consult key industry stakeholders on the best ways and places to apply technological solutions for the CDP shortage.

Barriers Preventing Widespread Adoption of Technological and Operational Solutions

To explore the challenges and opportunities associated with adopting transformative technological and operational solutions, the research team engaged with stakeholders from across the industry (n=55, Figure ES 6) at an in-person workshop hosted by the MIT CSHub in March 2023. The group included representatives from technology companies, research scientists, and operations and human resources managers from ready mixed concrete companies, among other stakeholders.

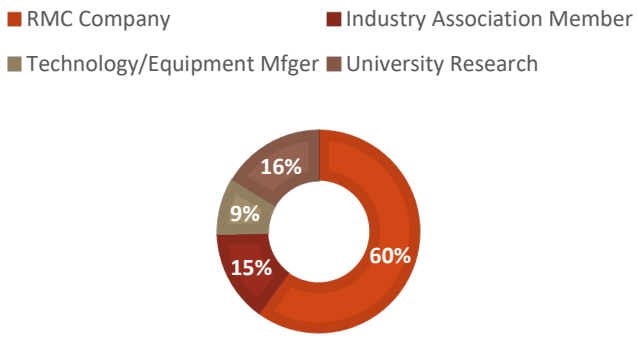

Figure ES 6 Attendees of the CDP Workshop in March 2023 and their affiliations.

The attendees were introduced to emerging technologies that could help with productivity, recruitment, and retention challenges. Presented with the CSHub's findings from its study, the group was tasked to identify opportunities and barriers that must be resolved before full-scale implementation of such technologies.

Workshop participants reinforced the importance of training – particularly for challenging pours, driving, and concrete properties – and interfacing with contractors as key challenges for new CDPs. Inconsistent schedules and management engagement were

affirmed as a challenge facing all CDPs and operations. Participants acknowledged the potential of existing and emerging technologies, but they also identified the upfront investment required as a major barrier to adoption as well as the need for case study demonstrations at RMC operations. In the following section, recommendations that improve productivity, recruitment, and retention are discussed. These solutions vary in their implementation, time, and complexity. Moreover, some solutions address more than one challenge at the same time.

Recommendations

A Significant Opportunity Exists to Increase Productivity

The trucking industry and many related industries are facing an extreme shortage of qualified candidates. Therefore, the industry must invest in advanced technologies that can achieve higher productivity and sustainability.

Automation Technologies

Technology can help the concrete industry increase productivity and overcome the problems of retaining and recruiting CDPs by changing the nature of their work. For example, technology can lower the physical and skill demands of the job such as the use of hydraulic telescopic chutes to reduce the number of on-the-job injuries and the time needed to retract and expand the chutes. Automation and sensor technologies are also technologies that improve repetitive processes and reduce difficult tasks for CDPs. Software technology enables automated testing of freshly mixed and hardened concrete. Sensors in the drum and software on mobile devices can reduce the complexity of the CDP job by eliminating the need for the CDP to measure fresh properties of the mixture. Technology also reduces or eliminates activities that do not add value, such as downtime, waste, errors, or redundancy, which improves the quality and efficiency of the work. For instance, automated truck washers reduce the need for the CDP to exit the truck after batching; it takes one minute to pass through the washer, delivering savings in time and safety.

Another aspect to consider is demand-side management.

Manage Customer Demand

The industry can achieve this management by using predictive models that can forecast the demand and timing of orders, and by applying surge pricing mechanisms that can encourage workers to accept less favorable shifts, while charging customers a higher price for deliveries during peak times.

Investing in New Technology Provides Strong Economic Returns

There are a number of technological solutions that could reduce the key challenges faced by CDPs. Automation of truck chutes and truck washing are two solutions already present in the marketplace that would both reduce physical demands and eliminate parts of the job that are sources of dissatisfaction. As noted earlier, however, many firms are hesitant to adopt these solutions because of the upfront cost and the lack of case specific analyses to support the business decision.

The CDP Recruitment and Retention simulation model allows us to provide insight into those business cases. Automation technologies not only increase the attractiveness of the job (increasing both recruitment and retention), but also increase driver productivity. As shown later in the report, in a labor constrained environment, a 1% change in productivity can provide up to a 1% increase in expected annual net revenue. That means that a firm could invest more than 5% of their expected annual net revenues in a new technology for every 1% gain in productivity and still come out ahead. (Assumes 10% real discount rate and technology lifetime of eight years).

As an example, some vendors suggest that something as simple as an automated truck washer could reduce batch-to-batch cycle time by 10 minutes. That 9% increase in productivity (See Figure ES 1) would provide a positive return on investment, as long as the upfront investment was less than 50% of annual expected net revenue.

In addition to integrating technological solutions to increase either CDP or operational productivity, there is great potential to apply them to recruitment and retention strategies.

Improving CDP Recruitment Requires Expanding the Candidate Pool and Increasing the Job Appeal

Change the Perception of the Job

Concrete Delivery Professionals (CDPs) perform a multifaceted role that extends beyond driving trucks. They engage with customers, skillfully maneuver heavy vehicles across diverse terrains, and perform physically demanding tasks throughout the day. They must also have fundamental knowledge of concrete. To enhance the perception of this occupation, all industry stakeholders should collectively adopt the term "concrete delivery professional" in their marketing and recruitment efforts. Just as the manufacturing sector grapples with branding challenges related to being perceived as dull, dark, and dirty, embracing advanced technology can act as a catalyst for changing perceptions, along with leading to improvements in productivity, recruitment, and retention.

Expand the Candidate Pool

To increase the candidate pool, the industry needs to establish a standardized set of skills demonstrating technical aptitude for the job. This would help facilitate job access for foreign workers who need to demonstrate their technical qualifications for a visa application. Other recruitment populations include younger workers (18–21-year-olds) and drivers without RMC knowledge. One operational strategy to recruit these workers is

to develop a new position, a concrete delivery technician. The goal of creating this position is to support the CDP and eventually move into a CDP role, creating a career pathway for younger workers or workers without RMC experience. This operational solution could help new CDPs to adjust to other aspects of their work, such as understanding the properties of concrete and interacting with contractors, by reducing the stress associated with the first-year challenges.

We used RMOS to evaluate the economic feasibility of employing concrete delivery technicians/technologists to support new hires at selected job sites. The results demonstrate that if the introduction of the technician role increases training and ramp-up speed while also increasing the average retention time of CDPs, it will result in net cost savings. At less than a 10% increase in tenure, the use of a technician resulted in increased net revenue. This result suggests that the deployment of delivery technicians could help companies increase their net revenue if the position enables longer retention of CDPs while reducing the amount of training needed for CDPs.

As companies adopt strategies to increase their candidate pool, they must also actively work to improve retention rates.

CDP Retention Can be Addressed Through Technology and Management Engagement

Roughly 40% of CDPs quit within the first year of employment, and results from RMOS showed every additional week of average retention generates additional value per year (Figure ES 3). Therefore, the industry must target solutions that reduce first year challenges for CDPs and increase the ways in which CDPs can become more involved in their scheduling, professional development, and improving communication with management.

Adopt Scheduling Strategies

The survey responses from the CDPs revealed that job satisfaction is mainly influenced by two factors: inconsistent scheduling and poor managerial relationships. Flexible scheduling tools such as bid-for-schedule applications could help address scheduling challenges by providing more flexible options and increased wages for unpopular shifts. However, as the industry works to build this technological solution, near-term solutions include: 1) rotating schedules between senior and new CDPs to allow for equality in scheduling and 2) fixed schedule hours.

Enhancing Careerlong Engagement

The next step to improving CDP retention is to increase engagement between CDPs and managers. NRMCA has several resources that companies can use to measure and improve employee engagement, such as the NRMCA 60-day check-in, an exit interview questionnaire, and job satisfaction survey.

Gamification allows companies to provide feedback on targeted performance enhancing behaviors. It has helped encourage positive behavior and performance in the RMC industry and increased retention rates. Gamification also reduces the engagement required by management to recognize workers and provides an

alternative way to interact with CDPs, especially younger generations who may be more likely to be exposed to gamification through digital applications.

In a similar vein, it is critical to address CDP desires for career growth. As the industry works to define a standardized set of skills for the CDP occupation it should extend this action by creating standardized skill sets for other positions at a concrete producing plant (e.g., batch plant operator, CDP trainer, etc.). This action can help define skill overlap and increases transparency for CDPs to recognize how their skill levels translate into other careers, promoting professional development. It also creates a clear career pathway for CDPs who want to advance within the industry or transition to other sectors.

The implementation of these two tools must also be combined with tools that aim to reduce tasks and challenges for first-year CDPs.

Reducing First Year Challenges

Virtual reality (VR) and augmented reality (AR) technologies have gained popularity for training and on-the-job assistance across industries. In the RMC industry, VR systems have been proven to improve the safety of the CDP job by simulating one of the most dangerous events – a rollover incident. VR can help train CDPs in many different scenarios. AR could be used on-the-job to aid CDPs, especially first-year CDPs, with maintenance and troubleshooting.

In addition to adopting technological solutions to train CDPs, creating a train-the-trainer course to standardize training across the industry would benefit new hires. A key feature of the course would be to ensure that the CDP trainee can map daily tasks and skills to competencies, because while specific skills may not directly translate into other occupations within the industry, competencies do. By learning how to articulate their skills in terms of competencies, CDPs can broaden their career horizons, which was brought up as a key concern to address.

In addition to standardizing training, as the candidate pool expands, the industry will encounter more employees who lack a CDL or ready mixed concrete experience. To address this challenge, firms should consider integrating virtual reality and/or gamification of the learning outcomes as additional tools that can enhance learning. These tools can complement each other and create a more engaging and effective learning environment for the employees.

Additional Research and Outreach Can Help Address the CDP Shortage

In conclusion, there are several additional areas of research and outreach that the CSHub research team believes can assist in addressing the CDP shortage.

Concrete producers operate in a highly competitive market, and as a result, they often need to have a clear understanding of the value proposition of new solutions, such as a bid-for-schedule app or emerging technologies (e.g., augmented reality). To increase buyer confidence, this study has demonstrated the value of investing in new technologies and adopting emerging solutions through RMOS. However, during the CDP workshop, it was made clear that case study demonstrations from early adopters of new

technologies would help other companies to understand the risks and benefits. These case studies could enable potential users to make informed decisions, which could encourage widespread adoption of existing and emerging technologies. NRMCA and state ready mixed concrete associations regularly provide opportunities for sharing case studies and best practices among peers in an environment that assures antitrust compliance.

The development of additional models and tools is an important element. RMOS could be expanded to a common platform to explore the effects of new solutions on cost and productivity. A proof-of-concept, bid-for-schedule simulator could be developed to test the functionality of allowing CDPs to select their preferred shifts based on their availability, preferences, and seniority, which can enhance their satisfaction, autonomy, and work-life balance. Building a prototype could provide insights into the optimal design and the return on investment for a more permanent and scalable solution.

As the RMC industry undergoes these changes, there will be an increasing demand for data. Few studies beyond those performed by the NRMCA have analyzed the CDP shortage, unlike the long-haul trucking industry. The creation of a CDP data hub, a centralized system for CDP data, can facilitate empirical analyses that can shed light on the CDP shortage and produce significant value for decision-makers.

Conclusion

The RMC industry faces a serious challenge of retaining and recruiting CDPs who are vital for the construction of infrastructure that supports economic growth. The industry needs to explore and adopt transformative technologies and operational solutions that can enhance the CDPs' skills, satisfaction, and performance.

Taking a systems approach to assessing the situation from multiple angles, this report identifies potential solutions that could be implemented near-term and long-term. We recommend that the industry stakeholders consider these solutions to build a sustainable workforce.

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Introduction

For eight years, the National Ready Mixed Concrete Association (NRMCA) has conducted a Mixer Driver Recruitment & Retention Survey among operation managers across the United States. The surveys reveal a chronic shortage of ready mix drivers who are essential for delivering concrete, one of the most manufactured materials in the world. This problem is evidenced by the fact that while cubic yardage produced increased by 9% between 2017 and 2021, the percentage of producers losing business due to the lack of drivers soared from 36% to 70% over the same period [2]. Producers attribute the shortage of drivers to the difficulty of finding candidates with both a CDL and ready mix driving experience. Consequently, they have become more open to hiring new CDLs (from 51% to 68% in 2021) and 18-21 year-olds (from 35% to 60% in 2021) [2]. In addition to recruitment, low retention rates are concerning. According to the 2022 NRMCA Survey, those who were hired and quit within the first-year of employment grew from 25% to 39%, with the national vacancy rate estimated to be 10.9% [2].

Figure 1 CDP assembling steel chutes before pouring concrete in Boston, MA.

Not retaining and recruiting enough CDPs imposes significant costs on the RMC industry, including the direct costs related to hiring, loss of driver productivity, and a decline in safety and customer satisfaction [3].

While there is yet to be a study that empirically estimates the replacement costs for CDPs, there is a body of literature that investigates the cost of replacing over-the-road truck drivers. As an example, Rodriguez et al. (2000) acquired data from 15 trucking companies and tallied the cost of recruitment, profit loss due to idle equipment, and other costs [4]. The authors found that the average cost of turnover per driver for all companies was $8,200 and ranged as high as $20,700 (in year 2000 dollars). In 2023 dollars, these values rise to $14,000 and $35,700 per driver, respectively.

Considering the cost of high turnover rates for CDPs, there is an immediate need to identify solutions to reduce that rate of turnover. This research attempts to do this by examining CDP job preferences and reviewing the landscape for technological and operational changes that can bring more drivers to the industry, keep those drivers in their jobs longer, and increase the value-added work delivered by each driver.

Novelty of Research

Outside of reports published by the NRMCA, there is little research on the CDP shortage compared to the long-haul trucking industry. Our study fills this gap using a systems approach to identify the challenges faced by new and experienced CDPs, and to benchmark the current level of technology adoption and usage among them. Recommendations to address the CDP shortage are organized into three categories: productivity, recruitment, and retention. To identify opportunities to reduce waste and increase CDP efficiency, over 36,000 deliveries were examined to identify the average time for one delivery and the average time per task. The results showed that the average delivery time was 120 minutes. Given that the national driver vacancy rate was 10.9% [2], reducing the delivery time per load by 12 minutes combined with other recruitment and retention strategies could lead to significant gains for the ready mixed concrete industry.

Next, we conducted 25 interviews with stakeholders from technology companies, concrete operation managers, human resources managers, trainers, and CDPs. Based on feedback from these interviews, we developed a representative ready mix operational simulation model to estimate the value of improving productivity, recruitment, and retention through various solutions. We designed a unique survey to elicit direct feedback from CDPs on their satisfaction and motivation, as well as their preferences for different technological solutions that address their challenges. The survey was completed by 439 drivers across the U.S.

In the following section, we summarize existing research relevant to the CDP shortage. We focused on the topics that are relevant to productivity, recruitment, retention, and technology in the trucking industry. Through this process, we discovered that most of the previous studies have concentrated on the long-haul freight sector while neglecting the ready mix sector, presenting a significant opportunity for the research community and industry.

Research Questions

The RMC industry has been battling the CDP shortage for several years and is discovering the need of an overarching solution that increases the attractiveness of the job while increasing CDP efficiency to mitigate the national shortage. Considering the challenges contributing to the CDP shortage, the MIT team conducted a study that builds on existing industry programs and survey results to understand how the CDP role may evolve with technological advancements, operational changes, competing industries, and new types of training. The research was informed by the following questions:

- What innovative strategies are currently deployed at companies to address the CDP supply shortage?
- What are the drivers of job satisfaction and dissatisfaction among CDPs?
- What is the value of adopting new technologies to improve productivity?

The results of this study will inform novel solutions to enhance CDP productivity, recruitment, and retention — thus mitigating the CDP shortage significantly. The Methods section below describes the methodology used by the research team to gather the data needed to develop solutions.

Methods

To conduct this analysis, we used a multi-pronged approach. First, we analyzed approximately 36,000 payload deliveries to evaluate CDP productivity and improvement opportunities. We also interviewed industry stakeholders to understand their perspectives on the CDP challenge and the existing solutions and technologies they use to handle these challenges. Based on feedback from these interviews, we developed a ready mix operational simulation designed to estimate the value of enhancing CDP productivity, recruitment, and retention. To elicit direct feedback from CDPs, a CDP job satisfaction survey was deployed across the U.S. to gather data on the factors that affect CDP motivation and satisfaction. Finally, we organized a workshop with key stakeholders to review our research findings and recommendations, which facilitated a constructive dialogue to evaluate the potential strategies and their implementation challenges and opportunities.

The following sections discuss in greater detail the methodology employed for each approach.

CDP Productivity Analysis

The 2022 Mixer Driver Recruitment and Retention Survey reports that the national vacancy rate in 2021 was 10.9% [1], implying that producers need ten percent more CDPs to meet their current demand. To understand how companies can increase their productivity by ten percent, telematics data from a ready mixed concrete company were analyzed to characterize the performance of CDP deliveries and identify opportunities to reduce the idle time per delivery.

The telematics dataset included ~36,000 deliveries between June 2020 and April 2022. This data included round-trip date/time information for each truck in the fleet for the individual delivery process steps such as batching, dispatching, driving, washing, waiting, and pouring. Each of the process steps was converted into a time interval and data reduction methods were used to eliminate invalid data. For example, if the waiting time after a pour was >2,000 seconds, this data point was eliminated. Negative time intervals were also eliminated from the dataset. The mean of each individual time interval across deliveries was estimated, and the unit of analysis was made deliveries per CDP per week to inform the number of additional deliveries needed to increase productivity by 10%. Since this dataset was for a single operation during the COVID-19 era, the results are not conclusive and additional data should be collected from operations in different locations over several years to inform a more representative analysis of the industry. However, this information can be used to begin to identify ways to improve a CDP's productivity.

Semi-Structured Interviews

This methodology involved the team interviewing a broad range of key stakeholders within the industry to gain an understanding of existing strategies and practices that concrete producers have implemented to address recruitment, retention, and productivity challenges. Those who shared insight were human resource managers, operation managers, CDPs, and dispatchers. Beyond those, others from non-profits such as Women in Trucking[1], CPI Foundation[2], and the National Center for Construction Education and Research were interviewed with the intention of identifying successful ways to attract and onboard women, students, and active military members into becoming a CDP. Finally, the team met with multiple technology companies to discuss applications and how in particular they affect the daily tasks of CDPs. Depending on the stakeholder, a different set of questions was used. The specific questions for each stakeholder group are included in the Appendix.

The interviews were structured into four main sections:

1) Demographic and general information,
2) Hiring and retention challenges,
3) Hiring and retention solutions, and
4) Potential opportunities and barriers

The semi-structured interviews were conducted with stakeholders at NRMCA's ConcreteWorks, Command Alkon's Elevate conference, ride-alongs with CDPs in the Massachusetts area, and via Zoom calls.

Twenty-five total interviews were conducted and learnings were incorporated into the development of a CDP job satisfaction survey.

Ready Mix Operational Simulation

To understand the true cost of unfilled positions as well as the benefits of implementing keys strategies to improve recruitment, retention, or productivity, a simulation tool was developed to estimate the direct cost of hiring a new CDP and the indirect cost of *not* filling that position. From the semi-structured interviews, we learned from companies that the real economic losses are from idle trucks and "the likelihood of a new CDP getting into an accident in the first 18 months." Many companies understand that new drivers are less productive (~15% less) than a veteran CDP, but many smaller companies do not have the resources to estimate the costs to their company.

The simulation estimates the direct and indirect costs to a company for costs related to CDP hiring, training, and wages. The model does not include all the costs of a ready mix operation (e.g., materials and energy). The direct costs include hiring expenses such as HR, recruiting, training, and CDP wages. The indirect costs are defined as lost productivity

[1] https://www.womenintrucking.org/
[2] https://www.cpi-foundation.org/about-cpi.html

due to changes in a CDP's level of experience as well as the impact on productivity because of idle trucks.

Model input data can be changed so companies can estimate their own direct and indirect costs. For the analyses presented here, typical operational characteristics were gathered from the literature and from interviews with several operators in various parts of the U. S. As such, the analysis does not reflect a single firm or location but is instead intended to be representative of many ready mix operations. The input data used for the simulation results can be found in the Appendix. To simulate inherently stochastic hiring and quitting events, a Monte Carlo simulation was performed drawing on a uniform probability distribution for each input value. The model calculates the direct and indirect costs using the equations provided below.

Quantified Direct costs

The direct costs[3] are calculated as the human resources costs for hiring (C_h), the costs for training (C_t), and the CDP wages (C_w).

$$C_D = C_h + C_t + C_w \qquad \text{Equation 1.}$$

The hiring costs include the annual staff labor costs (C_L) which include costs for an administrator (C_{admin}), recruiter (C_{rec}), mentor (C_{mentor}), and referral bonus (C_{ref}) for other employees. The administrator cost is calculated in Equation 2 where R_t is the time allocated to recruit, H_a is the number of admin hours spent per new hire, D_h is the number of drivers hired, W is the number of delivery weeks per year, A_s is the admin salary, and S_b is the salary benefits multiplier.

$$C_{admin} = R_t * \left(\frac{H_a * D_h}{40 * W}\right) * A_s * (1 + S_b) \qquad \text{Equation 2.}$$

The recruiter costs are calculated in Equation 3 where S_r is the recruiter salary, R_s is the number of recruiters.

$$C_{rec} = S_r * \frac{Rs * Dh}{W} \qquad \text{Equation 3.}$$

The mentor costs are calculated in Equation 4 where R_m is the mentor rate per trainee.

$$C_{mentor} = D_h * R_m \qquad \text{Equation 4.}$$

The referral costs are calculated in Equation 5 where R_r is rate for referrals and R_n is the number of referrals.

$$C_{referral} = D_h * R_r * R_n \qquad \text{Equation 5.}$$

Additionally, the cost of advertising (C_a) the job role annually and the annual testing fees (C_{test}) are also included. The advertising costs could include costs for flyers, magazine ads, newspaper ads, online ads, radio ads, social media ads, and television ads. The testing fees can include, for each driver hired, a criminal history testing fee, DAC testing

[3] In this analysis, the legal and insurance costs are not included due to lack of available data. However, these costs should be included in individual company assessments.

fee, Department of Transportation testing fee, drug testing fee, motor vehicle fee, or a physical testing fee.

$$C_h = C_L + C_a + (C_{test} * D_h)$$ Equation 6.

The costs for training include the cost of a CDL license (if the CDP comes in without a CDL) (C_{CDL}), the fixed costs for the vehicles used for training (F_{truck}), and the cost for a trainer ($C_{trainer}$).

$$C_t = C_{CDL} + F_{truck} + C_{trainer}$$ Equation 7.

The CDL costs include the CDL training fee (CDL_f) for each of the hires without a CDL (D_{new}).

$$C_{CDL} = CDL_f * D_{new}$$ Equation 8.

The fixed costs for each truck are calculated in Equation 9 as the number of drivers hired times the average training miles on the truck per driver (D_{avg}).

$$F_{truck} = D_{avg} * D_h$$ Equation 9.

The last training cost is the trainer costs. This is calculated in Equation 10 as the training rate per person, R_t, for each driver hired without ready mix experience (drivers without a CDL and drivers with a CDL, but no ready mix experience, $D_{onlyCDL}$.

$$C_{trainer} = R_t * (D_{new} + D_{onlyCDL})$$ Equation 10.

The CDP wages include the costs for CDP wages during the training phase. This is estimated as the total number of training weeks (T_t) times the total CDP wages (W_{CDP}).

$$C_w = T_t * W_{CDP}$$ Equation 11.

Quantified Indirect costs

The indirect costs (C_i)are estimated as the revenue lost due to idle equipment (R_{truck}) and the revenue lost from reduced productivity (R_{prod}). These are essentially the costs of not hiring.

$$C_i = R_{truck} + R_{prod}$$ Equation 12.

Revenue lost from idle trucks (R_{truck}) is estimated as the average price per cubic yard (P_{avg}) multiplied by the average load size (L_{avg}) and forgone loads due to idle trucks ($L_{forgone,truck}$).

$$R_{truck} = P_{avg} * L_{avg} * L_{forgone,truck}$$ Equation 13.

The number of forgone loads is estimated in Equation 14 as the expected weekly production, P_{weekly}, multiplied by the average number of idle trucks, T_{idle}, and the number of delivery weeks per year, D_{weekly}.

$$L_{forgone,truck} = P_{weekly} * T_{idle} * D_{weekly}$$ Equation 14.

The simulation simulates the number of trucks operating each week, which is a function of the number of drivers on staff. For the CSHub Mixer Plant Facility, there can be up to 50 trucks operating each week. The time step of the simulation is set at one week.

The expected weekly production expressed as P_{weekly} is calculated in Equation 15 and is as a function of average loads delivered by CDPs per week (P_{CDP}) multiplied by the average number of trucks operating that week, $T_{operating}$.

$$P_{weekly} = P_{CDP} * T_{operating} \quad \text{Equation 15.}$$

The average loads delivered per week by CDPs are based on the experience level of the drivers, which was randomly assigned from a uniform distribution with a mean of 416 weeks. The driver experience characteristics assumed for the model are shown in Table 1 below.

Table 1 Experience characteristics for drivers in the CSHub Mixer Plant Facility case study.

Average tenure of experienced driver	416 weeks
Average tenure new hire	26 weeks
Weeks to become experienced driver	52 weeks
Maximum tenure for driver	1040 weeks

Drivers are modeled as existing in one of four states: working, ramping, training, or not available. The final state, "not available", is a modeling construct to account for the period of time between when a driver exits and another driver is hired to operate a truck. A driver exits the firm because they either reach maximum tenure (set at 1040 weeks) or because they quit. Quitting is based on the average tenure of a new hire and the average tenure of an experienced hire. These values inform a uniform probability of quitting in a given week. Once a driver quits, it is assumed that the truck is now vacant until a new driver is hired to fill that position.

The working state of the driver on each truck is also randomly assigned as one of four states: working, training, ramping up, or no driver. For each experience level, there is a fixed schedule once the driver is hired that determines how many weeks are spent in training and a ramp-up period. For example, a driver with no experience spends about six weeks training while a driver with a CDL and previous ready mix experience only spends one week training.

There is also a different level of productivity assigned based on the working status. When there is no driver assigned to a truck or the driver is in training, 0% productivity is assumed. During the ramp-up period, a linear increase in productivity is assumed. In the final state of working, 100% productivity is assumed. The inputs assumed for the simulation are shown in Table 2 below.

Table 2 Operational characteristics for different driver working states in the CDP simulation.

Working State	No experience (weeks)	CDL only (weeks)	CDL + ready mix (weeks)	Productivity (%)
No driver	4	4	4	0
Training	6	4	1	0
Ramp-up	12	6	2	Linear increase over time
Working	1040	1040	1040	100%

Each week, a random number is generated in the model that indicates whether or not a CDP quits.

Hiring events are based on data input into the model for the average number of hires per year per truck. A triangular distribution defined by the minimum number of hires, maximum number of hires, and average number of hires is applied and a random sample informs how many new hires happen in a given week. Once a new hire is generated in the model, this new hire is assigned to an empty truck and is randomly assigned an experience level that informs their fixed schedule. The quitting and hiring events were simulated over a ten-year period to estimate the average number of quitting and hiring events over a year. These events inform the operational data necessary to compute the revenue lost from idle trucks.

To estimate the revenue lost from reduced productivity, the following equations and simulation data were used. Revenue lost from idle trucks (R_{prod}) is estimated as the average price per cubic yard (P_{avg}) multiplied by the average load size (L_{avg}) and forgone loads due to driver experience ($L_{forgone,driver}$).

$$R_{prod} = P_{avg} * L_{avg} * L_{forgone,driver} \quad \text{Equation 16.}$$

The number of forgone loads due to driver experience is estimated in Equation 17 as the maximum plant weekly capacity, P_{max}, divided by the number of facility trucks, $T_{facility}$, minus the expected weekly production for the facility divided by the average trucks operating.

$$L_{forgone,driver} = \left(\frac{P_{max}}{T_{facility}} - \frac{P_{facility}}{T_{operating}}\right) * T_{operating} * P_{weekly} \quad \text{Equation 17.}$$

The maximum plant weekly capacity is estimated in Equation 18 as the number of trucks at the facility multiplied by the average number of loads per day by the number of delivery days per week, D_{day}, and the net productivity of an experienced driver, $Prod_{net,experienced}$.

$$P_{max} = T_{facility} * L_{avg} * D_{day} * Prod_{net,experienced} \quad \text{Equation 18.}$$

The net productivity of an experienced driver is estimated as the experienced driver average tenure, $Tenure_{exp}$, divided by the experienced driver average tenure plus the lost productivity weeks per experienced driver exit, $P_{loss,exp}$.

$$Prod_{net,experienced} = \frac{Tenure_{exp}}{Tenure_{exp}+P_{loss,exp}} \quad \text{Equation 19.}$$

Finally, the lost productivity weeks per experienced driver exit is estimated as the idealized hiring time, H_{time}, plus the ramp-up time of a CDL only experienced driver, $T_{ramp,CDL}$, divided by 2.

$$P_{loss,exp} = \frac{H_{time}+T_{ramp,CDL}}{2} \quad \text{Equation 20.}$$

The ramp-up time of a CDL only driver is estimated from the simulation in the CDP simulation tool. The quitting and hiring event simulations inform the productivity data necessary to compute the revenue lost from decreased productivity. The direct and indirect costs associated with the representative case study are presented in the results section.

Sensitivity Analyses

The ready mix operational simulation can be used to perform various sensitivity analyses to understand the effects of potential operational and technological solutions. Parameters can be varied to estimate the impact of different operational and technological changes. The value of these changes has been characterized as normalized net gains in revenue. Normalized net revenue gains is expressed by dividing the baseline revenue by the net gains in revenue.

$$R_{norm} = \frac{R_{Net\ Gain}}{R_{Base}} \quad \text{Equation 21.}$$

Equation 22 presents the formula used to calculate the present worth of net gains in revenue. A discount rate of ten percent over eight years was used to estimate the present worth of net gains defined as R_{Δ}

$$P_{Net\ Gain} = R_{\Delta}\left(\frac{(1+\mathrm{i})^{N}-1}{i(1+i)^{N}}\right) \quad \text{Equation 22.}$$

After constructing the ready mix operational simulation and performing various scenarios, the next step was to construct a CDP job satisfaction survey that elicited direct feedback from CDPs. The intention was that it identified what solutions should be prioritized, and then using RMOS it would be possible to estimate the value of the changes.

CDP Job Satisfaction Survey

Survey Design

In all, the survey was comprised of four sections. In the first section of the survey, respondents were asked to identify their company's location, type of plant, type of

community, and whether the company is unionized. Respondents were then asked to identify their current role at the company. If the respondent selected an occupation other than CDP, they were asked a unique set of questions to capture additional data. These questions can be found in the Appendix.

If the respondent selected CDP as their occupation, they were directed to the next section. In the second section, the survey was constructed to have three pathways defined by a unique set of questions and was determined by the CDP's attitude towards the occupation (Figure 2).

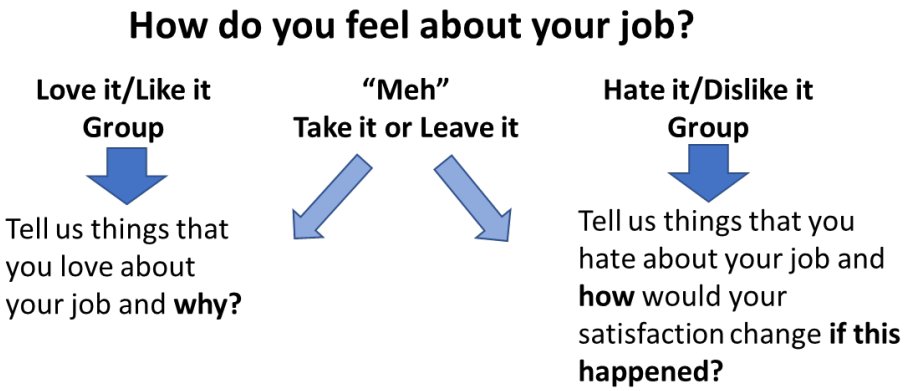

Figure 2 An illustration highlighting the three individual pathways of the CDP survey. The CDP's attitude towards the job determined which route was taken.

The CDP's attitude was measured using a Likert scale, allowing the person to indicate their overall job satisfaction. When asked how they like their job, the options were the following:

- Love it
- Like it
- Take it or leave it
- Dislike it
- Hate it

Those who selected either the "Love it" or "Like it" option were asked directly which tasks and responsibilities brought the most satisfaction, followed by answering why. The tasks and responsibilities included:

- The diversity of the job types, e.g., forms, foundation, sidewalks, etc.
- Responsiveness of management
- Handling and assembling the chutes
- My income and benefits/pension (if union)
- Rinsing and maintaining my truck throughout the day
- Interacting with contractors on jobsites
- Working with concrete and understanding its properties
- Operating my ready mix truck

- The scheduling
- Driver performance is recognized
- Daily logging and ticketing are all digital
- Cameras monitoring my driving behavior, making me a safer driver
- Breaktimes are adequate
- The comfortability of my truck

Those who selected "Dislike it" or "Hate it" were asked to select from the same list of options that were presented to those feeling positive about work. Instead of asking why it brought dissatisfaction, alternative options that were considered to increase satisfaction were presented, and the person was asked to specify how much their level of satisfaction would increase if this option was put into action. For example, interviewees shared that while hydraulic chutes have some drawbacks, they simultaneously offer other benefits to other groups because they require far less physical strain.

The third classification of CDPs were those who felt neutral about their job. They were the "Take it or leave it" CDPs. Any CDP who selected this option was asked to take both the satisfaction and dissatisfaction set of questions.

The survey was intentionally structured to have these pathways to understand why aspects of the job were viewed favorably, and identify ways to improve those that were not.

All respondents were then asked questions about their prior career experience. These questions included:

- How long have you been a CDP at your current company?
- Before joining your current company, did you have previous ready mix driving experience?
- Based on your company's seniority system, what is your current position?
- Select the reasons why you became a CDP.

In addition, all respondents were asked to answer questions about their career pathway. These questions included the following:

- Do you consider yourself a skilled operator or a truck driver?
- Do you see yourself driving a ready mix truck until retirement?
- If not, which careers would you consider?
    - Ready mixed concrete batch plant production manager
    - Ready mixed concrete dispatcher
    - Concrete quality control specialist
    - Sales representative for ready mix related products
    - Concrete flatwork technician/finisher
    - Jobsite superintendent
    - Project manager
    - Pump contractor
    - Other

Finally, all, including CDPs, managers, dispatchers, and HR mangers, were asked which tasks are the most challenging for CDPs who have less than one year of experience. Asking this question to CDPs and others enabled the team to see the align

Survey Deployment

The survey was implemented in the Qualtrics online platform [5] and was sent out to member companies of the NRMCA. As well as working with the NRMCA members, the team also used LinkedIn and a Ready Mix Facebook group to expand the survey's reach to a wider audience. Contacts were asked to share the survey with the CDPs via email or via a flyer posted in the driver lounge. The survey was deployed in January 2023 to CDPs across the U.S. and received over 500 responses. There were 439 responses where the respondent completed 100% of the survey. Not all survey questions were forced, meaning the respondent could advance to the next question without answering the previous one. Rather than the number of respondents being the sample size, the implication of this setting was the sample size is based on the number of responses to each question.

After the survey concluded on January 31, 2023, the team analyzed the responses to determine the key areas for technological or operational improvements. These potential solutions were then presented to industry stakeholders to assess the main challenges for their adoption.

Stakeholder Workshop

For the MIT-hosted workshop in March 2023, 55 stakeholders (Figure 3) gathered with the goal of identifying strategies to overcome the national shortage of CDPs.

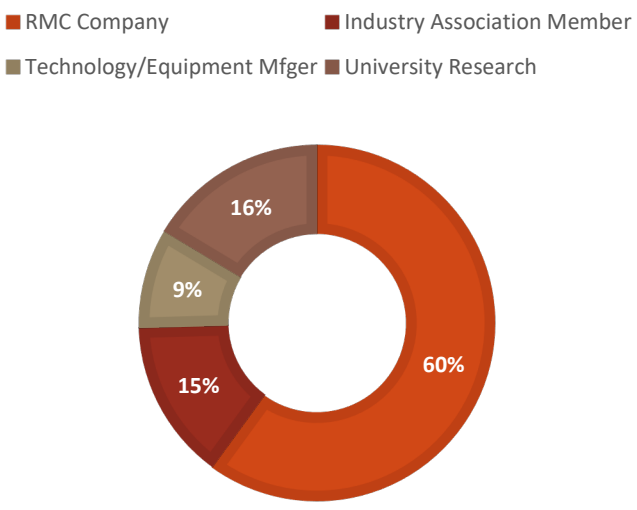

Figure 3 Breakdown of workshop attendees from the industry.

There were three separate panels with expert speakers that discussed a vision for the future CDP and identified key challenges and innovative strategies for retention, recruitment, and productivity:

- Panel 1: Emerging Technologies for Creating a More Productive Workforce
- Panel 2: Leveraging Data and Technology to Increase Driver Retention
- Panel 3: Increasing Driver Recruitment by Broadening the Talent Pool

After the panel presentations, the attendees participated in breakout sessions to discuss opportunities and barriers for the proposed strategies. The breakout questions are included in the Appendix and the data collected were synthesized into recommendations at the end of this report.

The workshop marked the end of the data collection phase of the project. The team synthesized the results from the productivity analysis of delivery, stakeholder interviews, the ready mix operational simulation, CDP survey, and workshop. These results are presented in the next section.

Results

CDP Productivity Analysis

Given that the national vacancy rate in 2021 was 10.9%, the purpose of the CDP vacancy and productivity analysis was to discover the additional increase in CDP productivity needed to mitigate the need for additional CDPs.

Table 3 summarizes the productivity analysis of 36,747 payload deliveries over a period of 93 weeks from June 2020 to April 2022. The mean delivery time per payload was 120 minutes, and the mean number of deliveries per CDP per day was 3.1. The mean number of working days per week was lower than expected, possibly due to the impact of COVID-19 since 21% of construction business reported reduced work hours between April 2020 and April 2022 [6].

Table 3 Descriptive statistics for CDP vacancies and productivity analysis.

	Average	Median
Average No. of CDPs per week	37.1	37
Payload deliveries per day	3.1	3
Weekly deliveries per truck	10.5	10
Days per week with deliveries	5.3	5
Days worked per week	3.5	4
Duration of delivery in minutes	120	114

In Figure 4, the distribution of the (A) total delivery time, (B) the number of weekly deliveries per truck, and (C) the distribution of working days per week is shown. Evaluating

the data, increasing the daily delivery average to 3.4 per day or the weekly average to 11.6 deliveries per truck per week, increasing the average working days to 3.85, or shortening the delivery duration by 10% (or 108 minutes) are areas where a 10% change leads to improvement. With these distributions, it is possible that accomplishing these goals seems plausible. For instance, we can see that even for current operations, the average deliveries per truck per week is already equal to or greater than 11.6 deliveries 43% of the time.

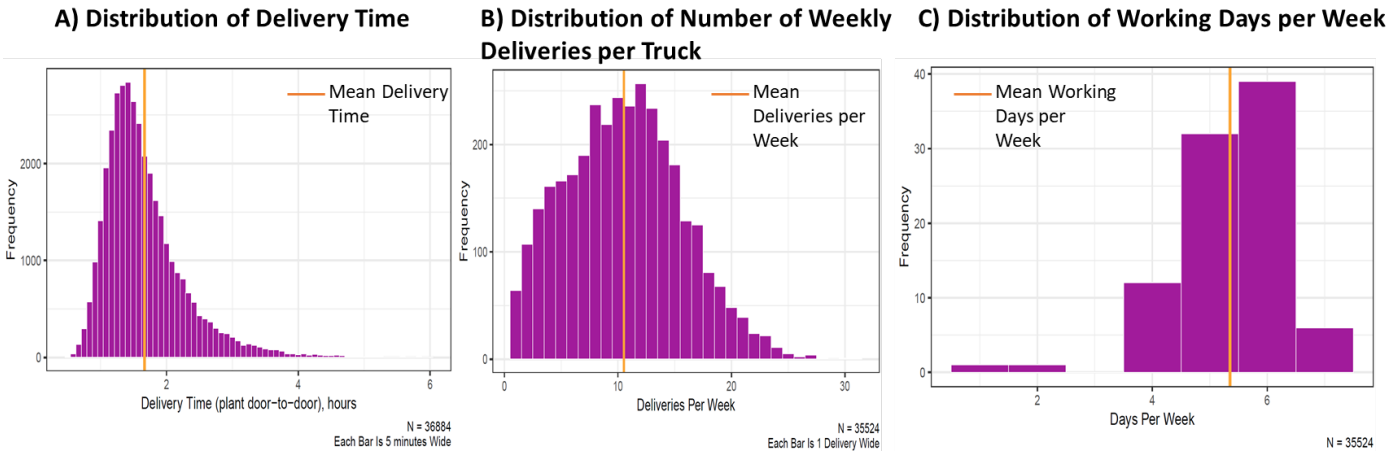

Figure 4 Distributions of the delivery time (hours) (A), number of weekly deliveries per truck per week (B), and the days per week with deliveries (C).

To find opportunities to reduce delivery time, an analysis of the duration of tasks for a typical concrete delivery was performed. Figure 5 illustrates the sequence and duration of tasks for a typical concrete delivery. Out of the seven categories, only pouring and batching are value-added tasks that enhance customer satisfaction and company profitability. The rest are non-value add tasks. Each delivery also involves idle time, comprising 11 minutes of waiting for dispatch and 19 minutes of waiting at the jobsite, both of which are non-value add tasks.

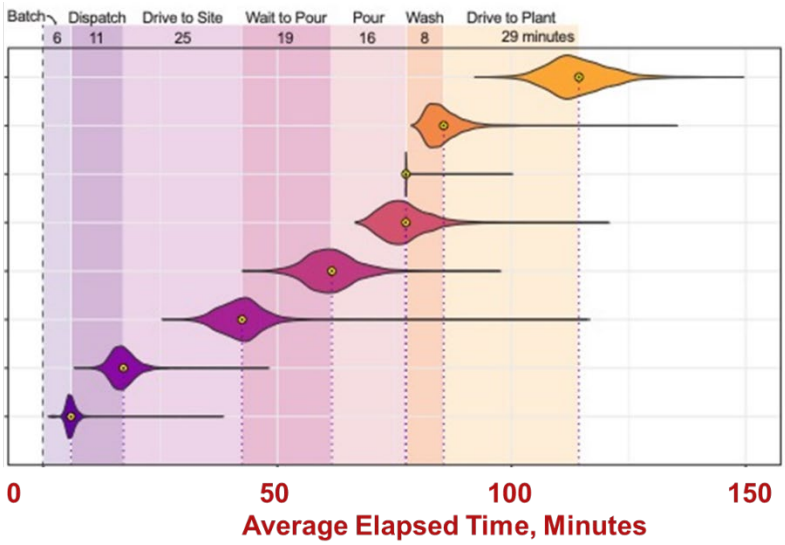

Figure 5 Components of average payload delivery in average elapsed minutes.

The results show there are significant opportunities to achieve higher levels of productivity. Beyond that, it was pertinent to explore through interviews, what other stakeholders were doing to address recruitment and retention challenges for CDPs, which is discussed in the following section.

Semi-Structured Interviews

Current Recruitment and Retention Strategies

During the semi-structured interviews, companies shared successful strategies for recruiting and retaining workers. On the recruitment side, many companies have improved their compensation and benefits policies and offer sign-on referral bonuses. Many companies attend high school career fairs and volunteer to present at local high schools about the ready mix industry and career opportunities. When they attend these events, some companies intentionally send both males and females to show potential recruits that the CDP role can be a job for any gender. It was also brought to attention that a key factor in appealing to active military members nearing retirement is advertising industry certifications. These types of credentials are valued in the service, where appointments depend on point systems that resemble certification processes. Additionally, some companies have developed internship programs (e.g., QC internships, part-time dispatcher) or other opportunities (e.g., dump truck driver options) to recruit younger workers. Mentor-driver programs, where drivers receive a mentor upon hire to help with their training and adjustment to the job, have also been successful in recruitment and retention.

"There is a very big difference between an active-duty member and a veteran, and there is a big difference between a veteran and a civilian. If it is your goal to recruit people from the military and you are talking to veterans, it's too late. You missed the opportunity. Active-duty members are planning in advance next steps."

Founding Director & President, Non-Profit Active Military Training Program, Spring 2023

Retention strategies include accrued paid time off, clean and safe work environments (e.g., improved driver lounges), and premium rates for night shifts. In some locations, companies have been able to close the business on Saturdays to allow for time off on the weekend or have experimented with rotation schedules to reduce the number of scheduled weekends. On the scheduling side, many companies have succeeded in increasing their part-time workforce to enable more flexibility in scheduling for their full-time workers. Examples of part-time workers who have been recruited successfully include retired CDPs, firefighters, school teachers, bus drivers, and airport bus drivers. Finally, financial basics courses have been implemented at several companies to help workers understand the financial implications of an off-season, particularly in areas with climates unsuitable for year-round concrete pouring. These strategies are summarized in Figure 6.

"The working environment has improved, but it is still not exciting in the eyes of kids coming out of high school. Their family members don't view this job as a great life style."

HR Director, RMC Company, Fall 2022

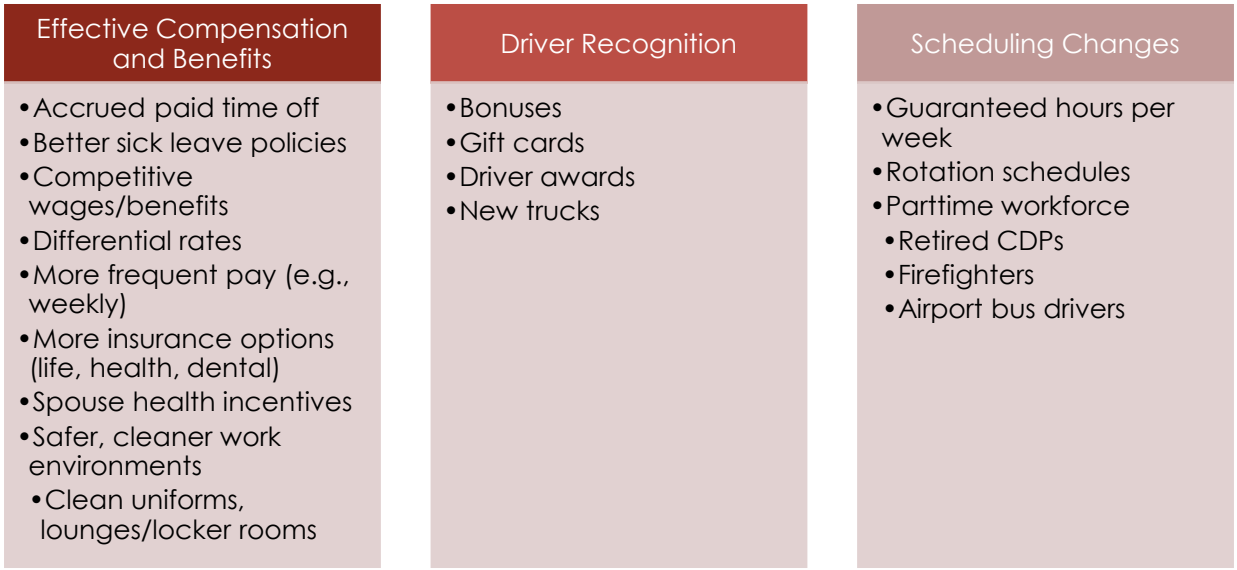

Figure 6 Existing retention and recruitment strategies used within the RMC industry discovered during the exploratory phase of the research project.

Technology Solutions

In addition to speaking with representatives from RMC companies, equipment manufacturers and technology companies were interviewed to learn how companies are innovating with technological solutions to improve the CDP experience. Increased technology adoption is also a strategy for attracting a younger workforce. One recommendation from companies across the board was that CDPs should be consulted on many of the solutions because the CDP can advance safety and efficiency.

Truck Technology

The tasks and responsibilities of CDPs are physically demanding, so it is quite easy to become fatigued and overworked within a short period of time. Therefore, truck manufacturers are utilizing emerging technologies that reduce driver fatigue and implementing ergonomic, safe solutions to make the equipment easier to use, safer, and more reliable. For example, there are control system sensors that recognize inclines or declines and automatically change the speed of the drum. Companies are also working to improve the ergonomics of the truck to make it easier to clean and easier to get in and out of the truck, especially for female drivers.

Many driver injuries occur from lifting steel chutes which are, on average, around 50 pounds. Companies have been working on designing hydraulic telescopic chutes so they do not have to be lifted and can be remotely operated. Most drivers enjoy these types of chutes because they are easy to retract and expand while pouring.

As the vehicles become more digital and incorporate more electronics, it is expected that CDPs will need new skills (e.g., programming) to operate the trucks. At the same time, some of the technological advancements can also alleviate some responsibilities of the CDP and improve the safety of the job.

Despite increasing levels of autonomous technology, most companies believe it is unlikely that there will be a ready mix truck entirely without a driver in the future. Some current autonomous features (e.g., lane assist and hydraulic steering) help improve the driver experience by helping alleviate fatigue.

Tablets and cameras are increasingly used in the cab of the truck to monitor safety and provide opportunities to digitize ticketing and mixture monitoring. However, many companies emphasized that there is a limit to what can be placed in the cab because it becomes a distraction for the drivers. Cloud-based software systems offer opportunities for integration of multiple technologies to help reduce the number of systems in the cab. While cloud-based has been successful in certain areas, it can often be a challenge for more remote or rural areas where the internet may not be as reliable.

Other truck and pouring technologies are taking advantage of the opportunity to improve repetitive processes and unsafe tasks with automation and sensor technology. Software technology enables automated testing of freshly mixed and hardened concrete. These technologies reduce the complexity of the CDP job because the CDPs do not have to measure the slump, air entrainment, or other quality control metrics. Software is also used for electronic ticketing, electronic proof of delivery, and to help with optimizing the dispatching process. While companies have shared that some CDPs have pushed back against these new technologies, it has been rare that a CDP has quit because of technology implementation.

> "Compared to other industries, there is not a lot of technology specifically developed for this industry. We have a lot of catching up to do."
>
> Operations Manager, RMC Company, Fall 2022

Training and Retention Technologies

In addition to truck and concrete specific technologies, many companies are also innovating in the recruitment, retention, and training space. For retention, technology systems have been developed to assess a person's fitness for duty. This has helped monitor alertness levels among workers, and in cases when the person performs poorly on a test, management may proactively intervene, thereby reducing the risks of accidents. Other recruitment and retention technologies include pay scheduling applications where workers are able to choose a more frequent payment schedule, which may help reduce financial stress for manual or technical workers. Scheduling applications are also becoming increasingly popular for many industries to involve

workers in the process. For example, bid-for-schedule applications allow workers to bid on specific shifts at certain rates depending on the demand for the shift.

Virtual reality (VR) and augmented reality (AR) technologies have gained popularity for training and on-the-job assistance across industries. In the RMC industry, VR systems have been proven to improve the safety of the job by simulating one of the most dangerous events – a rollover incident. VR can help train CDPs in many different scenarios. However, companies note that if it is safe enough to train a given exercise in person, the training should not be replaced with VR training. AR could be used on-the-job to aid CDPs with maintenance and troubleshooting. Both of these tools are recruitment and retainment tools for companies, and may be especially effective for younger workers that use these technologies for training in school.

Finally, gamification technologies are a retention tool that has been implemented in over 40% of Global Fortune 1000 companies with demonstrated improvements in job satisfaction, resulting in higher productivity and innovation [7]. Gamification allows companies to provide feedback on much more targeted performance enhancing behaviors and can track safety, concrete attendance, streaks, completed loads, and more. It has helped encourage positive behavior and performance in the RMC industry and retention rates are higher. The points that are earned in these systems can be used to redeem gift cards or items from companies like Amazon. While a challenge for companies can once again be in the initial investment, technology for gamification can reduce the engagement required by management to recognize workers and provide a fun way to interact with CDPs.

Productivity

Cameras installed inside and outside of the trucks are a tool that is widely used in the industry to improve safety. An additional benefit and motivation that was discovered during the interviews are the improvements in productivity that arises from the way in which the CDP receives direction from the laborer during various types of pours. When the trucks are not equipped with external cameras allowing drivers to visualize chute placement, there are more starting and stopping times that occur as a consequence of the verbal exchange between the CDP and laborer required to coordinate the placement of the concrete. More external cameras generally increase productivity as the truck stops operating less.

According to a pump manufacturer interviewed for the study, 30% more concrete placements could be done using concrete pumps. Unfortunately, market growth is limited by cost. Pumps are expensive equipment due to the sophisticated hydraulics needed in order to have a dynamic flow rate for wet concrete. Depending on their size and equipment, the rate output for concrete pump trucks can vary in amounts of concrete, from 40 to 260 cubic yards per hour on average [8]. Should pump technology decrease in upfront costs, indirectly increasing the number of pours that use a pump, this transition could create significant gains.

The team discovered a wide range of technological solutions, from existing to emerging, that could enhance productivity, recruitment, and retention in the industry after completing the interviews. The team built a ready mix operational simulation to evaluate the impact of these solutions and facilitate decision making.

Ready Mix Operational Simulation (RMOS)

The Ready Mix Operational Simulation (RMOS) is a representative case of a concrete plant used to understand the value of changes that affect productivity, recruitment, and retention.

Due to the closure of CDL schools during COVID-19 and competition from other industries that require similar skill sets, the industry struggles to find qualified CDPs to fill these open positions, causing significant revenue losses due to idle trucks.

The industry has identified several talent pools that are underrepresented as CDPs. As companies expand recruitment to consider candidates who do not have a CDL, intuitively, the CDP's profile for length to hire, time to train, and reach the same level as an experienced CDP will vary according to hiring type.

As such, the simulation considered three hiring types:

- A candidate without a CDL,
- A candidate with a CDL,
- And a candidate with a CDL and ready mix experience.

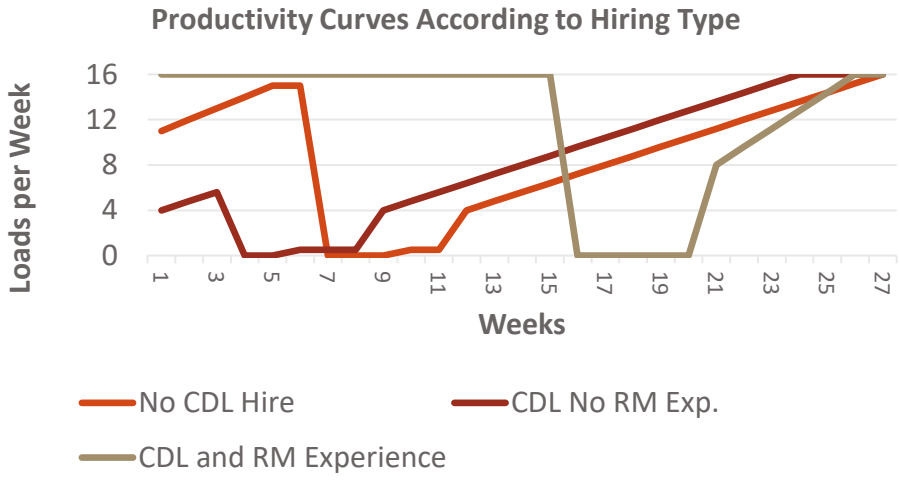

Figure 7 Productivity curves defined as loads delivered per week for each type of hire by the MIT CSHub plant.

Companies seeking to expand their recruitment pool are faced with considering the net financial benefits of hiring people with less experience. The analysis constructed to answer this research question began with a reference scenario which served as a

benchmark for comparison to what the value is of making changes that lead to increasing CDP productivity, recruitment pools, and retention rates.

Figure 8 presents the evolution of the reference case in terms of trucks operating (blue line) and loads delivered (orange line). In this scenario, in week one, there are 50 trucks available with five idle due to unfilled positions. The hiring rate is defined as the terms of hirable candidates per week per truck. In the reference scenario, the plant only hires those who have a CDL or a CDL plus ready mix experience, with 80% having a CDL at the time of the hiring event and 20% having both a CDL and ready mix experience. Holding all else constant, the business becomes unsustainable to operate as less loads for the plant can be delivered due to the increased time it takes to find qualified candidates and loads lost to training, overall leading to a gradual decline in the number of operating trucks.

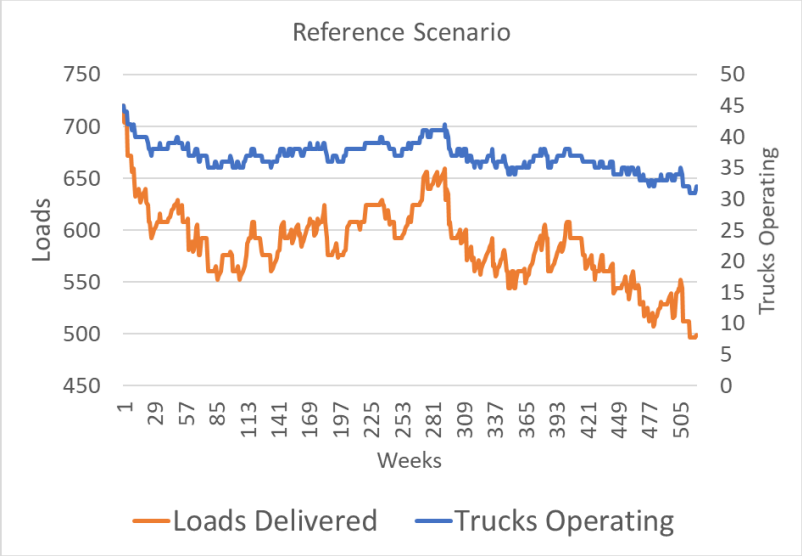

Figure 8. Reference scenario case for MIT CSHub Mixer Plant simulation showing loads delivered and trucks operating over ten years, holding the average hiring rate of 17 and prevalence of CDPs constant.

To normalize the gains from changes in recruitment, retention, and productivity, we divided the annual net revenue by the net gains attributable to these changes.

Figure 9 presents the estimated average annual direct and indirect cost of hiring 17 CDPs a year. According to results, training wages, compensation for the trainer ($500/trainee), HR costs, and job advertising collectively represent the majority of direct costs, which is estimated to be approximately $100,000 per year. The greatest cost to the business is foregone sales — loads not sold caused by idle trucks. Here, lost sales from idle trucks is almost eight times greater than direct costs. The second category for indirect cost is lost sales due to inexperience, as it takes time for those hires who did not have ready mix experience to increase their productivity until it matches a person who has at least one year's worth of experience. The cost of hiring is notable but dwarfed by the impact of foregone sales due to idle trucks. In light of this, even though the direct costs and lost

sales due to inexperience will increase as a result of hiring more CDPs, the lost sales from idle trucks decreases.

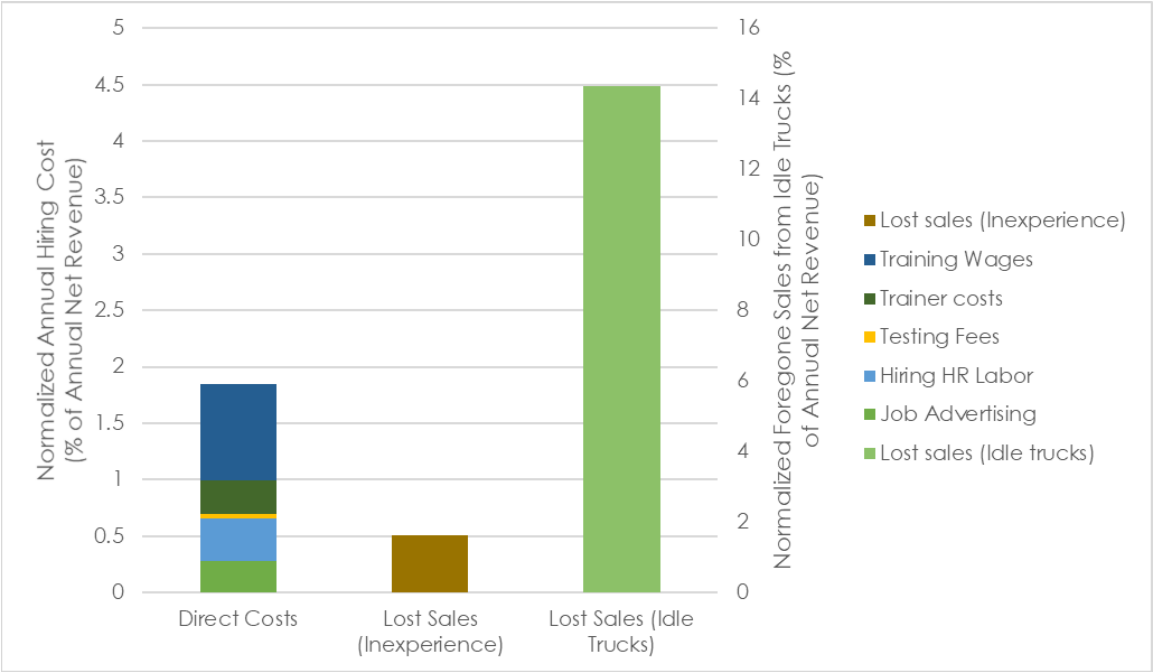

Figure 9 The estimated average normalized annual cost of hiring an average of 17 CDPs per year.

In the previous figure (see Figure 9), the costs presented were in relation to an average hiring rate of 17 CDPs per year. Figure 10 shows how those costs respond to changes in hiring rate. When the hiring rate increases by about 10% (19 from 17), direct costs climb by $26,000 (0.2%), while foregone revenue declines by $277,000 (7%). Clearly, increased hiring would provide significant financial returns. Even though those costs increased, they were offset by $277,000 gains in revenue from having two more trucks operating.

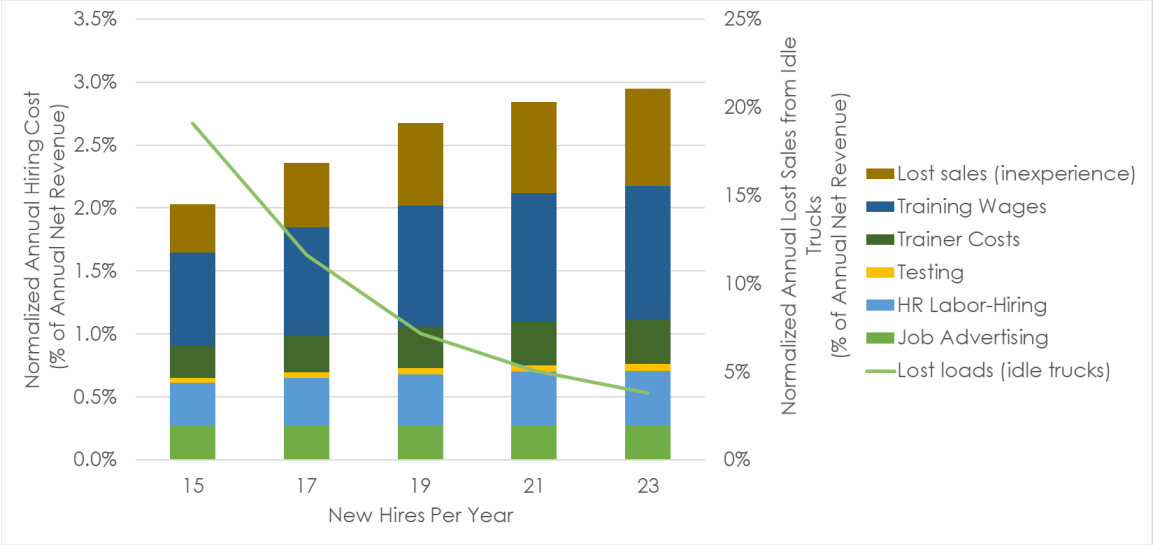

Figure 10 Direct and indirect costs associated with different CDP hiring rates per year at MIT CSHub Mixer Plant.

While the best scenario for the mixer plant is to have a greater hiring rate for those who have CDLs and ready mix experience, present market conditions and other circumstances make this an unlikely option for most ready mix producers. As a result of the recruitment pool of qualified drivers being too small, the question then becomes what are the gains when hiring drivers who do not have a CDL or ready mix experience.

To quantify the value of increasing CDP retention, we use the simulation model to explore the economic implications of increased average driver tenure. Specifically, *Figure 11* plots change in normalized net revenue in response to changes in new driver retention (plotted here are additional weeks that the average new driver is retained). The results show that every additional average week that a new CDP stays beyond six months (the current average tenure for new drivers) generates ~$35,000 of value per year. Furthermore, increasing new hire tenure by 2.5 months provides the same value as doubling the hiring rate. These results reveal that increasing retention leads to significant productivity gains and therefore significant value (see Figure *11*).

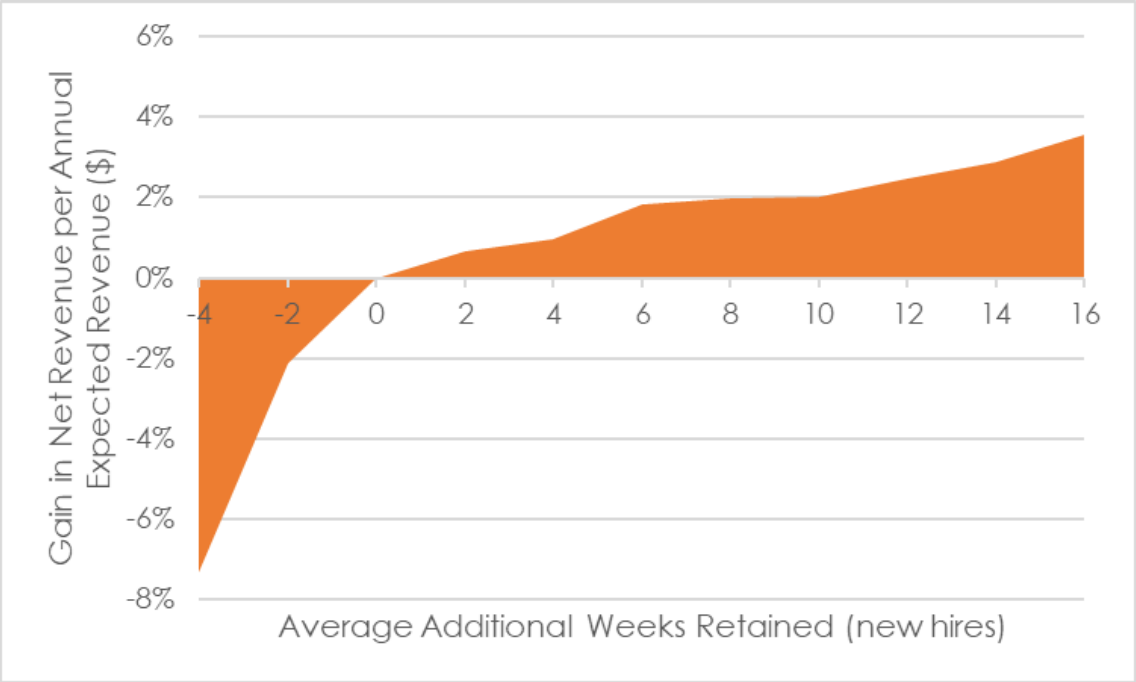

Figure 11 The net revenue gained from each average week that a newly hired CDP stayed longer than six months.

Quantifying the Economic Value of Investments Using RMOS

Changes that address productivity, recruitment, and retention will require investments of both capital and time. The ready mix operational simulation provides a powerful platform to explore the gains in net economic value from such investments.

To quantify the economic value of these different types of investments, the team performed sensitivity analyses, selecting five variables from the Ready Mix Operational Simulation: hiring rate (hires per year), average tenure for new hires (weeks), productivity for experienced CDPs (loads per day), training speed (weeks), and the percentage of concrete technicians used on new hire jobs to adjust in order to identify the normalized gain in net revenue (*Table 4*).

Changes to normalized net gains occur when there is a change from the baseline scenario to another state. The baseline scenario, which is presented in the first row, shows the average hiring rate at the plant is 17.5 CDPs per year, the average tenure for new hires is 26 weeks, and an experienced CDP delivers, on average, 3.2 loads per day. In addition, it takes six weeks to train a new hire, and the company does not have a concrete technician to support CDPs. As a plant makes technological or operational

investments to address productivity, recruitment, and retention, it is expected to affect the variables listed in *Table 4*.

Table 4 Variables from Ready Mix Operational Simulator used perform sensitivity analyses.

	Hiring Rate Per Year	Avg. Tenure for New Hires (Weeks)	Productivity (Loads per Day, Experienced CDP)	Training Speed (Weeks)	Technicians Used for New Hire Jobs
Baseline	17.5	26	3.2	6	0%
2	12.5	18	3.04	4.8	50%
3	15	22	3.28	3	100%
4	20	30	3.36		
5	25	34	3.52		
6	30	38	3.68		

The following section explores different scenarios modeling the impact of hypothetical technological or operational alternatives discovered during the interviews and from CDPs.

The Benefits of Reducing Non-Value Added Time

As the RM industry continues to battle the CDP shortage, technological solutions can help productivity. Examples include RM automated truck washers, hydraulic chutes, and concrete pumps. We can assume that the adoption of these technologies would increase CDP productivity, which was defined as the average loads of concrete per day delivered.

Figure 14 shows the additional normalized net revenue gains when CDP productivity increases from 3.2 loads per day (baseline) to 3.36 (5%) and 3.56 (10%). In a two-sample equal variance test, the cost difference between the 5% and 10% increase in productivity scenario and the baseline were found to be statistically significant ($p \leq 0.05$). Beyond 10%, the difference in total net revenue is no longer statistically significant because those trucks operated by experienced CDPs have reached their maximum capacity. According to the figure, it shows that there are significant gains when CDP productivity increases by 5%. Under this scenario, there is a 34% increase in normalized net revenue gains compared to when a CDP averaged 3.2 loads a day. This difference almost doubles to 71% when CDP productivity increase by 10%.

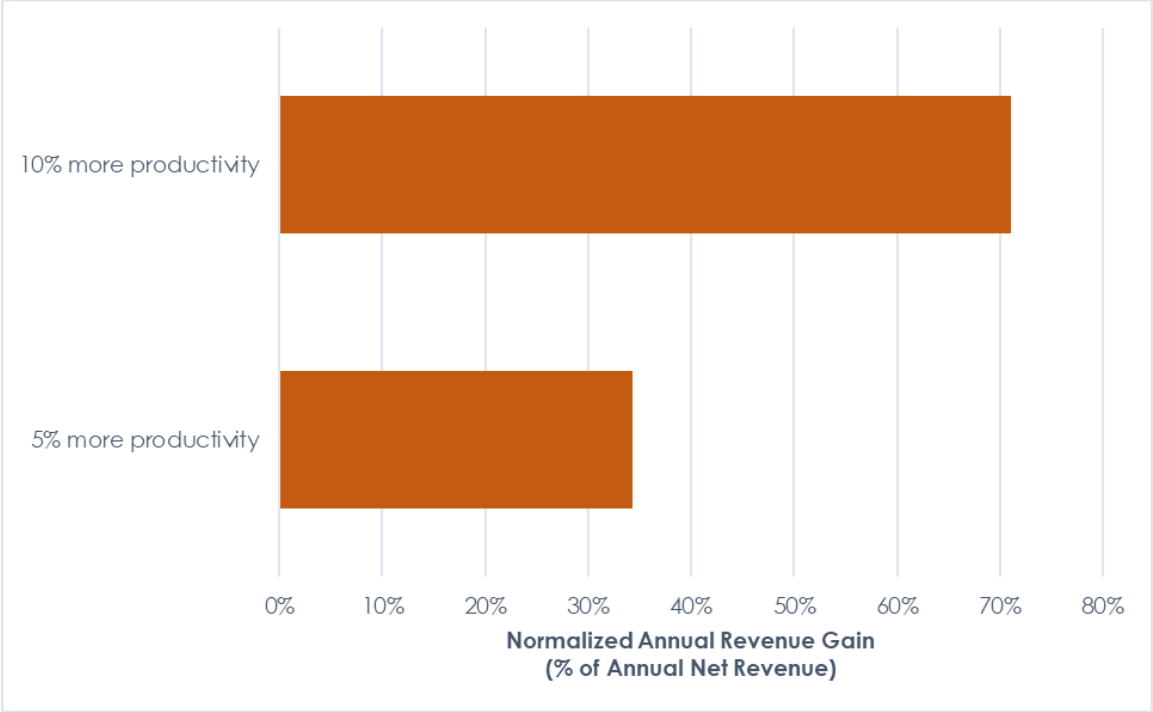

Figure 12 Total net revenue across different levels of productivity.

The following section uses an automated truck washer as a type of technology that could be adopted to improve productivity and retention.

Automated Truck Washer Example

According to productivity analysis, and shown in Figure 5, in between batching and driving to the job-site, a truck will be in the yard for 11 minutes on average. Based on the interviews and ride-alongs, this time is spent rinsing the truck, which involves driving it to a station where drivers manually rinse the truck with a hose. This involves climbing onto the exterior part of the truck and washing away the wet concrete residue. This poses a significant safety hazard for the CDP, as they could slip and fall or injure themselves with the hose. Moreover, this process is potentially costly for the RM company, as it increases the risk of accidents and liability. Furthermore, in colder climates, this task is very unpleasant for the CDP, as they have to endure the low temperatures coupled with the frigid water of the hose. This could lower their motivation and make them more likely to quit the job sooner.

The adoption of an automated truck washer eliminates the need for manual rinsing and reduces the time to only 60 seconds per truck. This enhances the efficiency, safety, and satisfaction of the CDPs, as well as the profitability of the RM company.

The team hypothesized that the adoption of an automated truck washer would enhance productivity (by 5%, 10%, or more) and increase retention rates for new hires. They subtracted the initial cost of $150,000 for the automated truck washer from the net gains that resulted from its use. Figure 15 shows the range of total net revenue under different scenarios. The results indicate that the benefits of improved productivity outweigh the

upfront investment of the automated truck washer. Moreover, these benefits could be even higher if the savings from reduced accidents and water consumption are taken into account, as these factors are not included in the analysis. After deducting the upfront investment cost of $150,000, there is still roughly $200,000 costs saving when increasing productivity (5% more and 10% more) and retention rates.

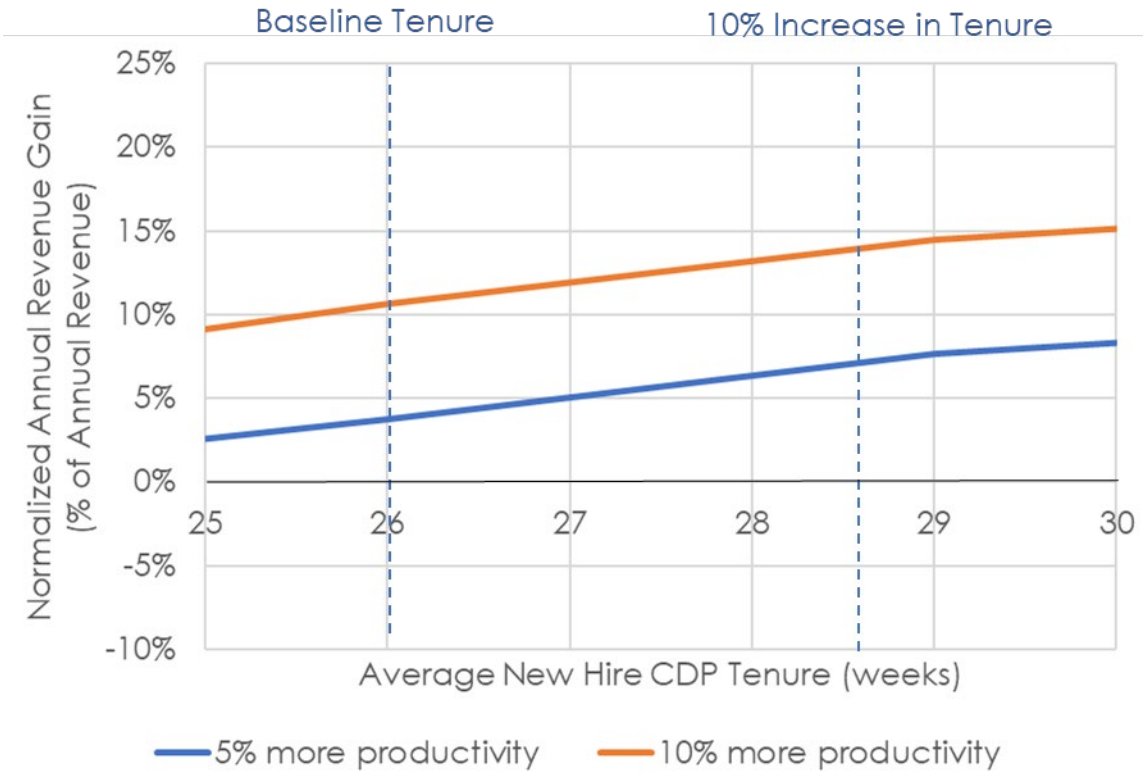

Figure 13 Effects on total net revenue under different productivity scenarios when training speed is increased and average retention is increased.

The Benefits from Efficient Training

Technologies such as virtual reality (VR), augmented reality (AR), and gamification are tools that could improve safety, enhance training, and increase worker productivity. A significant barrier for many companies is the upfront investment required for deploying these technologies within operations. However, in other industries, AR/VR has been shown to reduce training time, improve the quality of execution, and is less expensive compared to live training over time. Therefore, a sensitivity analysis was constructed to understand the cost implications of faster training time.

In Figure 12, the total net revenue was estimated under a baseline scenario for CDP training and for two scenarios where training time was decreased (20% faster training and 50% faster training). In a two-sample equal variance t-test, the cost difference between the 20% and 50% faster training scenario and the baseline were found to be statistically significant ($p \leq 0.05$). This suggests that improving the training time for CDPs

could result in cost savings that could help pay for the technology over time. In the 20% faster scenario, an additional ~$22,000 is saved in a year and in the 50% scenario, ~82,500 is saved in a year.

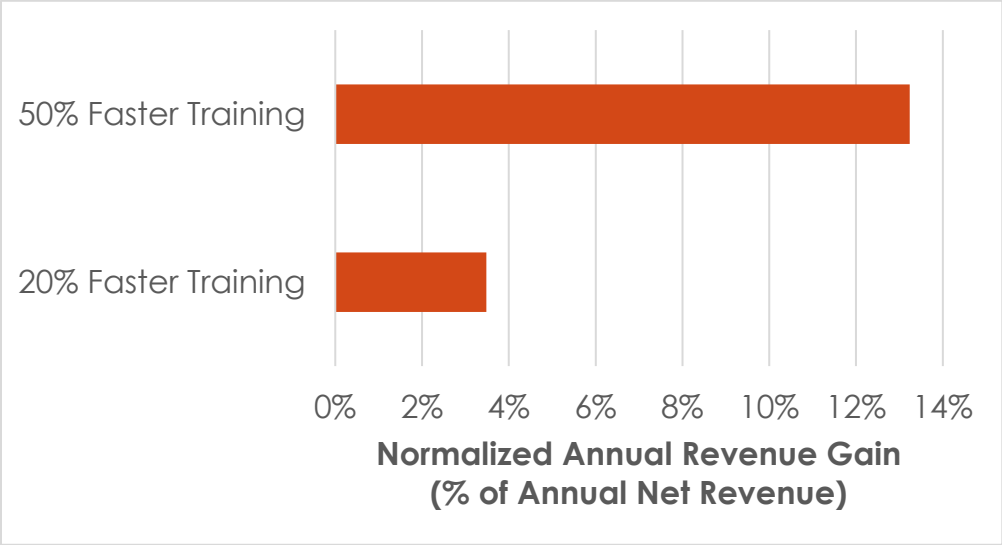

Figure 14 Effects on normalized net revenue gains from increasing training speed.

The Introduction of a Concrete Delivery Technician

Another strategy that could help improve training time as well as retention is the development of a new role—a concrete delivery technician. In interviews, stakeholders shared that first-year CDPs have difficulty with understanding concrete properties and interacting directly with the customer. The technician could play a supportive role to a CDP and could be responsible for these two areas of the job. This could help reduce the responsibilities and therefore the stress of a CDP, resulting in enhanced job satisfaction. The introduction of a new role will impact the typical delivery job structure and will increase costs for employing an additional person. However, there could also be cost benefits realized from less training required for the CDP and longer retention of CDPs from increased job satisfaction.

To test this hypothesis, a scenario was constructed to explore the cost implications. Additional costs were added to the model to account for the wage of the technician. Assuming that the technician would decrease the training and experience needed for CDPs, the number of weeks for training and ramp-up were decreased for each CDP level.

At several faster training and ramp-up times (baseline, 20% faster, 50% faster), the range of total net revenue was calculated for each technician option. The scenarios for technician use with a CDP are 0% of the time, 50% of the time, and 100% of the time. In the 50% of the time scenario, it is assumed that technicians would only accompany a CDP for specific jobs while the 100% scenario assumes they accompany a CDP for every delivery. The results demonstrate that faster training and ramp-up alone do not justify the introduction of a technician.

However, if the introduction of the technician role increases training and ramp-up speed while also increasing the average retention time of CDPs, this will result in cost savings. At less than a 10% increase in tenure from the baseline (Figure 13), both the 50% technician (orange) and 100% technician (grey) scenario result in an increase in total net revenue from the expected total net revenue. This result suggests that deployment of delivery technicians could help companies increase net revenue if the position enables longer retainment of CDPs and reduced training needed for CDPs.

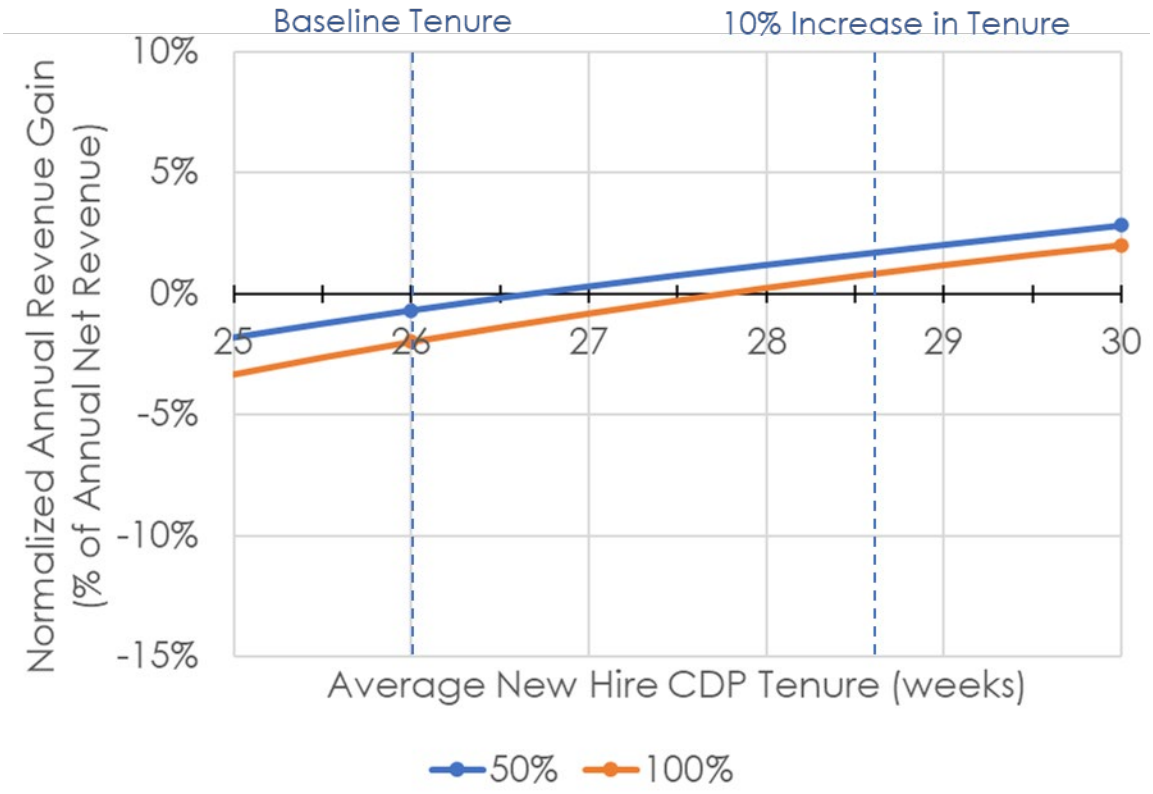

Figure 15 Effects on total net revenue compared to expected total net revenue under different technician scenarios when training speed is increased and average retention is increased.

CDP Responses to Job Satisfaction Survey

Learnings from the interviews described in the previous section were used to inform the construction of a job satisfaction survey for CDPs. The survey results are presented in four major sections. First, we detail demographic responses about the CDP and their company. Next, we present job satisfaction results and then job dissatisfaction results to highlight parts of the job that CDPs would like to change. Finally, we share results collected from other job positions at the plant – HR/operations, plant managers, and plant dispatchers.

CDP Survey Demographics

Question
Where is your company located?

There were 439 responses where the respondent completed 100% of the survey, with the highest number of respondents from the state of Illinois (>120). The locations for all respondents are shown in Figure 16.

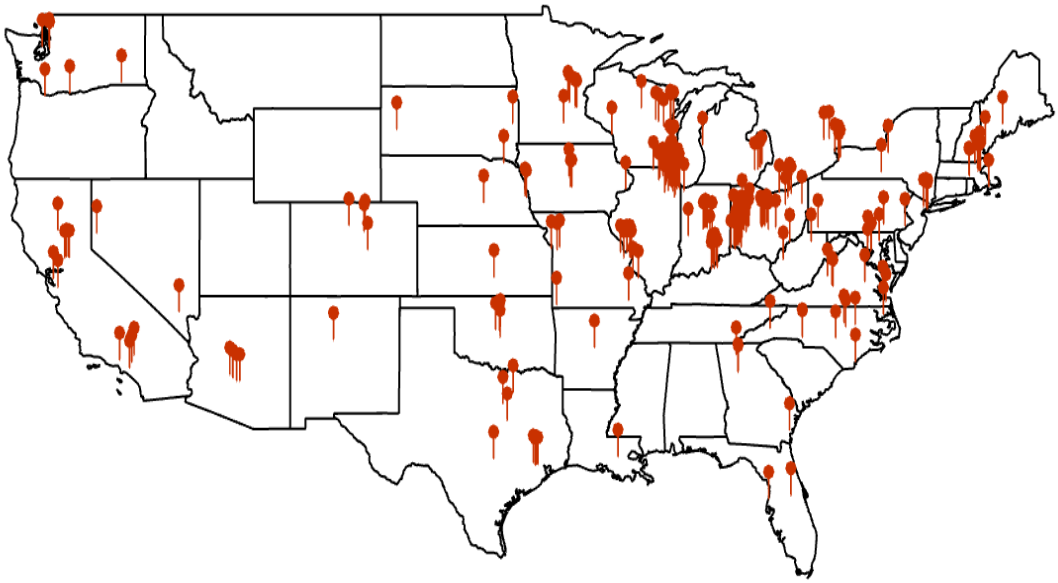

Figure 16 Geographic distribution of CDP job satisfaction survey responses with most respondents from IL, OH, and MO.

Question
How long have you been a CDP at your current *company?*

When asked about their tenure as a CDP, most CDPs that participated in the survey were with their company for 10 or more years with the next largest group representing newer drivers of less than two years of experience (Figure 7).

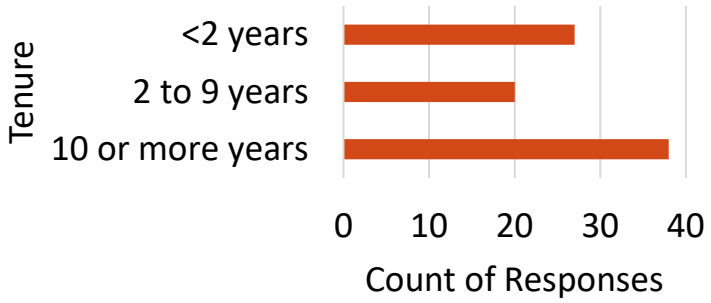

Figure 17 CDP participant results for the length of tenure as a CDP driver at their firm. A majority of drivers that participated and answered the tenure question had a tenure of 10 or more years.

Attitude Towards Job

Question
How do you feel about your job?

CDPs were then asked about their overall attitude towards their job role. Most respondents shared that they like or love (n=371) their job (Figure 18). The responses for like it or love it were evenly distributed between levels of tenure. This echoes the findings of the NRMCA driver survey in which most CDPs take pride in their job and building their communities. However, there were still some responses where CDPs shared that they don't like or hate their job (n = 63).

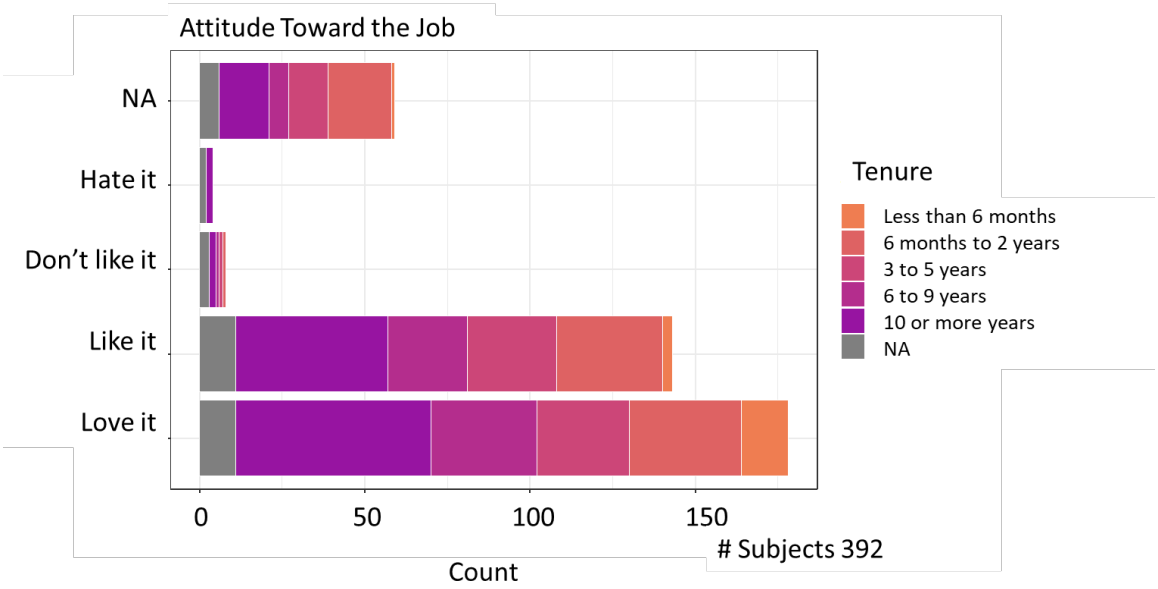

Figure 18 Level of job satisfaction indicated by CDP respondents where most shared that they like or love their job. A response of "NA" (grey) indicates that the person did not answer the tenure question but did answer the satisfaction question.

CDP Career Pathway

Question

Why did you become a CDP?

The respondents were asked why they decided to become a CDP (Figure 19). Most CDPs highlighted the competitive hourly pay, proximity to home, and the significant variation in daily tasks. Once again, the responses were evenly distributed between tenure levels.

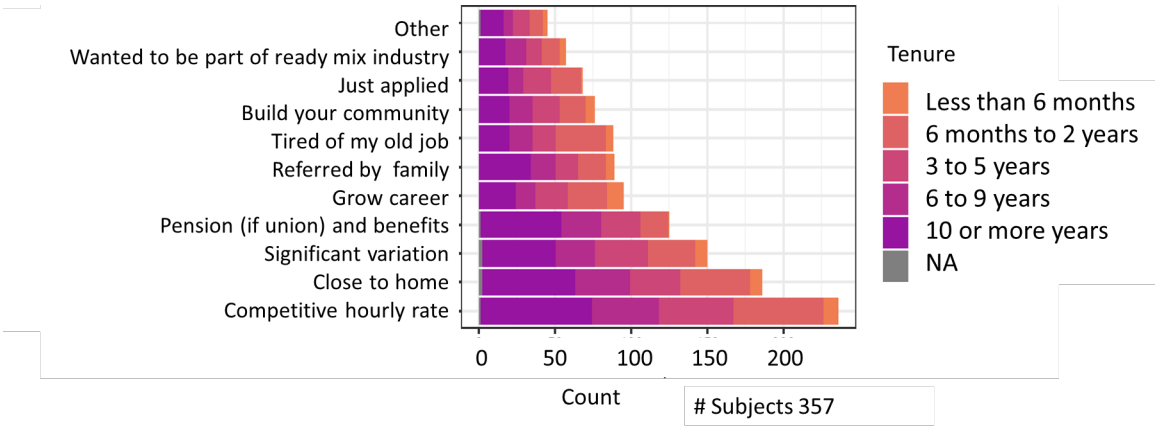

Figure 19 CDP respondents shared that they became a CDP for the competitive hourly rate, proximity to home, and significant variation in daily tasks.

Question

Which of the following careers would you consider?

Many CDPs shared they would be interested in career pathways within the industry. Specifically, many would be interested in a batch plant production manager position down the line. As a part of check-ins with CDPs, sharing information about other careers and showing a career map could help retain workers longer term. However, many CDPs do not view this as a current possibility and one CDP even shared, "if you have a CDL you never get out of a truck. You are struck there." It is important for companies to show that there are opportunities to move up if that is of interest to the CDP.

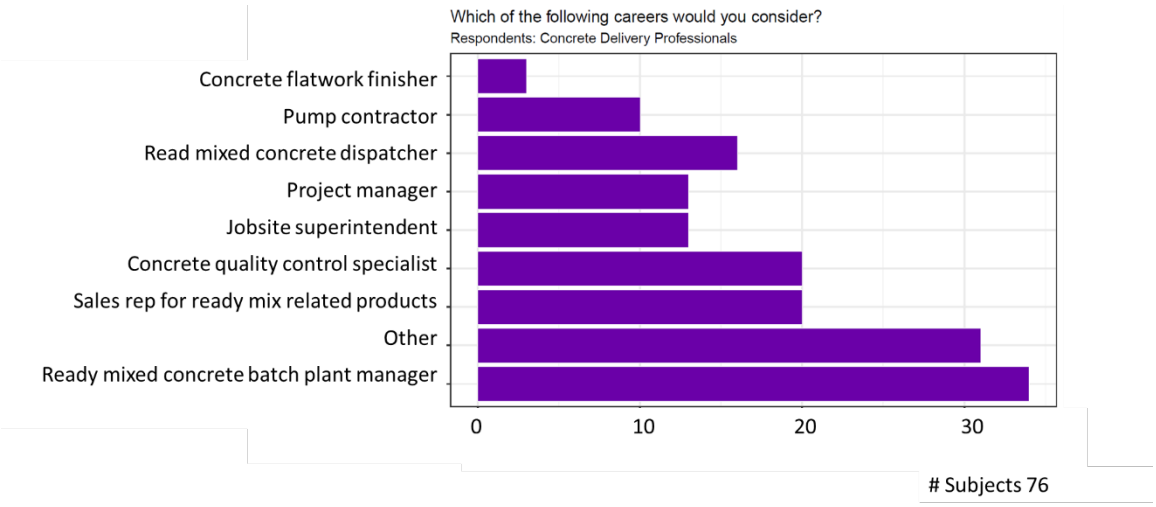

Figure 20 Many CDPs would consider careers beyond a CDP if offered the opportunity. Many shared they would consider a batch plant production manager, sales representative position, or quality control specialist.

First Year Challenges

CDP Response

Question
What are the most difficult tasks for first year CDPs?

To understand the most difficult parts of the job for CDPs in their first year, respondents were asked to rank everyday CDP tasks and note which tasks are hardest for new hires in their first year. The hardest task for first years was said to be learning and understanding the properties of concrete (Figure 21), suggesting that more training time in this area could help improve the first-year experience. Other challenges include placing concrete for challenging types of pours, interacting with contractors at jobsites, and driving and operating the truck off-road. A possible operational solution for this challenge is to create a new role of a concrete delivery technician, as mentioned in previous sections. This role would be responsible for being the concrete expert and liaising with contractors at the jobsite. Playing a supportive role, the concrete delivery technician enables the new hire to focus on other tasks, thereby reducing their stress and enhancing their job satisfaction and retention. Another benefit of creating a concrete delivery technician role is that it expands the career opportunities and pathways for the employees, which to date has been a major focus of the RMC industry.

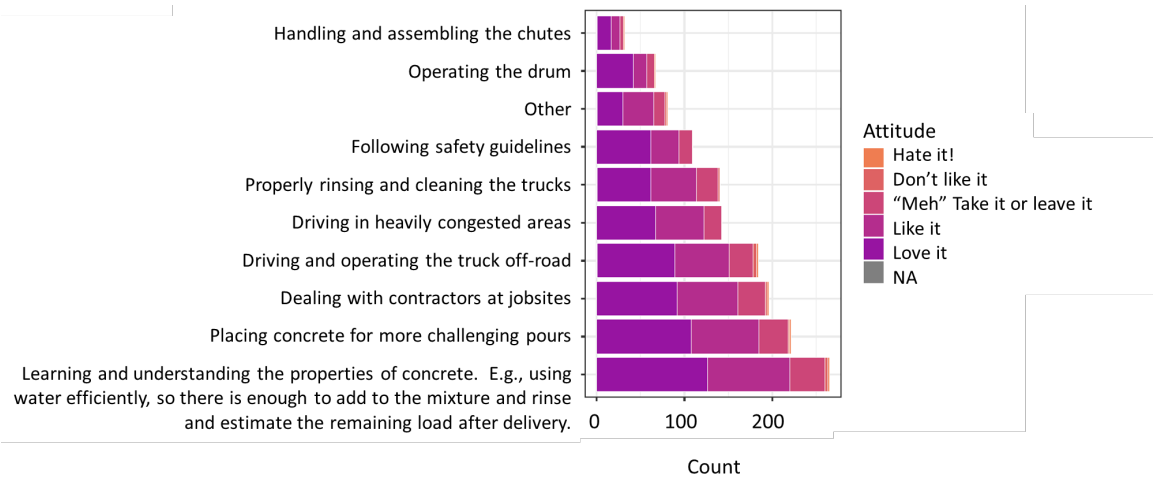

Figure 21 The most challenging tasks for first year CDPs ranked from the least challenging (top) to the most challenging (bottom).

Non-CDP Responses

Question
In your opinion, what are the most difficult tasks/job features for first year drivers?

When asked to rank the most difficult tasks for first year CDPs, the managers ranked learning and understanding the properties of concrete, inconsistent schedule, and dealing with contractors as the top three hardest tasks. Two of these were also ranked as the most difficult parts of the job by CDPs – properties of concrete and dealing with contractors. These results suggest that additional training and time on these tasks would be useful for new CDPs and could help to retain these workers longer.

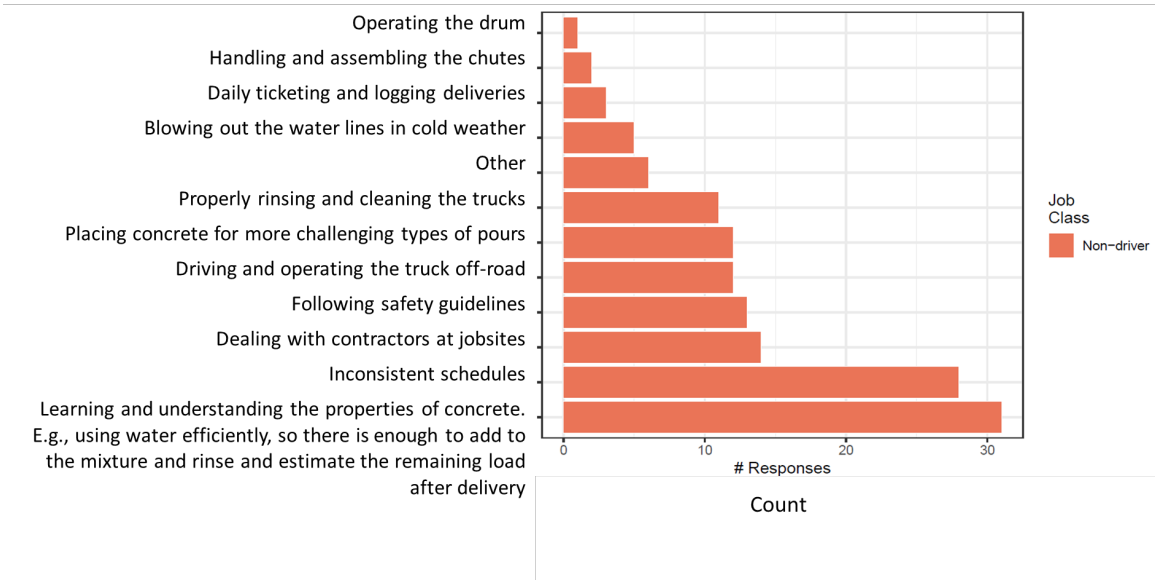

Figure 22 The management roles ranked the most difficult tasks for first year CDPs. Learning and understanding the properties of concrete ranked as the most difficult by both the manager and CDP respondents.

CDP Job Satisfaction

Question
From this list, select five things that contribute the most to your job satisfaction.

For those who like or love their job, the respondents were asked to choose the job attributes that contribute the most to their satisfaction (Figure 23). The top three attributes that CDPs enjoy the most include operating the truck, interacting with contractors on jobsites, and the diversity of job types. This type of information can be used to ensure that the parts of the job that CDPs enjoy the most are emphasized as often as possible. For example, companies can try and diversify the types of jobs assigned for each CDP on a weekly basis to increase the opportunities for them to work on a variety of sites and pours.

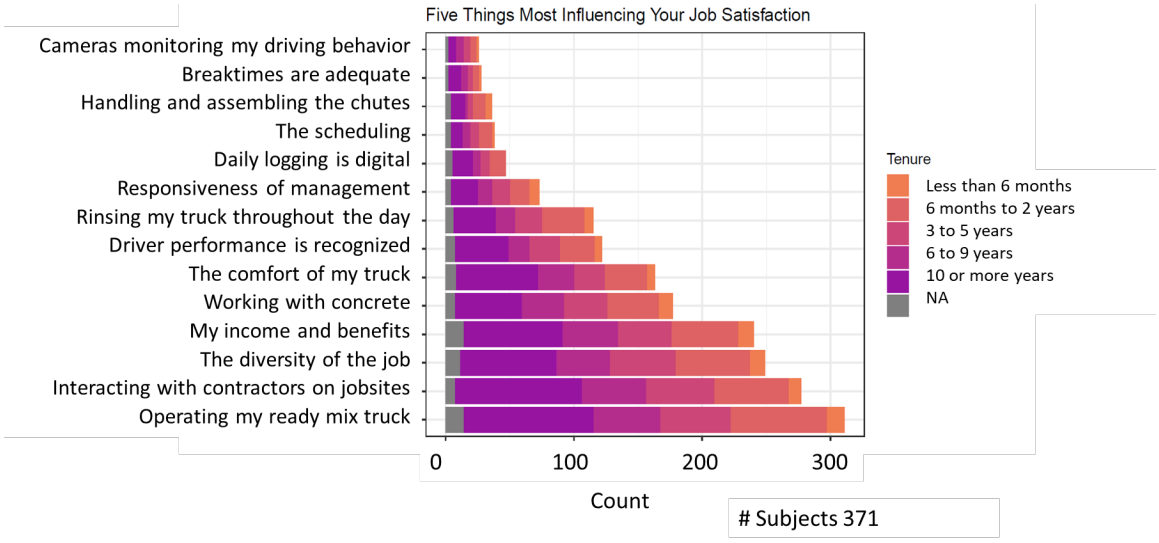

Figure 23 CDPs who like or love their job ranked the source of their job satisfaction with operating the truck as their favorite part of the job.

Question
Select the reasons why you are satisfied with your schedule. Select all that apply.

Inconsistent scheduling for CDPs is a major factor that influences retention rates. Those CDPs who enjoy the existing CDP schedule tend to be more senior drivers who have increased flexibility compared to newer drivers. Other scheduling strategies that CDPs like include schedule rotation, a fixed set of hours, and CDP involvement in selection of start and stop times (Figure 24).

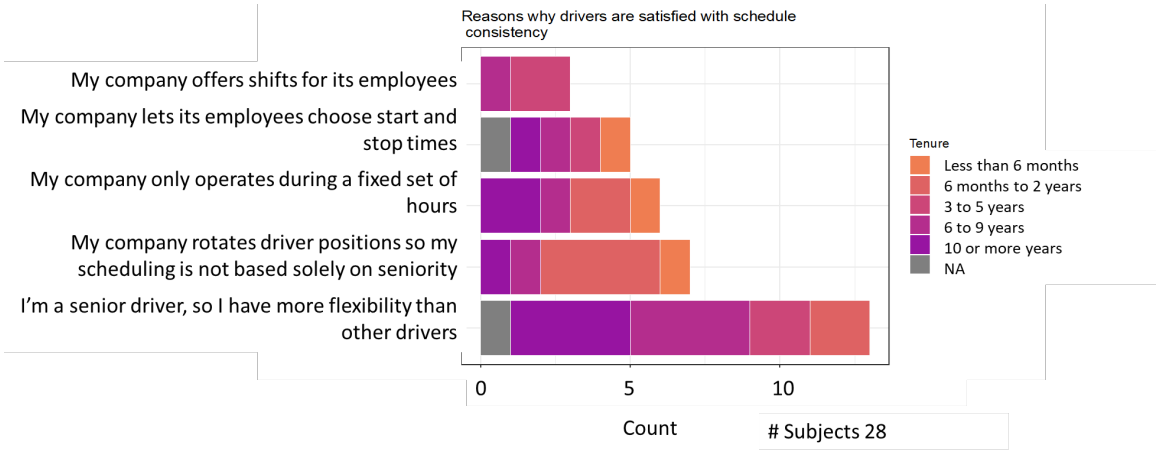

Figure 24 For CDPs who like or love their job, some CDPs enjoy the existing schedule due to flexibility from driver seniority, rotational schedules, fixed set of hours, and CDP involvement in choosing start and stop times.

Question
Select the ways that your company recognizes driver performance. Select all that apply.

When asked how their company currently recognizes performance, CDPs who like or love their job shared that they are recognized with bonuses, newer trucks, and/or generous recognition and praise (Figure 25). Other strategies for recognition that the CDPs shared included:

- "Lunches, profit sharing, hats, shirts, etc."
- "Posts performance on board for all drivers to see"
- "Yard manager will say Good Job"
- "All around they make sure drivers are part of their plan"
- "It's nice when both management and customers compliment me on my truck"
- "We get gift cards every year, they maintain our trucks very well"

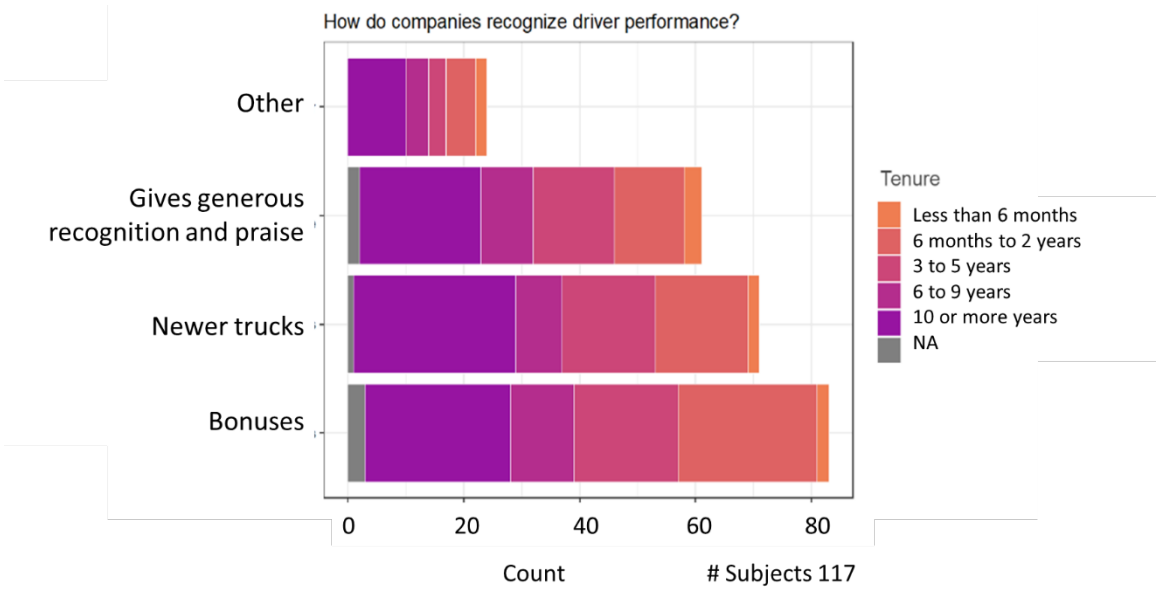

Figure 25 highlights ways that companies currently recognize CDPs for performance.

CDP Job Dissatisfaction

Question
Select five things that contribute the least to your job satisfaction.

For those who reported disliking or hating their job, the respondents were asked to choose the job attributes that contribute the least to their satisfaction (Figure 26). The top attributes that contribute the least to CDP satisfaction include the inconsistent schedules, lack of adequate breaktimes, responsiveness of management, and lack of performance recognition. These results highlight areas that companies should focus on to increase satisfaction and therefore retention of CDPs.

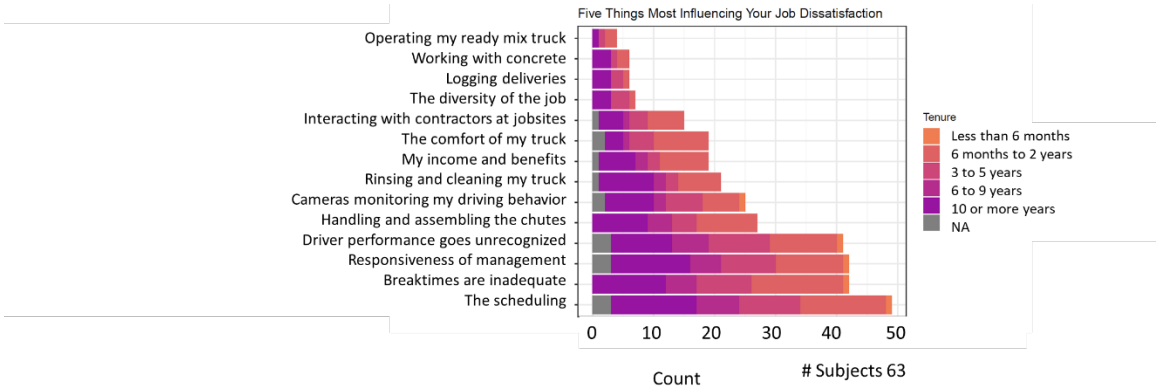

Figure 26 CDPs who dislike or hate their job ranked the highest source of their job dissatisfaction as the inconsistent scheduling.

Question
How much would your job satisfaction increase if you had more control over determining your daily start and stop times?

For those who reported disliking or hating their job, the respondents were asked if having more involvement in the scheduling process would increase their job satisfaction. Most CDPs indicated that this would significantly improve their job satisfaction. These results highlight the importance of introducing novel scheduling solutions to help improve satisfaction and therefore retention of workers.

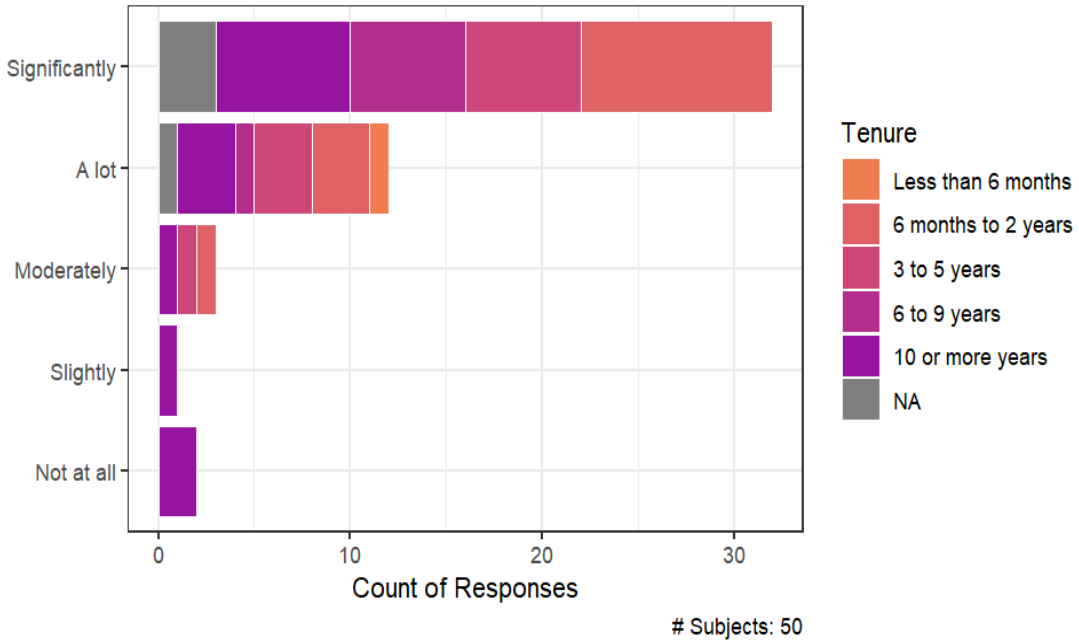

Figure 27 CDPs who dislike or hate their job shared that having more control over their schedule would significantly improve their job satisfaction. For those who did not feel it would improve their job, they have a tenure of 10 or more years and therefore are likely used to the invariable schedule.

Question

How much would your job satisfaction increase if management was responsive to your input?

One of the drivers of dissatisfaction for CDPs was the responsiveness level of management. Many CDPs shared that if management was more responsive, their satisfaction would improve a lot. These results suggest that more communication opportunities are needed between management and CDPs to ensure that CDPs are heard.

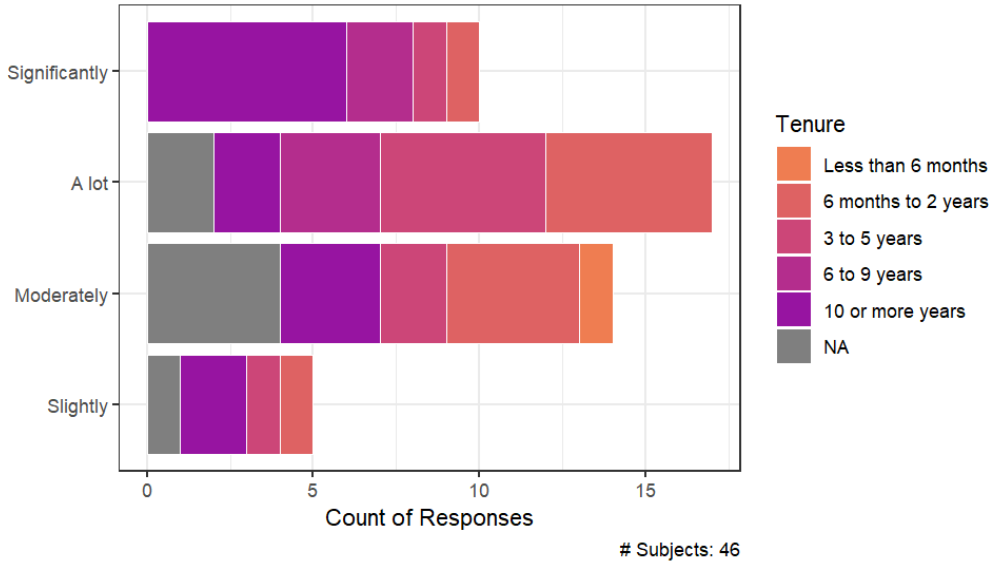

Figure 28 CDP job satisfaction would increase if management was more responsive. Many CDPs with 10 or more years felt this would significantly improve their satisfaction.

Question
How much would your job satisfaction increase if management routinely recognized drivers' performance, safety, and teamwork?

Similarly to the results for management responsiveness, CDPs that reported disliking or hating their job felt that their satisfaction would improve a lot or significantly if there was recognition of performance, safety, and teamwork more regularly. These results suggest that the current recognition structure does not happen often enough and therefore companies should seek to reward CDPs several times throughout the year for their performance, safety, and teamwork.

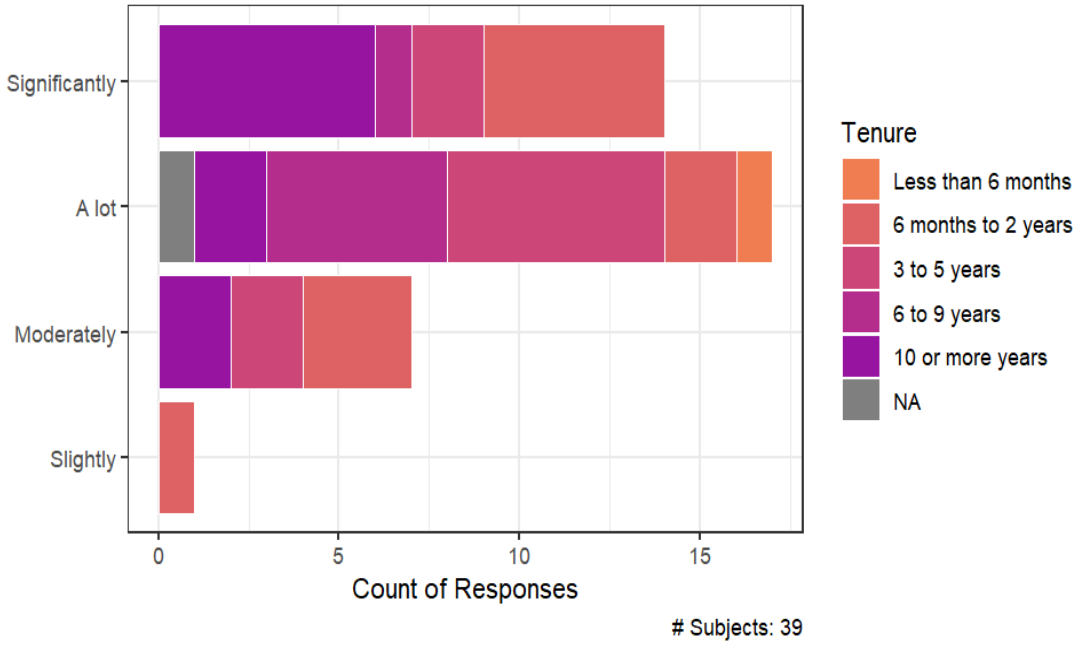

Figure 29 CDPs indicated that their satisfaction would increase a lot or significantly if they were more routinely recognized for their performance, safety, and teamwork.

Non-CDP Response to Scheduling

In addition to collecting responses from CDPs, we also were able to capture responses from other workers at RMC companies that decided to participate in the survey. These included plant managers, plant dispatchers, and human resources coordinators.

Question
If a driver had a 'rough' scheduling week, what actions are taken at your company to acknowledge and improve the person's job satisfaction for the following week?

When asked if actions are taken at the company when a CDP has a 'rough' scheduling week, most indicated that they may inform the CDP that they know it was a rough week, but many shared they do not intervene at all. For those that do intervene, they shared that they try to spread the late loads out among drivers if possible or make sure that drivers that had early times one week get later times the following week. All in all, there are opportunities for management to intervene when CDPs have a 'rough' scheduling week, especially since this is the number one reason that most CDPs are dissatisfied.

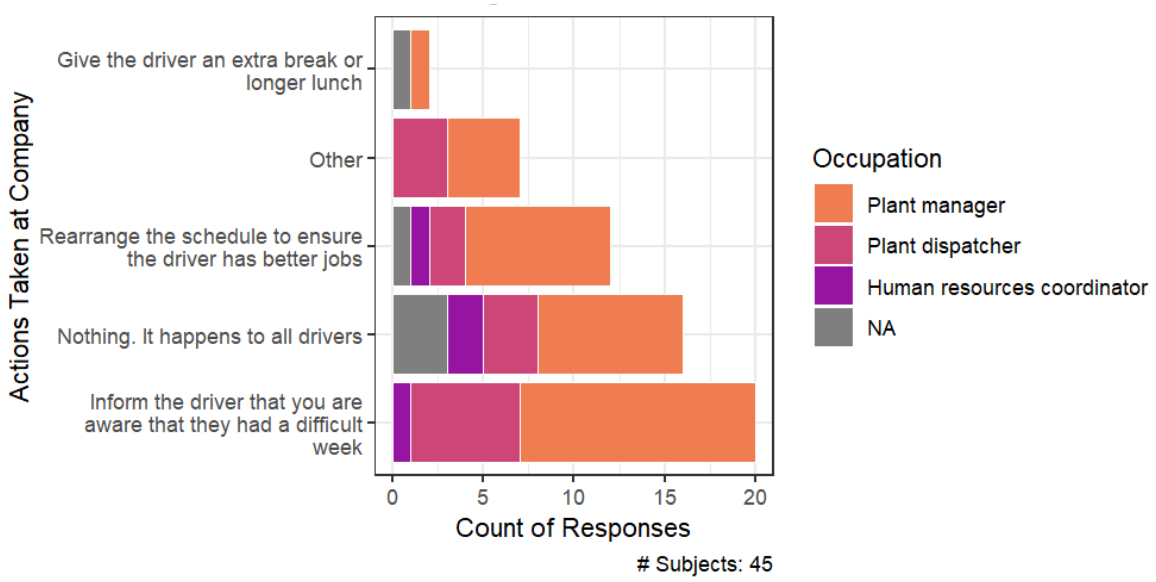

Figure 30 Managers shared that when a CDP has a rough scheduling week, some may acknowledge that they had a difficult week, but many do not intervene at all.

In concluding this part of the results, the CDP survey revealed the key results that highlight the significance of training, the necessity of positive managerial-employee relationships, and the demand for more scheduling flexibility. These are the main areas to focus on when implementing new solutions. Before introducing new solutions, it is essential to identify and address the possible obstacles that could hinder their effectiveness. Therefore, the MIT CSHub hosted a workshop to present ideas to key industry stakeholders. Results from that event are discussed in the following section.

CDP Workshop Findings

A fourth layer of this multidimensional study was to form a large audience of high-profile industry leaders and 1) present key findings from the survey and 2) propose technological and operational solutions carefully selected for their ability to enhance productivity and diminish daily frustration for our invaluable CDPs.

Over the two days, the workshop attendees were presented with a diverse array of proposed solutions organized by the following themes:

1. Emerging technological solutions capable of improving comfort, training, and productivity
2. Data feedback systems used to improve internal communication patterns
3. Collective industry actions required to alleviate challenges around recruitment and mapping career pathways
4. Tactically crafted alternative operational approaches designed to recruit groups with varying demographic characteristics

After the panelists' presentation of various solutions, the group was tasked with providing a comprehensive list of potential impediments that may hinder the implementation of the proposed measures.

Collectively, the audience saw the attractiveness of the potential benefits of using augmented reality and virtual reality as platforms to improve training and safety. The primary concern raised by the stakeholders regarding the adoption of the technology was centered on the associated expenses and the anticipated return on investment. Moreover, the apprehension about the cost and return on investment was also linked to gamification platforms.

These participants also emphasized that another important source of inefficiencies derives from last-minute changes in customer orders. To accommodate possible last-minute additions to the schedule, plants may over staff only to find out that cancelations exceed orders. This situation leads to underutilized drivers and presents the need to manage customer ordering to improve operational productivity.

Beyond the need for more detailed economic analyses, the group reiterated the importance of career mobility for CDPs. Comments and survey responses showed that CDPs have the desire to advance to other careers but feel "stuck." Due to the shortage of CDPs, this may inhibit mobility within the company, because managers must prioritize the delivery of loads to customers rather than consider other opportunities for CDPs.

A final point brought forward was that in addition to these technological solutions, it is crucial to have a compassionate manager at the helm who considers their employees to be their greatest asset [9].

By the end of the workshop, the compilation of results from the productivity analysis, stakeholder interviews, ready mix operational simulation, and CDP survey provided a clear understanding of where the greatest opportunities are to introduce transformative

technological and operational solutions. The following sections discuss these recommendations in detail.

Recommendations

The CDP shortage shows no signs of abating. The American Trucking Association forecasts that the overall driver shortage could surpass 160,000 by 2030 [10]. The lack of truck drivers is projected to persist for the next ten years. Hence, it is vital that the RMC industry embraces transformative technology and operational models to alleviate this pressure and increase individual CDP productivity.

The following recommendations address the challenges of productivity, recruitment, and retention. We have identified recommendations that are interrelated and can be applied to one, two, or all three of these challenges.

We also acknowledge that these recommendations vary in terms of effort, investment, and time required for implementation, and some of the solutions may require continuous maintenance. Therefore, the RMC industry must collectively strategize and determine the best roadmap and priorities for these solutions.

Productivity

Modeling results underscore the significant opportunity to increase CDP productivity, demonstrating that it is just as crucial as implementing transformative recruitment and retention strategies. Productivity gains – measured as payloads delivered per shift -- can arise from various changes. Two important strategies to improve productivity are adopting automation technologies, which reduce the time required per delivery, and adopting data analytics (e.g. predictive models to estimate customer orders) which increase system-wide productivity by aligning driver availability with customer demand. The subsequent sections expand upon these topics in more depth.

Adopt Technology to Increase CDP Productivity

Adopting more automated technology and processes can enhance productivity by streamlining the CDP workflow, decreasing time needed per task, and reducing errors and non-value-added time. Several technologies are already available to realize these benefits within concrete delivery operations. The two that were mentioned most often during stakeholder interviews were automated truck washing and hydraulic chutes. Automation can also reduce the risk of accidents that occur when performing tasks. For example, advanced driver assist in truck steering reduces both accidents and fatigue that arises from continuous all-day maneuvering.

As an added benefit, automated technologies can help expand the CDP candidate pool by reshaping the skill requirements for workers. In manufacturing, repetitive, manual tasks are being replaced by automation, enabling workers to leverage their existing skill sets or develop new ones [11] [12]. These technologies can also lower the physical

requirements of the job. In turn, this can attract more female applicants and extends the working years of older employees.

Autonomous Ready Mix Trucks

There are various levels of autonomous driving from Level 0 (manual control) to Level 5 (fully autonomous without a human driver). If autonomous concrete mixer trucks were adopted, it could transform the role of the concrete deliver professional. However, while there are currently "moments of autonomy" emerging the trucking world – such as cruise control or lane assist, based on input collected during stakeholder interviews and from presentation at the workshop, fully-autonomous concrete mixer trucks operating at scale are not expected this decade. Deployment of autonomous vehicles faces real challenges beyond the technology including policy, consumer apprehension, and union resistance.

New technologies are also emerging that could be adopted by the ready mix industry to increase productivity. Two promising technologies are virtual reality (VR) and augmented reality (AR). While VR technology operates in a completely virtual environment, AR is a technology that enhances the real world with computer-generated content, such as images, sounds, or texts. AR has been applied in industries such as manufacturing to improve efficiency and widen the talent pool, as it can provide guidance and assistance to the workers [13]. The advantage of AR is that it can optimize the sequence of activities and eliminate unnecessary micro-actions, leading to productivity gains. When applied to the trucking industry, Morgan et al. (2011) found that when a person used a simulator for training, they spent 40% less time on training than a person who learned the same skills in a truck [14].

Manage Customer Demand to Improve Operational Productivity

During the stakeholder interviews and the workshop, it was discovered that another important source of inefficiencies derives from last-minute changes in customer orders. To accommodate possible last-minute additions to the schedule, plants may overstaff only to find out that cancelations exceed orders. This common situation leads to underutilized drivers. Managing or at least better understanding demand presents an opportunity to reduce this source of productivity loss.

Demand side management is a way to directly or indirectly influence customer ordering [15], which is commonly applied in other markets such as retail [16] and energy markets [17]. The idea is to better understand the magnitude and timing of demand and, if desired, use pricing or other forms of penalty or benefit to change that pattern. An RMC could borrow similar approaches and build predictive models to forecast the demand and timing of orders. This would allow plant operators to make informed decisions on when and how many drivers are needed on duty. Based on this information, a surge pricing mechanism (or even lull pricing discount) could even be developed and applied to encourage customer demand to align with driver availability.

Both changes to hardware and available information can allow significant gains in productivity, but this is not the only lever to reduce driver shortages. The research team

identified several strategies that can lead to recruitment and retention gains. The easiest place to start is to change the perception of the job.

Recruitment

Change the Perception of the Job

Concrete Delivery Professionals (CDPs) perform a multifaceted role that extends beyond merely driving trucks. They engage with customers, skillfully maneuver heavy vehicles across diverse terrains, and perform physically demanding tasks throughout the day. They must also have fundamental knowledge of concrete. When asked in the CDP survey, "Do you consider yourself a skilled operator or truck driver?" 84% reported that they identified as being skilled operators.

To enhance the perception of this occupation, all industry stakeholders should collectively adopt the term "concrete delivery professional" in their marketing and recruitment efforts. Just as the manufacturing sector grapples with branding challenges related to being perceived as dull, dark, and dirty, embracing advanced technology can act as a catalyst for changing perceptions, along with leading to improvements in productivity, recruitment, and retention.

While technology can be adopted to improve CDP productivity, it can also help address the most challenging aspects of the job, especially for first year drivers. As shown in Figure 21 in the survey results, learning properties of concrete, placing concrete for more challenging pours, dealing with contractors, and driving off-road were the most challenging activities for first year CDPs. As was described above, technologies such as automation and VR/AR can improve driver experience with these tasks and aid in the perception of the job. VR can accelerate learning and improve knowledge retention from training. As such, VR should improve driver knowledge of concrete and could even be used to simulate challenging pours and driver conditions. In addition to training, it is possible to improve driver experience in the field by providing the new driver with context specific information. AR is well-suited to this task; it could be used to provide information and coaching tips for placement, driving, and even customer interactions. In the near term, these same benefits could be realized by providing new drivers with an in person technical resource – see section on Concrete Delivery Technician.

Our research also revealed that job variety is a significant source of job satisfaction. Notably, many CDPs cited the significant variation in daily tasks as the primary reason for choosing this profession, and those who liked or loved their job attributed that satisfaction to the diversity inherent in their job responsibilities (see Figure 19 and Figure 23). Daily job variety should be emphasized when attracting new recruits.

In examining how it could improve worker perception of the CDP role, the industry should come together to invest in and develop both VR and AR solutions. These would improve training and worker experience. In the meantime, the industry should explore the development of a concrete technician role (see later section). Finally, the industry should collectively promote the inherent variety of day-to-day work as a CDP.

Define Standardized Skill Set for CDPs and Other Concrete Plant Positions

Workers today often prefer jobs with opportunities with career flexibility. That is, workers want to have the option to pursue other types of positions within their industry (and to some degree within other industries). This has been shown to be true even for construction workers [18]. The nature of ready mix operations makes this challenging. Nevertheless, the industry could come together to characterize the skills associated with the CDP and for other positions at a concrete producing plant. This action defines overlap and increases transparency for CDPs to recognize how their skill levels translate into other careers, promoting professional development. It also creates a clear career pathway for CDPs who want to advance within the industry or transition to other sectors. This formalization of skills has been shown to be a key first step to clarifying career pathways to workers [19].

The industry should also consider formalizing the definition of the concrete delivery professional within the federal system for tracking occupations. The O*NET-Standard Occupational Classification (SOC) taxonomy, which reflects the spectrum of occupations in the world of work is maintained by the U.S. Department of Labor [20]. The database is updated regularly to capture the evolving occupational landscape [20]. Ongoing surveys of workers and experts in each occupation are continuously used to ensure the latest information exists within the database. To date, the Concrete Delivery Professional occupation is not listed on O*NET, while there is information for Heavy and Tractor-Trailer Truck Drivers.

Once these skills have been clearly defined, an opportunity arises to strategically align them with the concrete curriculum provided by key stakeholders throughout the industry. Many industry organizations provide specialized training or curricula including NRMCA, the National Center for Construction Education and Research (NCCER), American Concrete Institute (ACI), the American Society of Concrete Contractors (ASCC), and the National Concrete Pavement Technology Center (CPTech Center) among many others. With standardized skills, workers who receive training from one group could be eligible for accelerated certification in another related program. This alignment increases career flexibility, improves perception of the CDP occupation, and therefore, expands the potential talent pool of candidates with concrete experience, facilitating their entry into the occupation.

While the RMC industry works to build these skill sets, there are additional opportunities to increase the recruitment pool by widely advertising NRMCA's certifications.

Develop and Broadly Advertise Industry Certificates to Attract New Talent

Stakeholder interviews revealed that industry-recognized credentials could become an important asset when recruiting CDPs. Research from other industries shows that developing credentials (e.g., certified concrete delivery professional) increases the number of individuals interested in an occupation [21]. This seems to occur because it

clarifies the pathway for individuals to enter an occupation and gives them more security that they can stay in that career even if changing employers [22].

Credentialing, in the form of technical certifications, could be especially attractive for recruiting military veterans into the CDP workforce. Civilian education, including technical certification, can contribute to military promotion. Ensuring that CDP certification is Department of Defense (DoD) approved provides exposure to potential future applicants and would be expected to incentivize veterans to apply once they exit active duty. Analogous programs already exist for concrete preservation (e.g., www.cpi-foundation.org) and could be built for CDPs. Therefore, to incentivize active military members to consider ready mix as a career, developing a CDP certificate and advertising both CDLs and certificates is strategic to expand the talent pool.

At the same time, while the industry works to expand its recruitment pool, there are retention strategies that can be adopted today and others that will require investment.

Retention

Many of the strategies defined to improve productivity (e.g., automation) and recruitment (e.g., augmented reality) would also improve worker retention. Here we explore a few other strategies to encourage CDPs to stay within the profession.

Adopt Scheduling Strategies to Address Today's Challenges

Many producers reward CDPs for retention by basing their scheduling system on seniority or tenure at the plant. We learned that this has a significant impact on new hires who may struggle with family planning and income stability. CDPs who enjoyed their job and are satisfied with their schedule were asked to explain why (see Figure 24). The second most common reason was that their company rotates driver positions, so scheduling is not solely dependent on seniority. Obviously, firms do not want to lose experienced drivers, but given the turnover associated with newer drivers, a balance must be struck between satisfying senior drivers and the firm's objective of retaining all drivers. This could be implemented in the short term until the industry develops more sophisticated tools such as a bid for schedule app.

Another strategy proposed during stakeholder interviews was to develop a bid-for schedule algorithm and app for ready mix operations. Such an app would empower Concrete Delivery Professionals (CDPs) with greater control over their schedules. Experience in other industries has shown that workers place a high value on this empowerment.

Create RMC Industry Bid-for-Scheduling App

Employees now seek greater freedom in their work arrangements, both in terms of working hours and location [23]. And there is a growing demand for highly flexible job opportunities [24]. The rise in secondary earners and single-parent households contributes to this desire for flexibility. This trend also impacts the RMC industry, drawing away potential workers to other occupations [2].

The responses from the CDP survey validated what operational mangers reported in the NRMCA 2022 Mixer Driver Recruitment & Retention Survey – inconsistent scheduling is a major source of frustration and job dissatisfaction for CDPs (see Figure 26).

To address this challenge, we propose developing a bid-for-schedule algorithm and app that meets the specific needs of the RMC industry. Effectively, drivers would be matched with deliveries based on their preferences. In such a system, drivers would be compensated more for less desirable times and less for deliveries at favored times. As was noted earlier, systems like this are already used for pilots and nurses.

As a first step, a proof-of-concept app could be developed as a research effort to demonstrate the feasibility and benefits of this solution. The feedback and data from the pilot study could be used to design and implement the final version of the app with the most relevant and useful features.

The development of a bid-for-schedule app will require investment and time. Nevertheless, it could be a powerful tool for CDP retention. It would combine the other positive features of the job (e.g., day-to-day variety) with the flexibility found in other industries. The next section explores methods to foster employee engagement, another opportunity for immediate improvement of work experience and therefore retention.

Enhance Careerlong Engagement Using Digital Communication Tools

Face-to-face check-ins with employees are a critical method for management to demonstrate that employees are valued. In an increasingly competitive environment, CDPs are arguably the most valuable asset for RMCs. Expressing the value of CDPs can contribute to employee retention, enhanced company reputation, and higher productivity. The NRMCA has several resources that can help measure and improve employee engagement, such as the NRMCA 60-day check-in[4], an exit interview questionnaire[5], and stay interview questionnaire[6]

Most managers know that employee engagement is important for worker retention. Unfortunately, most managers already find themselves stretched thin. Despite their best intentions, managers find it hard to allocate the time for regular employee feedback. During the workshop, several industry stakeholders recounted formal feedback programs that quietly failed because the managers simply did not have the time to follow through. Fortunately, digital platforms have emerged to reduce this time burden. Generally, these platforms use data collected about a driver's day-to-day work to automatically assess performance. When certain performance targets are met, the system generates and sends feedback to the driver. This feedback can be customized by managers without requiring them to interact with each driver. Early evidence suggests these platforms increase employee satisfaction.

[4] www.nrmca.org/wp-content/uploads/2022/09/Employee_Check-in60Days.pdf
[5] www.nrmca.org/wp-content/uploads/2021/03/HR-Checklist_Exit_Interview.pdf
[6] www.nrmca.org/wp-content/uploads/2022/11/HR_Stay_Interview_Questionnaire.pdf

A novel way to leverage digitized worker data towards worker retention would be the development of algorithms to predict when a CDP is most likely to quit. In the long run, such information could be used to reduce exposure to the conditions that foster quitting (e.g. too many challenging pours or challenging customers in one day). In the near term, a predictive model for employee exits would enable managers to strategically intervene before the event occurs.

In all, firms should immediately implement digital tools that facilitate management-to-worker relationships. The industry should work together to develop algorithms to predict dissatisfaction and quitting. Together, these tools would help to retain drivers. Interestingly, improving worker retention can also start before the driver delivers their first load. The next section explores how enhancing training programs can yield significant and lasting effects on retention [25].

Enhance and Standardize Training

As the RMC industry looks to expand its recruitment pool to include those who do not have a CDL or ready mix experience, it becomes more critical to identify solutions that can enhance and standardize CDP training. The positive outcomes of high-quality training include work quality, productivity, motivation, and teamwork [26]. Effective training also improves employee retention [27].

> *"Fix training, and you will keep drivers." CDP, Massachusetts*

Game-based learning and gamification are underutilized strategies that the ready mix industry could apply to achieve this goal. Frederick et al. (2008) and others have defined game-based learning as the use of games to enhance learning in a meaningful way. Gamification, on the other hand, is the application of game mechanics to non-game activities [28]. More and more industries are looking to gamification as way to facilitate learning and enhance training for a multitude of purposes such as developing technical skills, improving interpersonal skills, and supporting learning outcomes. It is important to note that gamification is not intended to replace "classroom" learning but is meant to supplement or enhance the training material [29].

Another strategy to reduce first year challenges could be to standardize training by developing a competency-based, train-the-trainer program. A train-the-trainer course developed by the NRMCA, for instance, could benefit from a hierarchical framework that organizes skills into competencies. Unlike specific skills, competencies are adaptable to different roles and contexts. Therefore, it is essential that the trainer helps the CDPs understand and communicate their competencies acquired in the CDP role and how they can apply them to other careers within the industry. Beginning training with this approach may also help with retention, because CDPs would learn that there is opportunity to grow professionally.

Employing a Concrete Delivery Technician represents an additional strategy for mitigating first-year frustrations new CDPs.

Develop Concrete Delivery Technician Position

A pressing issue facing the RMC industry is the high turnover rate of CDPs, especially in their first year of employment. According to the NRMCA's Mixer Driver Recruitment & Retention Survey [2], 40% of CDPs quit within the first year. The main reasons cited by the CDPs who participated in our survey were the difficulty of learning the properties of concrete and dealing with the contractors within the first year of employment (see Figure 21). These challenges may be compounded as the industry works to expand its recruitment pool to those who do not have a CDL or ready mix experience.

Findings from our ready mix operational simulation indicate that, under specific scenarios, it is economically viable to employ a CDP technician who can reduce training time and increase new hire tenure. This technician's role would involve assisting new CDPs by providing knowledge of concrete properties and alleviating the customer service burden. Notably, this individual could attain the Concrete Technologist Certificate offered by the NRMCA without requiring a Commercial Driver's License (CDL). Such an approach would also benefit drivers whose primary language is not English, further expanding the candidate pool. There may also be other indirect benefits associated with the addition of this role such as improved mood for CDPs due to companionship, like what was found in Hatami et al. [30], though that study focused on long-haul truck drivers. Finally, the Concrete Delivery Technician role would provide another point of entry for younger workers who are not yet old enough to drive as a CDP while still being capable of learning the more technical aspects of the job.

Firms should explore hiring for a Concrete Delivery Technician role and partner those technicians with new drivers still learning about concrete and its placement.

Finally, in addition to addressing the technical challenges of new drivers, there are opportunities to improve retention by implementing strategies to enhance comfort and well-being.

Improve Daily Comfort

The physical demands of the CDPs' daily tasks and responsibilities are a source of dissatisfaction for some drivers and pose a risk of serious injuries over time. Moreover, CDPs tend to tie workplace satisfaction with the comfort and amenities inside the truck. In fact, the nature of the job often leads CDPs to take their breaks in their trucks, which may account for their preference for comfort over driver performance recognition (see Figure 23). Plant managers should invest in equipment, technology, and other amenities that enhance the interior comfort of trucks. Beyond the truck itself, creating more inviting break rooms is a way of expressing appreciation to the CDPs, which can improve recruitment, retention, and productivity.

In comparing these recommendations, some can be achieved today, while others will require greater consideration and investment. However, mitigating the CDP shortage is achievable with the adoption of technology and operational changes. The team has also found areas of additional research that may support decision-making related to investments.

Additional Research and Outreach

Construct Proof-of Concept Bid-for-Schedule Simulator

The rising cost of living is changing the workforce landscape by often requiring both parents in a family to work [31], which amplifies the stress of inconsistent work schedules. If the industry does not develop a solution that addresses inconsistent scheduling, the challenges of retaining and recruiting CDPs are likely to persist.

A proof-of concept bid-for-scheduling simulation is beneficial because it demonstrates the practicality of the process and can reduce costs by minimizing errors when developing an industry CDP scheduling app.

A bid-for-schedule application allows for workers to be have more agency over their schedules as well as the wages they will receive for completing a job. As an example, ShiftKey[7] is one application used for nurses where nurses can bid on shifts at specific locations, times, and rates. In the freight transportation industry, Uber Freight[8] has become an increasingly popular in-app bidding option for carriers.

In the RMC industry, a similar concept could be applied in which RMC companies create postings for load deliveries at a certain location and time of day for a set rate. This rate could be higher or lower depending on the time of day and type of shift. A pool of CDPs in that area could then bid on that posting. If no one takes the first rate, the company could offer a higher rate to secure a CDP for that shift. The pool of CDPs would be a pre-approved group of certified CDPs that live in the area. Over time, the RMC companies would pass on the premiums and discounts to their customers as they learn which shifts have higher and lower pricing. By incorporating this scheduling strategy at companies, the companies are able to expand their CDP pool. As the pool of CDPs grows, surge pricing from having too few CDPs would statistically be less of a challenge.

To demonstrate a bid-for-schedule application in the RMC industry, a study could examine a simulation model developed to test whether this concept would help reduce the shortage of CDPs for the industry. One type of model that could be used is a multi-agent systems model: A model that simulates decisions and interactions of different agents (e.g., RMC companies and CDPs) and is able to account for negotiations and changing conditions between agents [32]. Agents can make independent decisions based on a predetermined set of rules. Using this type of model, a bid-for-schedule system can be explored for the RMC industry under different sets of conditions.

Develop National CDP Datahub

Recently, a comprehensive study sponsored by Tableau — a company owned and operated by Salesforce — and performed by the International Data Corporation (IDC) utilized a survey methodology to investigate the presence of five key trends that underpin a successful data-driven culture. This study involved over 1,100 business leaders from

[7] ShiftKey - Connecting the people of healthcare
[8] Transportation & Logistics Solutions | Uber Freight

diverse technical and non-technical backgrounds across ten countries. It found that while a majority of businesses interviewed wanted a data-driven organization, only a third felt comfortable questioning the business's key performance indicators and metrics. The research showed that those companies that had a strong data culture saw significant improvements in retention and new customer acquisitions [33].

With such access, data scientists are better equipped to test and estimate the effect of various technologies, operational changes, and new policies on retention, recruitment, and productivity. Data is essential for conducting empirical analyses and making informed decisions. However, there is a scarcity of data on CDPs that goes beyond telematics data.

Perform Case-Studies on Existing Technology

While workshop participants identified and mapped technological solutions to systemic issues that persist in the RMC industry, more work is needed to assure producers of the return on investment of these innovations. Case studies are vital for academic research as they offer a thorough and systematic investigation of a specific event, technology, or situation. They enhance the understanding of real-life applications by reviewing and analyzing the factors that influence outcomes.

The industry has several technologies available to potentially improve productivity, quality control, retention, safety, and training. Some examples are:

- Gamification
- Hydraulic chutes
- Virtual reality to prevent rollovers
- Ready mix truck washers
- Smart sensors to monitor quality of concrete
- Customized alertness testing
- Daily pay apps

However, these technologies are not currently widespread in the CDP industry. Case studies performed on the examples above can help others make more informed decisions about the best solutions for different scenarios.

Form Regional Communities of Practice

Throughout the research phase of the project, it was apparent that many within the industry are independently developing strategic ways to address challenges like scheduling. The results from the CDP survey validate how managerial policies can have a positive impact on such things as the important topic of scheduling despite the absence of a scheduling app. There were other discoveries such as the need to put hiring forms in a format that is compatible with mobile phones, since most CDPs use their phones to apply for jobs. In the workshop, the audience learned that there are tax advantages for working with those who had been previously incarcerated or hiring for apprenticeships.

The list of discoveries is lengthy, which is why it would behoove the industry to form regional communities of practice to identify which findings are most pertinent to implement in a given region. Operating in this environment means that knowledge sharing is crucial for organizational development. Communities of practice (CoPs) have emerged as an effective approach for sharing knowledge and ideas. Through this collaboration, innovation can be sparked by individuals' brainstorming.

Those groups to be included in CoPs should be the following:

- Guidance counselors from high schools and trade schools
- Career counselors from community colleges
- Trainers from CDL schools
- CDPs
- Presidents/CEOs of non-profits that work with potential recruitment pools
- Concrete plant managers

By pooling their expertise and sharing proven strategies, these entities can effectively exchange ideas and solutions that have been rigorously tested and validated. Prior to COVID-19, forming this level of collaboration would have been a challenge. However, in the wake of the pandemic, the barriers of distance and geography have been mitigated through virtual collaboration platforms, rendering this collective effort feasible and highly effective in promoting shared learning and cooperation.

Conclusion

The RMC industry faces a serious challenge of retaining and recruiting concrete delivery professionals (CDPs) who are vital to construct infrastructure supporting economic growth. Despite offering various incentives and implementing operational strategies, the industry has not been able to overcome the CDP shortage that affects its productivity and profitability. Therefore, the industry needs to explore and adopt transformative technologies that can enhance the CDPs' skills, satisfaction, and performance.

Taking a systems approach to assessing the situation from multiple angles, this report has presented and evaluated several potential solutions that could be implemented today and in the future. We recommend that the industry stakeholders consider these solutions to build a sustainable workforce.

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Appendix A: Interview Questions for Different Stakeholder Groups

CDP Interview Phase I Questions: HR/Operations/Executive

We are trying to understand short and long-term solutions to the driver shortage. We'd love to hear about strategies that have worked (and not worked) for your firm. We'll start with some general questions and then dive in to understanding your workforce.

Demographic/General Information

1. What state(s) do you operate in for concrete?
2. Approximately how many mixer drivers do you currently employ?
3. How many mixer driver hires (replacements or additions to staff) do you hire per year?
4. How long does it typically take to hire a mixer driver?
    a. Less than 30 days, 30-60 days, Greater than 60 days
5. How do you currently find mixer drivers?
    a. Referrals
    b. Advertisements
    c. Postings on job sites
    d. Other
6. Are drivers paid by the hour or by the job?
7. What industries or backgrounds do your drivers come from?
8. What is the typical career path of a driver at your firm? Are there advancement opportunities?
9. When a driver leaves, do you facilitate exit interviews?

CDP Hiring and Retention Challenges

1. The 2019 ConcreteWorks and 2022 NRMCA Mixer Driver Survey results indicate that retaining CDPs is a greater challenge than recruitment. Do you agree with this statement?
    a. Strongly agree, agree, neutral, disagree, strongly disagree
    b. Why?
2. The 2021 NRMCA survey results highlight that CDPs rank the inconsistent daily schedule as the top reason why drivers quit. Has your company tried to address the inconsistent daily schedule for drivers?
3. Other respondents indicate that they lacked a steady 12-month income. Has your firm tried to address this challenge?
4. Finally, drivers indicate that they only want driving duties. Do you think this is possible? Practical?

CDP Hiring and Retention Solutions

1. What are strategies you have used to address the CDP shortage (part-time vs. full-time workers)? Challenges for scalability/for other regions?
2. In your organization, whose responsibility is it to communicate delays to customers? Drivers, dispatcher, operation managers, etc.?
3. What do you think are obstacles to creative solutions (e.g., insurance, government regulation, immigration policies)?
4. How do you see technological advancements changing or replacing some driver duties?
5. What are the opportunities with advancements like digitization of communications and delivery tickets, automation of quality assurance systems, autonomous vehicles and safety features, etc.?
6. What are the barriers to implementation and acceptance of technological advancement by producers, customers, regulators, the public?
7. Finding a ready mix workforce, faces many challenges. The industry wants to attract the 18–21-year-old population. However, due to cost and inexperience, managers express concern about putting a younger driver behind the wheel. Do you think a training program that allows a younger applicant to rotate (excluding driving) positions (dispatcher, QC tech, batchmixer) would help recruit and excite people to become a ready mix driver?

CDP Interview Phase I Questions: Equipment and Technology Manufacturers

We are trying to understand if there are technologies/software that can help with the shortage of mixer truck drivers. I would love to learn more about your company and your product.

Demographic/General Information

1. What is your role at the company?
2. Where is your company primarily located?
3. What types of products do you manufacture?
4. Who are your typical customers?
5. Do you agree that the industry is struggling to find drivers?

Driver Interaction with Product

1. How do drivers currently interact with your product?
2. Is there training involved to use your product?
3. Do you think your product **could change or replace** some driver duties? Does your product already do this? Please explain.
4. What are future opportunities to help with mixer driver duties?
5. What are the barriers to implementation and acceptance of technological advancement by producers, customers, regulators, the public?

Truck Manufacturers

1. What's changing in the industry?
2. Thoughts on autonomous? How is this changing the vehicle?

CDP Interview Phase I Questions: Trainers/Faculty

Demographic/General Information

1. What state(s) do you operate in for training?
2. How long have you taught?
3. Did you transition from industry to education? If so, why?
4. If you were in industry first, how long?
5. Is it a typical career pathway to transition from industry to education?
6. When a driver leaves the industry, what other industries do they go to?
7. When a driver leaves the industry, what are the main driving forces behind the decision-making process?

Student Enrollment/Demographics

1. What trends have you noticed in student enrollment?
2. Can you describe the student demographics? Age distribution, gender, returning student, switching careers?
3. What is the average completion rate of the program?
4. If it is low, why are students leaving and where are they going?
5. What drives students to enroll in the program?

Training/Degree Programs:

1. How would you describe the educational landscape? Which training bodies are responsible for the most training? Community colleges? Trucking Associations?
2. Does your school allocate enough marketing money the program?
3. What are the most significant limiting factors?
    a. Equipment
        i. What type of equipment is required to stay advanced?
    b. Enough faculty/trainers
4. How does your program revise/insert content to ensure program is aligned with industry skills need?
5. How does your program engage industry?
    a. Advisory boards
    b. Applied projects from industry and feedback
    c. Company tours, other?
6. How often do students have internship/co-op opportunities?
7. How do you collaborate with other schools/trainers in your region?
8. What are the "core" courses?
9. What are your recommendations to improve training/degree programs?
8. What are the outside certification bodies? Does your school have subscription to a specific certifying body? If so, what are the main driving forces behind the decision-making process?
9. How is sustainability embedded into the program?

Final Questions:

1. How can we inspire students to enroll?
2. What would improve retention rates?
3. How can industry help?

CDP Interview Phase I Questions: Driver

Demographic/General Information

1. What state(s) do you operate in for concrete?
2. How did you find out about the mixer driver job? What was most attractive about the job?
3. How long have you been a mixer driver?
4. What industry/background did you come from previously?
5. What is the typical career path of a driver at your firm? Are there advancement opportunities?
6. When a driver leaves the industry, what other industries do they go to?
7. Why do you think some drivers leave after a few months and others stay for years? What helps some get through the first few months?

CDP Hiring and Retention Challenges

1. What do you like most about your job?
2. What do you like least about your job?
3. Please rank the following job responsibilities from 1 to 6, with 1 being the most enjoyable and 6 being the least enjoyable
    - Plant maintenance
    - Deliver concrete to production area
    - Operate mixer on truck
    - Vehicle maintenance
    - Customer service
    - Daily reporting
4. The 2021 NRMCA survey results indicate that irregular daily schedules and weekend and night work are main factors in why drivers leave. Do you think there are opportunities to have a more consistent schedule?
5. Survey respondents shared that another challenge was lack of a 12-month income. How does your firm handle this?
6. Are you compensated for detention?
7. What does your company do to help your growth and development as a driver?
8. What do you wish you had more training on?

CDP Hiring and Retention Solutions

1. Some drivers indicate that they only want driving duties. Do you think this is possible? Practical?
2. How can your company improve communications with drivers?
3. During the "off season", what happens? Do you find another job?
4. How much does site infrastructure impede moving and delivering loads?
5. Do you think your position could be divided into two separate positions: a driver and an onsite technical worker? Thoughts?

6. If autonomous trucks become more prevalent, how do you think this would change the role and responsibilities moving forward?
7. How do you see technological advancements changing or replacing some driver duties?
8. Are there any new technologies that have been implemented? Have they helped?

Appendix B: CDP Survey Questions

Ready Mixer Driver Survey

Start of Block: Questionnaire Introductory Materials

Survey on Job Satisfaction for Concrete Delivery Professionals

Overview

We aim to learn directly from concrete delivery professionals about which parts of the job you like and dislike. Results from the survey will be used to build a robust pathway to finding and retaining qualified drivers, so **your input significantly matters.**

Consent to Participate

For the purposes of this survey and drawing, a Concrete Delivery Professional (CDP) is a person who can be verified to be legally employed or contracted by a U.S. ready mixed concrete company and be involved in the transport of concrete or cement products. Such a person will hold a legal Commercial Driver's License (CDL) from a U.S. state or territory.

The purpose of this research project is to collect data on U.S. Concrete Delivery Professional job satisfaction. This is a research project being conducted by the MIT Concrete Sustainability Hub. Respondents are invited to participate in this research project because they are Concrete Delivery Professionals.

Your participation in this research study is voluntary. You may choose not to participate. If you decide to participate in this research survey, you may withdraw at any time. If you decide not to participate in this study or if you withdraw from participating, you will not be penalized.

We will do our best to keep your information confidential. Individual responses and personal information will not be shared with any person or entity outside the MIT Concrete Sustainability Hub. The results of this study will be used for scholarly purposes only.

Participating in this survey implies that you understand and agree to provisions within this disclaimer. To be eligible for the drawing, participants must be at least eighteen (18) years of age. Any of those Concrete Delivery Professionals (CDP) who choose to participate in and *fully*, *faithfully* complete the MIT Concrete Sustainability Hub Driving Survey will be automatically enrolled for a drawing on January 31, 2023. The winner will be notified by their selected mode of correspondence, email or phone, no later than 9:00pm (EST) on February 1, 2023. If the selected participant does not respond before the close of the next business day, their eligibility will have expired. Another drawing will be held the following business day and the process will be repeated until the selected participant responds.

Once a winning participant has been successfully reached, they will be asked to provide their full legal name and U.S. address. If the participant can be verified to meet the above definition of Concrete Delivery Professional (CDP), a payment of five hundred U.S. dollars, in the form of a check, will be sent to the address provided by the winner no later than two weeks after they provide their full name and address.

The winning participant's winnings are subject to any applicable federal, state, and local taxes. Such taxes will be the sole responsibility of the winning participant.

- ○ I understand the procedures described above, and I agree to participate in this study. (2)
- ○ I do NOT agree to participate in this study. (3)

Shall we contact you by email or phone to **notify** you that you are the **WINNER** of **$500.00?**

- ○ Phone (1)
- ○ Email (2)

Enter the best phone number where you can be reached, entering all ten digits, including the area code.

Enter the best email address where you can be reached.

_____

In which state is your company located?

Is it a dry batch or central mix plant where you work?

- ○ Dry batch plant (4)
- ○ Central mix plant (5)

In addition to being a ready mixed concrete supplier, does your company finish concrete?

- ○ Yes (1)
- ○ No (2)

Does your company operate in an urban community, rural community, or mixed urban-rural community?

- ○ Urban community (1)
- ○ Rural community (2)
- ○ Mixed urban-rural community (3)

Is your company unionized?

- ○ Yes (1)
- ○ No (2)

Within the concrete industry, what is your current occupation?

- ○ Plant dispatcher (1)
- ○ Plant manager (2)
- ○ Concrete delivery professional (Ready mix driver) (3)
- ○ Mechanic (4)
- ○ QC tech (5)
- ○ Human resources coordinator (6)
- ○ Concrete batchman (7)

How long have you worked at your current company?

- ○ Less than 6 months (1)
- ○ 6 months to 2 years (2)
- ○ 3 to 5 years (3)
- ○ 6 to 9 years (4)
- ○ 10 or more years (5)

In your opinion, what are the **toughest** parts of the job **at your company** for drivers who have **less than one year** of ready mix experience?
Select all that apply.

- [ ] Driving and operating the truck off-road (1)
- [ ] Learning and understanding the properties of the concrete, e.g. using water efficiently and knowing setting times under different conditions at jobsites (2)
- [ ] Operating the drum (3)
- [ ] Placing concrete for more challenging types of pours (4)
- [ ] Dealing with contractors on jobsites (5)
- [ ] Properly rinsing and cleaning the trucks (6)
- [ ] Following safety guidelines, e.g. rollover prevention, wearing protective gear, and properly entering and exiting the truck (8)
- [ ] Handling and assembling chutes (9)
- [ ] Daily ticketing and logging deliveries (11)
- [ ] Blowing out the water lines in colder weather (13)
- [ ] Inconsistent schedule - different start and stop times (14)
- [ ] Other (15)

From your perspective, would concrete delivery professionals' satisfaction **increase** if there was a "smart" app that enabled them to play a **more active** role in their scheduling?

- ○ Yes (1)
- ○ No (2)

If a driver had a "rough" scheduling week, what actions are taken at your company to acknowledge and **improve** the person's job satisfaction for the **following week**?
Select all that apply.

- ☐ Rearrange the schedule to ensure the driver has better jobs (1)
- ☐ Inform the driver that you are aware that they had a difficult week (2)
- ☐ Give the driver an extra break or longer lunch (3)
- ☐ Nothing. It happens to all drivers (5)
- ☐ Other (6) _____

From your perspective, how well are the following things explained to **people OFFERED concrete delivery driving positions** at your company**?**

	Very poor (1)	Poor (2)	Acceptable (3)	Good (4)	Very good (5)
The inconsistent pay (1)	○	○	○	○	○
The inconsistent scheduling (2)	○	○	○	○	○
The seniority system (3)	○	○	○	○	○
Daily tasks and expectations (4)	○	○	○	○	○

As technology advances, do you believe autonomous-operated ready mix trucks will help with the recruitment and/or retention of concrete delivery professionals?

- ○ It would only help with recruitment (1)
- ○ It would only help with retention (2)
- ○ It would help with recruitment and retention (4)
- ○ It would not have any impact (5)

What is your perception of your drivers? Are they skilled operators or truck drivers?

- ○ Truck drivers (1)
- ○ Skilled operators (2)

From your perspective, which **occupations** do drivers go into when leaving your company?
Select all that apply.

- [ ] Ready mixed concrete batch plant production manager (1)
- [ ] Ready mixed concrete dispatcher (2)
- [ ] Concrete quality control specialist (5)
- [ ] Sales representative for ready mix related products (6)
- [ ] Concrete flatwork technician/finisher (7)
- [ ] Jobsite superintendent (8)
- [ ] Project manager (9)
- [ ] Long-haul driver (10)
- [ ] Ready mix driver at another company (12)
- [ ] Pump contractor (13)
- [ ] Warehousing job (14)
- [ ] Other (15) _____

How do you feel about your job?

- ○ Love it! (5)
- ○ Like it (6)
- ○ "Meh" Take it or leave it (7)
- ○ Don't like it (8)
- ○ Hate it! (9)

Select **FIVE** things that bring you the **MOST JOB SATISFACTION**.

- [ ] Responsiveness of management (1)
- [ ] The diversity of the job types, e.g. forms, foundation, sidewalks, etc. (2)
- [ ] Handling and assembling the chutes (3)
- [ ] My income and benefits/pension (if union) (4)
- [ ] Rinsing and maintaining my truck throughout the day (7)
- [ ] Interacting with contractors on jobsites (13)
- [ ] Working with concrete and understanding its properties (5)
- [ ] Operating my ready mix truck (14)
- [ ] The scheduling (15)
- [ ] Driver performance is recognized (16)
- [ ] Daily logging and ticketing is all digital (6)
- [ ] Cameras monitoring my driving behavior, making me a safer driver (18)
- [ ] Breaktimes are adequate (19)
- [ ] The comfortability of my truck (20)

How is management responsive to your input?
Select all the apply.

- [ ] Company policies change based on drivers' feedback or recommendations (1)
- [ ] There are regular check-ins with employees (2)
- [ ] My manager is not a micromanager and trusts employees to perform (3)

How would you rate the following jobs?

	Very difficult (1)	Difficult (2)	Neutral (3)	Easy (4)	Very easy (5)
Pump jobs (1)	○	○	○	○	○
Filling forms using chutes (2)	○	○	○	○	○
Curbing (3)	○	○	○	○	○
Pouring slabs with chutes (5)	○	○	○	○	○

Select the reasons why handling and assembling the chutes adds to your job satisfaction.
Select all that apply.

- ☐ It's a hydraulic system that is remotely operated (1)
- ☐ The chutes are aluminum, weighing less than steel (2)
- ☐ Steel chutes don't bend when fully extended and pouring concrete (3)
- ☐ Lifting and assembling chutes keeps me active throughout the day (4)

Select the reasons why you are satisfied with your monthly income and benefits. *Select all that apply.*

- [ ] I'm a senior driver, so I am given more opportunities to deliver additional loads (1)
- [ ] I'm in the union, making me eligible to receive a pension after retirement (2)
- [ ] The hourly rate is competitive (3)
- [ ] My company gives drivers other jobs at the plant to increase hours (4)
- [ ] I'm good at budgeting and saving money (5)
- [ ] The benefits package (6)

Select the reasons why you enjoy rinsing and maintaining your truck throughout the day. *Select all that apply.*

- [ ] It keeps me active throughout the day (1)
- [ ] I love my truck, so it's important to take care of it (2)
- [ ] Those drivers who keep their truck clean are rewarded with newer trucks (3)
- [ ] Preventing concrete from drying on the chutes makes them easier to handle (6)

Select the reasons why you **enjoy** interacting with contractors at jobsites.
Select all that apply.

- [ ] I enjoy representing my company (1)
- [ ] I consider myself the expert; therefore, I want to be actively engaged in the job (2)
- [ ] It gives me an opportunity to break up the daily tasks (3)
- [ ] My company does well with scheduling, so the customer is typically happy (6)

Select the reasons why you **enjoy** working with concrete.
Select all that apply.

- [ ] Its resiliency over other products like wood (1)
- [ ] It captures carbon dioxide, a greenhouse gas (2)
- [ ] My truck has sensors monitoring its properties, making the job easier (3)
- [ ] I continuously learn new things about concrete (6)
- [ ] It's used to build my community (7)

Select the reasons why you enjoy **operating** a ready mix truck?
Select all that apply.

- ☐ It's an automatic (1)
- ☐ It's a manual (2)
- ☐ It requires different driving skills than other types of trucks (6)
- ☐ The truck is loaded with sensors, digital tablets, and forms of technology (8)

Select the reasons why you **enjoy** the consistency of your work schedule?
Select all that apply.

- ☐ My company only operates during a fixed set of hours (1)
- ☐ My company offers shifts for its employees (2)
- ☐ My company lets its employees choose start and stop times (6)
- ☐ I'm a senior driver, so I have more flexibility than other drivers (7)
- ☐ My company rotates driver positions so scheduling is not based solely on seniority (8)

Select the ways that your company recognizes driver performance.
Select all that apply.

- ☐ Bonuses (1)
- ☐ Newer trucks (2)
- ☐ Gives generous recognition and praise (6)
- ☐ Other (8) _____

Select the reasons why electronic logging and ticketing **increases** your job satisfaction.
Select all that apply.

- ☐ There are less errors compared to when I have to write down information (1)
- ☐ It increases my productivity, because I do not have to spend time logging details (2)
- ☐ It reduces the amount of communication with the customer (6)
- ☐ I enjoy new technology (8)

Select the reasons why a camera installed in the cabin **increases** your job satisfaction.
Select all that apply.

- [ ] It can exonerate me if there was an accident and it wasn't my fault (1)
- [ ] It makes me a safer driver (2)
- [ ] Footage can be used to teach other drivers things to do or not to do in certain situations (6)

Select the reasons explaining how your breaktimes are adequate.
Select all that apply.

- [ ] The breakroom is comfortable (1)
- [ ] It's enough time to recuperate (2)
- [ ] I chat with my coworkers (6)
- [ ] The cabin of my truck is comfortable (10)

Select the features of your truck that make it comfortable to drive.
Select all that apply.

- [ ] Orthopedic seat pillows (1)
- [ ] Bluetooth (2)
- [ ] Comfortable seat (6)
- [ ] Low-speed creeper gears (10)
- [ ] Adjustable steering column (11)
- [ ] Heated side mirrors (12)
- [ ] Backup cameras (13)
- [ ] Horsepower (14)
- [ ] Suspension system (15)

Select **FIVE** things that contribute most to your job **DISSATISFACTION.**

- [ ] Responsiveness of management (1)
- [ ] The diversity of the job types, e.g. forms, foundation, sidewalks, etc. (2)
- [ ] Handling and assembling the chutes (3)
- [ ] My income and benefits/pension (if union) (4)
- [ ] Rinsing and cleaning my truck throughout the day (7)
- [ ] Breaktimes are inadequate (8)
- [ ] The comfortability of my truck (9)
- [ ] Interacting with contractors on jobsites (11)
- [ ] Logging deliveries and ticket information is all written (12)
- [ ] The scheduling (13)
- [ ] Cameras monitoring my driving behavior (16)
- [ ] Operating my ready mix truck (17)
- [ ] Driver performance goes unrecognized (18)
- [ ] Working with concrete and understanding its properties (19)

How much would your job satisfaction **increase** if management was responsive to your input?

- ○ Not at all (1)
- ○ Slightly (2)
- ○ Moderately (3)
- ○ A lot (4)
- ○ Significantly (5)

How much would your job satisfaction **increase** if you did not have to exit your truck for various types of placement jobs?

- ○ Not at all (1)
- ○ Slightly (2)
- ○ Moderately (3)
- ○ A lot (4)
- ○ Significantly (5)

How much would your job satisfaction **increase** if the **quality** of the breaks improved?

- ○ Not at all (1)
- ○ Slightly (2)
- ○ Moderately (3)
- ○ A lot (4)
- ○ Significantly (5)

How much would your job satisfaction **increase** if your company supplied you with financial planning resources?

- ○ Not at all (1)
- ○ Slightly (2)
- ○ Moderately (3)
- ○ A lot (4)
- ○ Significantly (5)

How much would your job satisfaction **increase** if the chutes were hydraulic and remotely operated or weighed less?

- ○ Not at all (1)
- ○ Slightly (2)
- ○ Moderately (3)
- ○ A lot (4)
- ○ Significantly (5)

How much would your job satisfaction **increase** if the number of times you washed your truck decreased by half?

- ○ Not at all (1)
- ○ Slightly (2)
- ○ Moderately (3)
- ○ A lot (4)
- ○ Significantly (5)

How much would your job satisfaction **increase** if your truck was modified or replaced to have features such as orthopedic seat cushions, Bluetooth, back-up cameras, advanced climate control features, better suspension, etc.?

- ○ Not at all (1)
- ○ Slightly (2)
- ○ Moderately (3)
- ○ A lot (4)
- ○ Significantly (5)

How much would your job satisfaction **increase** if you did NOT have to interact with dissatisfied or unhappy contractors on jobsites?

- ○ Not at all (1)
- ○ Slightly (2)
- ○ Moderately (3)
- ○ A lot (4)
- ○ Significantly (5)

How much would your job satisfaction **increase** if daily logging and ticketing information were only electronic?

- ○ Not at all (1)
- ○ Slightly (2)
- ○ Moderately (3)
- ○ A lot (4)
- ○ Significantly (5)

How much would your job satisfaction **increase** if you had more control over determining your daily start and stop times?

- ○ Not at all (1)
- ○ Slightly (2)
- ○ Moderately (3)
- ○ A lot (4)
- ○ Significantly (5)

How much would your job satisfaction **increase** if there were no camera in the cabin of the truck?

- ○ Not at all (1)
- ○ Slightly (2)
- ○ Moderately (3)
- ○ A lot (4)
- ○ Significantly (5)

When operating your truck, which part makes it unenjoyable?

- ○ Driving in traffic (1)
- ○ Operating the sensors, drums, etc. (2)

How much would your job satisfaction **increase** if the truck could **operate autonomously**, using various sensors to monitor the concrete until arriving at the jobsite where you would take over driving?

- ○ Not at all (1)
- ○ Slightly (2)
- ○ Moderately (3)
- ○ A lot (4)
- ○ Significantly (5)

How much would your job satisfaction **increase** if management routinely recognized drivers' performance, safety, and teamwork?

- ○ Not at all (1)
- ○ Slightly (2)
- ○ Moderately (3)
- ○ A lot (4)
- ○ Significantly (5)

How much would your job satisfaction **increase** if your duties no longer required you to understand the properties of concrete and sensors were in place to continuously monitor its setting time, moisture content, and remaining load after delivery?

- ○ Not at all (1)
- ○ Slightly (2)
- ○ Moderately (3)
- ○ A lot (4)
- ○ Significantly (5)

Have you ever been compensated by a company to train new concrete delivery professionals (ready mix drivers)?

- ○ Yes (1)
- ○ No (2)

In your opinion, what are the **toughest** parts of the job for drivers who have **less than one year** of ready mix experience?

Select all that apply.

- ☐ Driving and operating the truck off-road (1)
- ☐ Learning and understanding the properties of the concrete, e.g., Using water efficiently, so there is enough to add to the mixture if needed and rinse, knowing setting times, and estimating the remaining load after delivery (2)
- ☐ Operating the drum (3)
- ☐ Placing concrete for more challenging types of pours (4)
- ☐ Dealing with contractors at jobsites (5)
- ☐ Properly rinsing and cleaning the trucks (6)
- ☐ Following safety guidelines, e.g., rollover prevention, wearing proper gear, and entering and exiting the truck properly (8)
- ☐ Handling and assembling the chutes (9)
- ☐ Driving in heavily congested areas (13)
- ☐ Other (14) _____

In your opinion, do you think enough training is devoted to the subjects you selected?

	Absolutely not (1)	No (2)	Neutral (5)	Absolutely (6)	Absolutely yes (7)
Driving and operating the truck off-road	○	○	○	○	○
Learning and understanding the properties of the concrete, e.g., Using water efficiently, so there is enough to add to the mixture if needed and rinse, knowing setting times, and estimating the remaining load after delivery	○	○	○	○	○
Operating the drum	○	○	○	○	○
Placing concrete for more challenging types of pours	○	○	○	○	○
Dealing with contractors at jobsites	○	○	○	○	○
Properly rinsing and cleaning the trucks	○	○	○	○	○
Following safety guidelines, e.g., rollover prevention, wearing proper gear, and entering and exiting the truck properly	○	○	○	○	○
Handling and assembling the chutes	○	○	○	○	○
Driving in heavily congested areas	○	○	○	○	○
Other	○	○	○	○	○

How long have you been a concrete delivery professional (ready mix driver) at your current company?

- ○ Less than 6 months (4)
- ○ 6 months to 2 years (5)
- ○ 3 to 5 years (6)
- ○ 6 to 9 years (7)
- ○ 10 years or more (8)

Before joining your current company, did you have previous ready mix driving experience?

- ○ Yes (4)
- ○ No (9)

Based on your company's seniority system, what is your current position?

- ○ In the bottom-third (1)
- ○ In the middle-third (2)
- ○ In the top-third (3)

Select the reasons why you became a ready mix driver.
Select all that apply.

- ☐ Competitive hourly pay rate (1)
- ☐ Close to home (4)
- ☐ Pension (if union) and competitive benefits package (5)
- ☐ Opportunities to grow career (7)
- ☐ Build your community (6)
- ☐ Significant variation in daily tasks - no two days are the same (8)
- ☐ Another family member or friend suggested it (9)
- ☐ Tired of my old job (10)
- ☐ Wanted to be part of the RMC industry (11)
- ☐ Read a job opening and applied for the position (12)
- ☐ Other (13) _____

From your perspective, how well are the following things explained to people **OFFERED** ready mix driving positions at your company?

	Very poor (1)	Poor (2)	Acceptable (3)	Good (4)	Very good (5)
The inconsistent pay (1)	○	○	○	○	○
The inconsistent scheduling (2)	○	○	○	○	○
The seniority system (3)	○	○	○	○	○
Daily tasks and expectations (4)	○	○	○	○	○

In your opinion, should scheduling be based solely on seniority?

○ Yes (1)

○ No (2)

Do you consider yourself a skilled operator or a truck driver?

○ A skilled operator (1)

○ A truck driver (4)

Do you see yourself driving a ready mix truck until retirement?

○ Yes (1)

○ No (2)

If not, which of the following careers would you consider?
Select all that apply.

- ☐ Ready mixed concrete batch plant production manager (1)
- ☐ Ready mixed concrete dispatcher (2)
- ☐ Concrete quality control specialist (5)
- ☐ Sales representative for ready mix related products (6)
- ☐ Concrete flatwork technician/finisher (7)
- ☐ Jobsite superintendent (8)
- ☐ Project manager (9)
- ☐ Pump contractor (10)
- ☐ Other (11) _____

Is there anything else that you would like to add that you consider important when discussing the ready mix driver shortage?

_____

I wish to receive a copy of the confidentiality agreement.

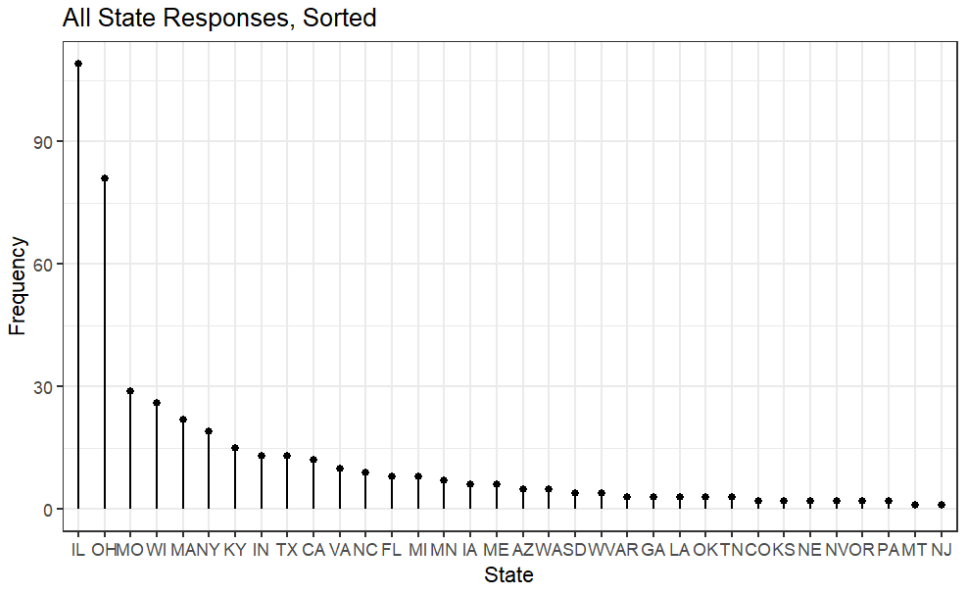
- ○ Yes (1)
- ○ No (2)

Enter your email.

_____

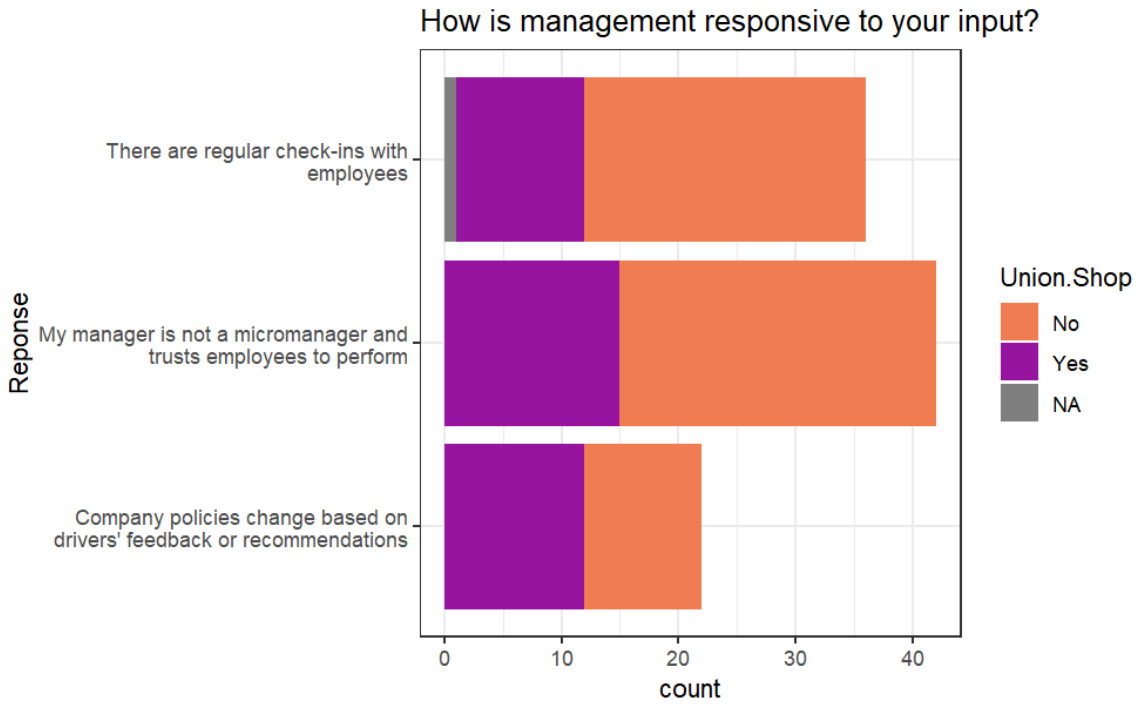
Appendix C: Additional Figures and Results from CDP Survey

Question
In which state is your company located?



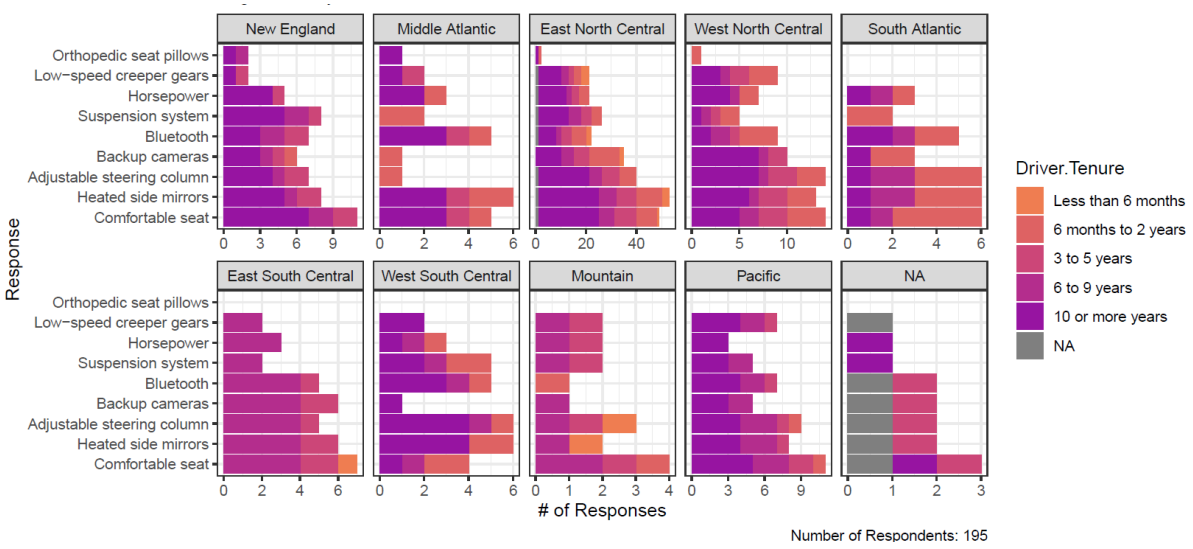
Question
For those who feel management is responsive, please select the ways this is expressed.

Those CDPs who were dissatisfied were their job, stated that an unresponsive management was a significant factor contributing to their dissatisfaction. Therefore, the team wanted to learn from those who said they were satisfied with management why. Performing regular check-ins with employees and trusting employees on the job were the top ways management showed their responsiveness to CDPs.



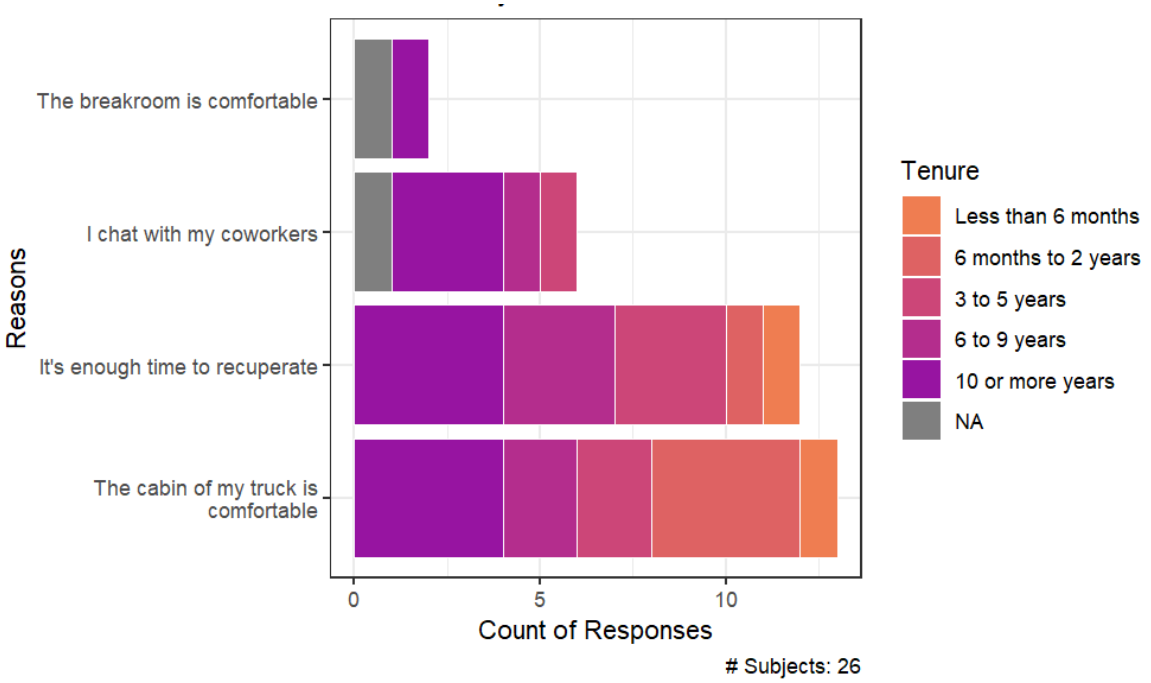
Question
Select the features on your truck that influence your satisfaction. Select all that apply.

CDPs can spend up to 70 hours in their trucks per week, and responses from the interviews underscored the attachment that a CDP has to their truck. Therefore, CDPs were asked to select the features on their truck that bring the most satisfaction. The results shown in the figure below indicate that CDPs prefer comfort over the truck's performance. No matter the region, CDPs prioritized a comfortable seat, heated side mirrors, and adjustable steering column.



Question
Select the reason why you are satisfied with your break times. Select all that apply.

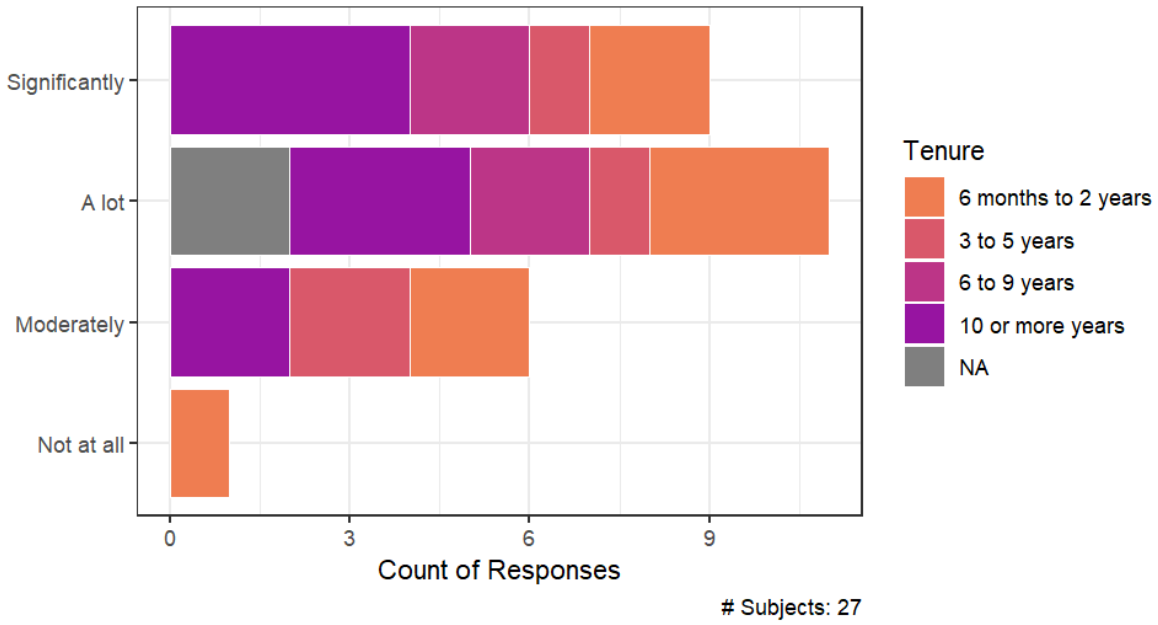
For those CDPs that are satisfied with breaktimes, the CDPs shared that they are most satisfied with the comfort of the cabin of the truck while not many CDPs indicated that the breakroom environment is comfortable.



Question

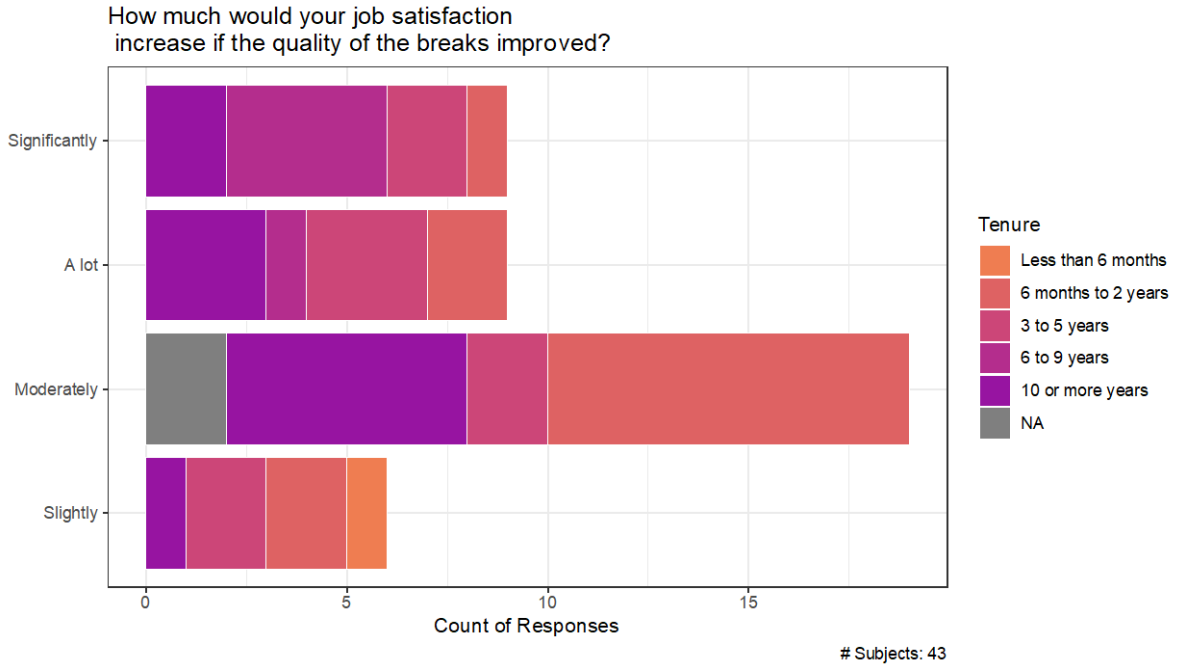
How much would your job satisfaction increase if the chutes were hydraulic and remotely operated or weighed less?

For those that dislike or hate their job, many CDPs shared that their job satisfaction would greatly improve if chutes were hydraulic and remotely operated or weighed less. This type of technology could also create more opportunities for expanding the talent pool by allowing more people to be able to physically operate the chutes.



Question
How much would your job satisfaction increase if the quality of the breaks improved?

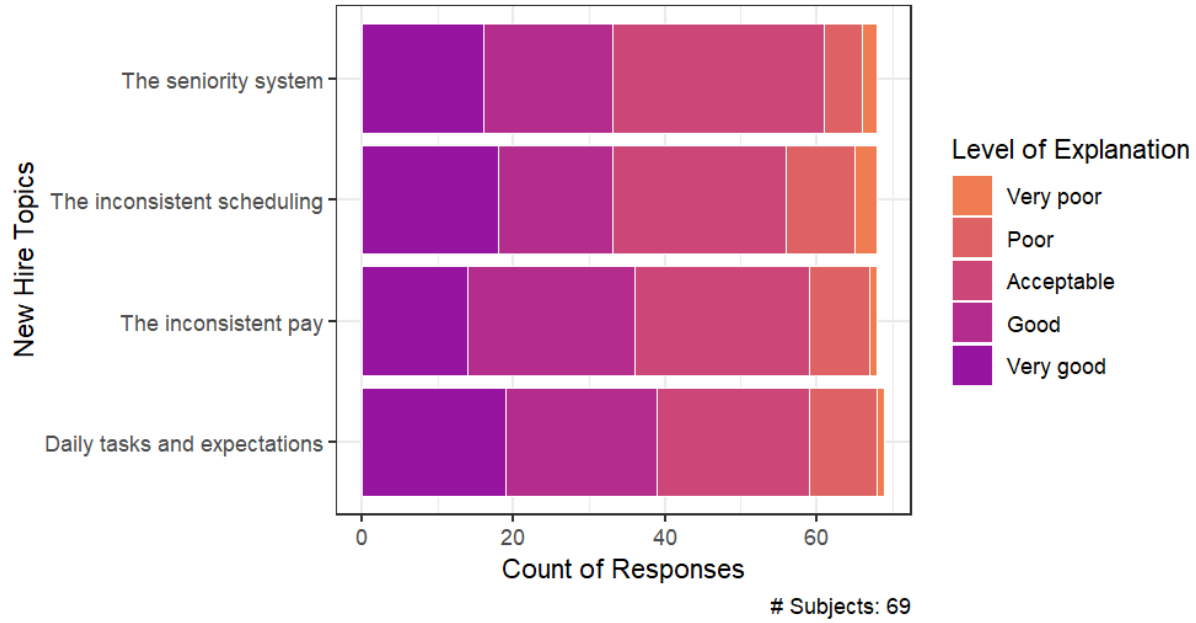
While some CDPs shared improved quality of breaks would increase their satisfaction, most CDPs that answered this question felt it would only moderately increase their job satisfaction. These results indicate that a greater focus on scheduling would make a greater difference to CDPs than efforts to improve breaks.



Question

How well are the following explained to people OFFERED ready mix positions at your company?

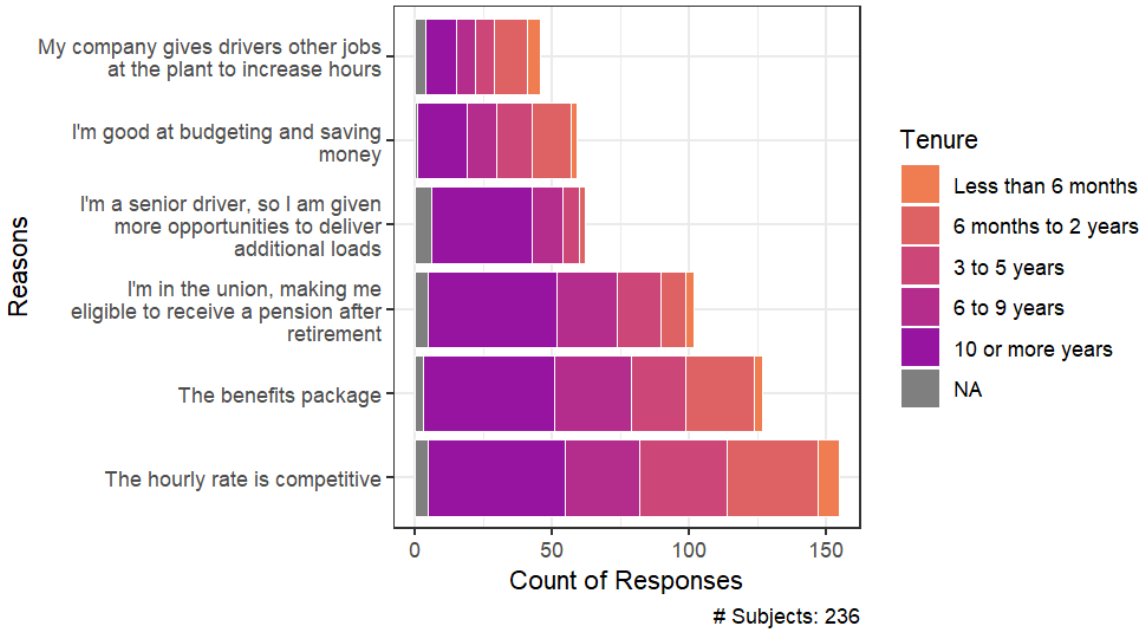
When asked how well CDPs thought aspects of the job were explained to new hires, most CDPs felt the explanations were acceptable. A few CDPs ranked the daily tasks and expectations as well as the inconsistent scheduling as poor or very poor. These results suggest that companies could improve their current description of the job to help all CDPs better understand the expectations.



Question

Select the reasons why you are satisfied with your monthly income and benefits. Select all that apply.

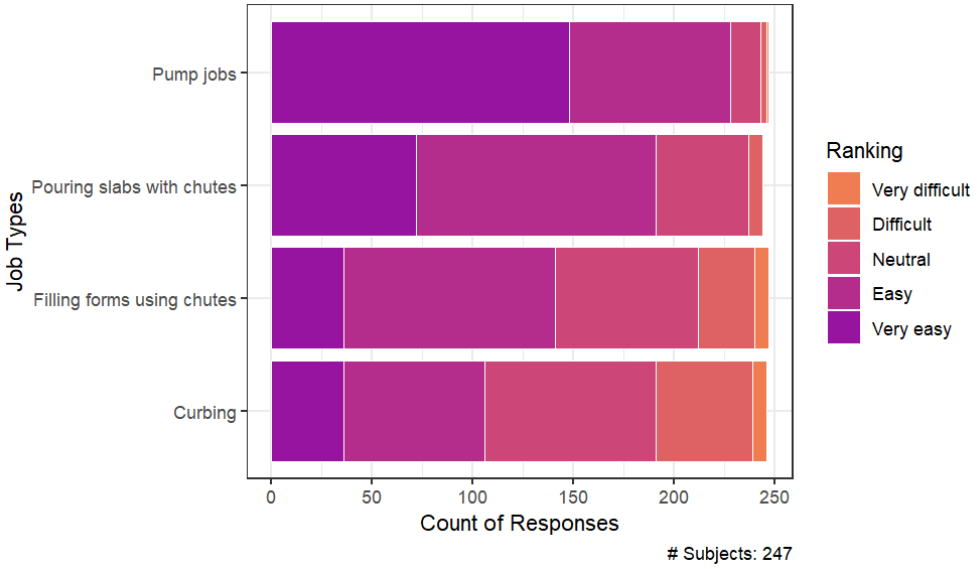
Many CDPs shared that monthly income was one of the job attributes that CDPs enjoy the most. Specifically, many CDPs like the hourly rate, the benefits package at their company, and those in the union mentioned the pension after retirement. These results emphasize that companies should continue to pay competitive wages and offer benefits packages to retain CDPs.



Question

You have stated that the diversity of the job types brings satisfaction. How would you rate the level of difficulty for each job type?

Another driver of satisfcation for CDPs is the variety of jobs that can change day-to-day. When asked to rank different job types in terms of difficulty level, CDPs didn't rank many of these jobs as very difficult. Instead, CDPs felt pump jobs are the easiest with curbing as the most difficult. These results underscore the importance of trying to ensure diversity in scheduling of CDP jobs to help with retainment.



Appendix D: CDP Workshop Breakout Questions

Emerging Technology Panel (2 questions)

1. Pick 2-3 challenges and identify which technology solutions are most likely to impact that challenge in the next 5 years? 10 years? What is driving the adoption of these technologies?

Challenges:	**Technology Examples:**
• Lack of diverse hiring pool (e.g., <21 years of age, women) • Lack of RMC experience • Irregular daily schedule • Lack of capacity to train • Physically difficult work environment • Relationship between management & CDPs **Challenges informed by NRMCA 2022 Driver Survey report*	• Augmented/virtual reality • Production & QC software systems • Dispatch & Logistics software • Trucking and Telematics software • Sensor technology • Autonomous trucks • Automated and remotely operated chutes

2. Why are the technologies mentioned above not already implemented today? What are the barriers to acceptance and adoption of future technologies (e.g., autonomous vehicles, battery electric trucks, smart mix software) by producers, customers, regulators, the public?

Retention Panel (3 questions)

1. Which of the following solutions have the greatest promise for improving retention?
   Solutions:
   - Bid-for-schedule scheduling application
   - Scheduling by CDP skill and preference
   - 5-star customer review
   - Gamification of performance evaluation
   - Daily pay opportunities
   - Clear career pathways
   - Truck telematics and load sensors

2. The 2021 NRMCA survey results highlight that CDPs rank inconsistent daily schedule as the top reasons why drivers quit and the 2023 MIT survey shows that scheduling is the part of the job CDPs dislike the most.
   The most transformative way to address this challenge is a bid-for-schedule system. What are the barriers and challenges to this system? What would need to be changed to make this work?

3. If you were to implement a gamified system, what aspects of performance should be tied to the game? What are the technological and institutional barriers?

Recruitment Panel (2 questions)

1. How can employers better communicate the benefits and opportunities of working as a CDP to new types of candidates (e.g., women, 18–21-year-olds, immigrants, etc.)?
2. What aspects of a CDPs job would be most impacted (i.e., made less frustrating) through effective AR? What parts of training would be most improved through VR or AR?

Appendix E: MIT CSHub Simulation Inputs

Appendix E Table 1 Inputs used to construct the MIT CSHub Simulation to estimate the cost of hiring CDPs with various levels of experience.

	Model Inputs	
Delivery Schedule		
Delivering weeks per year		50
Delivering days per week		5
Load Description		
Average no. of loads delivered per day (experienced driver)		3.2
Average load size in cubic yards		8
Net revenue per cubic yard	$	20
Truck Input Variables		
Trucks at this facility		50
Initial idle trucks		5
Driver Pool		
No. of drivers at beginning of year		45
Average hiring rate per year per truck		0.35
Reference Case: Prevalence of Driver Types among Hires		
No Commercial Drivers License (NoExp)		0%
with Commercial Drivers License (CDL_only)		80%
with CDL and Ready mix driving experience (CDL_RMx)		20%
Model Assumptions for Tenure		
Average tenure of experienced driver in weeks		416
Average tenure new hire in weeks		26
Weeks to become experienced driver		52
Maximum Tenure for driver in weeks		1040
Typical paid hours per week		40
Hourly Rates		
First year driver	$	25
Inexperienced driver (1 year)	$	30
Highly experienced driver (>10 years)	$	45
Weekly pay for experienced driver	$	1,800
Wage per load	$	112

(continued)

Appendix E Table 1 Inputs used to construct the MIT CSHub Simulation to estimate the cost of hiring CDPs with various levels of experience (continued).

	Model Inputs	
Training Costs		
Average training miles per driver		50
Trainer pay per trainee		
Driver with CDL Only	$	500
Driver with CDL and Ready mix Experience (CDL_RMx)	$	-
CDL training school	$	5,000
Mentor rate per driver/three months		0
HR Costs		
Admin time in hours spent per new hire / driver exit		8
Minimum percentage of admin time allocated to recruiting and hiring drivers		10%
Recruiter weeks allocated per new hire		0.5
Admin salary	$	45,000
Recruiter salary	$	50,000
Salary multiplier for benefits		40%
Fraction of new hires that are referrals		50%
Rate for referrals	$	200
Sign-On bonus		0
Marketing for Recruitment		
Local job fair advertising cost (annually)	$	5,000
Newspaper advertising cost (annually)		
Magazine advertising cost (annually)		
Radio and television advertising cost (annually)		
Flyer advertising cost (annually)		
Social media advertising cost (annually)	$	5,000
Online job search engines advertising cost (annually)	$	5,000
Driver Training		
No. of miles driven per driver during training (no deliveries)		75
IRS mileage rate	$	0.75

(Continued)

Appendix E Table 1 Inputs used to construct the MIT CSHub Simulation to estimate the cost of hiring CDPs with various levels of experience.

	Model Inputs	
Testing Fees		
Disability access testing fee	$	25
Motor vehicle testing fee	$	25
Criminal history testing fee	$	25
Department of transportation testing fee	$	25
Physicals testing fee	$	25
Drug test testing fee	$	25

Appendix F: Mapped Learning Outcomes from NCCER Concrete Construction Program to CDP Skills

Appendix F Table 2 Mapped learning outcomes to CDP skills.

Name of Course	Course Code	Learning Outcome	Industry Skill Alignment Indicator
Properties of Concrete	M23212	Identify standards related to concrete testing and describe field sampling practices.	1
Properties of Concrete	M23212	Explain how to conduct a field slump test.	1
Properties of Concrete	M23212	Explain how to prepare samples for concrete compression testing.	1
Paving	M36108	Explain the use of stringlines and other methods of grade control.	0
Paving	M36108	Identify and describe various types of concrete joints.	0
Paving	M36108	Describe hand-paving operations.	0
Paving	M36108	Describe concrete reinforcement.	0
Paving	M36108	Describe concrete paving methods equipment.	0
Paving	M36108	Describe the concrete recycling process.	0
Paving	M36108	Identify methods and tests used to ensure quality control of concrete.	1
Architectural Finishes	M23205	Identify and describe concrete surface classes and the function of mockups.	0
Architectural Finishes	M23205	Describe how colored and white cements are created.	0
Architectural Finishes	M23205	Explain how concrete surfaces can be colored.	0
Architectural Finishes	M23205	Explain how to create various textured surfaces.	0
Architectural Finishes	M23205	Explain how the aggregates and other ingredients are selected.	0
Architectural Finishes	M23205	Describe various methods used to place aggregates.	0
Architectural Finishes	M23205	Describe various methods used to expose embedded aggregate.	0

Name of Course	Course Code	Learning Outcome	Industry Skill Alignment Indicator
Troubleshooting and Quality Control	M23211	Define quality control and explain how contractors are apprised of quality expectations.	0
Troubleshooting and Quality Control	M23211	Describe the scope of pre-placement inspections required to ensure acceptable results.	0
Troubleshooting and Quality Control	M23211	Explain how to organize and conduct a troubleshooting process.	0
Troubleshooting and Quality Control	M23211	Identify common problems encountered in fresh concrete and how they might be resolved.	0
Troubleshooting and Quality Control	M23211	Explain how to organize and collect concrete field samples.	1
Troubleshooting and Quality Control	M23211	Explain how to prepare specimens for strength testing.	0
Troubleshooting and Quality Control	M23211	Explain how to perform a slump test.	1
Troubleshooting and Quality Control	M23211	Explain how to perform a yield test and calculate yield, unit weight, and gravimetric air content.	0

Name of Course	Course Code	Learning Outcome	Industry Skill Alignment Indicator
Introduction to Concrete Construction	M23101	Summarize the history of concrete	0
Introduction to Concrete Construction	M23101	Describe concrete and its main components	1
Introduction to Concrete Construction	M23101	Identify the strengths, weaknesses, and other characteristics of concrete	1
Introduction to Concrete Construction	M23101	Describe various forms of concrete	1
Introduction to Concrete Construction	M23101	Describe common types of concrete construction	1
Introduction to Concrete Construction	M23101	Describe the concrete construction process	1
Introduction to Concrete Construction	M23101	Describe the types and roles of concrete craftworkers in the industry	1
Introduction to Concrete Construction	M23101	Identify personal characteristics common to successful craft professionals	0
Concrete Safety	M23102	Explain the importance of safety and a workplace culture that supports it.	1
Concrete Safety	M23102	Understand the role of OSHA and your rights and responsibilities as an employee in the construction industry	1
Concrete Safety	M23102	Identify general clothing and the personal protective equipment (PPE) commonly required for concrete operations.	1
Concrete Safety	M23102	Describe the hazards associated with silica dust and how to manage them.	1
Concrete Safety	M23102	Identify and describe hazards related to mixing and transporting concrete.	1
Concrete Safety	M23102	Identify and describe hazards related to formwork and concrete placement.	1
Concrete Safety	M23102	Identify and describe hazards related to finishing and curing concrete.	0

Name of Course	Course Code	Learning Outcome	Industry Skill Alignment Indicator
Concrete Tools and Equipment	M23104	Identify and describe the use of various measuring and leveling tools.	0
Concrete Tools and Equipment	M23104	Identify and describe the use of shovels, rakes, and tampers	0
Concrete Tools and Equipment	M23104	Identify and describe the use of screeds and floats.	1
Concrete Tools and Equipment	M23104	Identify and describe the use of various trowels.	0
Concrete Tools and Equipment	M23104	Identify and describe the use of groovers, jointers, and edgers.	0
Concrete Tools and Equipment	M23104	Identify and describe the use of brushes, brooms, and rubbing stones.	0
Concrete Tools and Equipment	M23104	Identify and describe the use of concrete mixers and trucks.	1
Concrete Tools and Equipment	M23104	Identify and describe the use of various buggies, buckets, conveyors, and pumps.	1
Concrete Tools and Equipment	M23104	Identify and describe the use of powered compactors, screeds, vibrators, and trowels.	0
Concrete Tools and Equipment	M23104	Identify and demonstrate the proper use of instructor-selected hand tools.	0
Concrete Tools and Equipment	M23104	Identify and demonstrate the proper use of instructor-selected power tools and equipment.	0

Name of Course	Course Code	Learning Outcome	Industry Skill Alignment Indicator
Preparing for Placement	M23105	Describe basic subgrade considerations and preparations.	0
Preparing for Placement	M23105	Describe how elevations are established.	0
Preparing for Placement	M23105	Identify and describe basic foundations.	0
Preparing for Placement	M23105	Identify and describe basic form types and their preparation.	1
Preparing for Placement	M23105	Identify and describe various types of concrete joints.	0
Preparing for Placement	M23105	Describe basic approaches to concrete reinforcement.	0
Preparing for Placement	M23105	Describe final inspections and the concrete ordering process.	0
Finishing Concrete	M23107	Describe cement dermatitis and how it can be remedied.	1

Appendix G: Competency-Based Assessment Example

Industry Cross-Skills Analysis with Concrete Curriculum

Interviews with CDPs and survey results highlighted the desire for CDPs to have mobility in their career. As a result, the development of a career path within the concrete industry could help to recruit and retain more workers. To understand potential partners for recruiting workers and creating a successful career path, agencies, institutions, and organizations were identified and interviewed. The National Center for Construction Education and Research (NCCER) stood out as a strong candidate for multiple reasons. In 2020, NCCER introduced a revamped curriculum for its concrete construction program[9], which is offered at twenty-three institutes, including naval facilities, colleges, and penitentiaries across the U.S. The program has a two-level concrete construction curriculum that complies with the U.S. Department of Labor's standards for apprenticeship programs. Within each level, there are modules that must be completed before advancing. Since 2020, 2,513 modules have been completed within the concrete construction programs, and in 2022, there were 694 in-person trainees and 391 active online trainees.

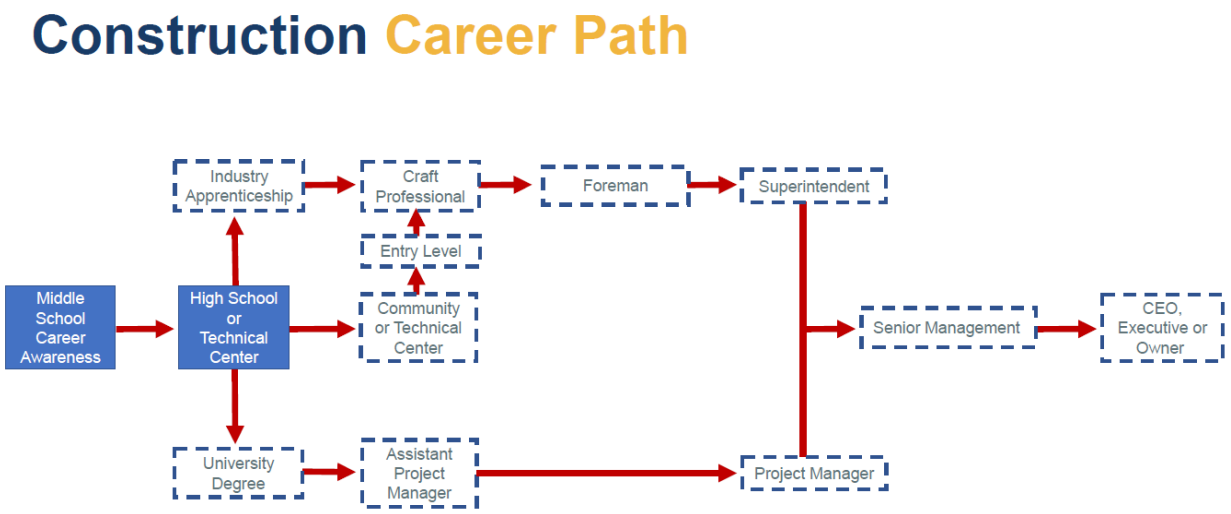


Figure 31 National Center for Construction Education and Research's Construction Career Path.

Eight modules listed in Table 4 are from the concrete construction program and were selected as candidates to measure the alignment between the module's learning outcomes and industry skill sets for CDPs. Learning outcomes are goals and objectives

[9] NCCER Concrete Construction Program

for students to achieve, and they are significant because they serve as a benchmark for evaluating students' performance.

Table 5 NCCER modules and the number of corresponding learning outcomes.

NCCER Module	No. of Learning Outcomes
Introduction to Concrete Construction	8
Concrete Safety	7
Concrete Tools and Equipment	11
Preparing for Placement	7
Troubleshooting and Quality Control	8
Properties of Concrete	10
Foundations and Slabs-on-Grade	1
Paving	7
Total	**66**

Sixty-six learning outcomes were put in an Excel spreadsheet and presented to the owner of a ready mixed concrete plant. The owner started working at the plant in June 1977 as a CDP, and in 1993, he became the owner of the company. Having almost forty-six years of experience in the ready mix business, during an onsite visit at the concrete plant, the owner matched learning outcomes to daily tasks or knowledge expected of CDPs, a 1 indicated a match, while a 0 indicated otherwise.

Below are examples of learning outcomes from NCCER's modules that were marked "True" and considered a skill required for a CDP position. The complete list of learning outcomes can be located in the Appendix F: Mapped Learning Outcomes from NCCER Concrete Construction Program to CDP Skills.

Learning outcomes identified as a CDP skill:

- Identify and describe basic form types and their preparation.
- Describe cement dermatitis and how it can be remedied.
- Describe chemical admixtures and how they influence concrete.

Criterion (Score 0 if element is absent)	Aware of (1)	Familiar with (2)	Competent (3)	Score	Examples of Tasks Reflecting Proficient Performance
Communicates details of a product, a problem, an operation or a design with clarity, accuracy, and relevance.	With direction, lists basic information when identifying product or process details, a problem, an operation and/or a design.	With minimal direction, describes product or process details, a problem, an operation and/or a design with limited clarity, accuracy, and relevance.	Independently explains product or process details, a problem, an operation and/or a design with clarity, accuracy, and relevance.		1- The CDP can explain a solution logically, concisely, and clearly. 2- The CDP can explain how to use a piece of equipment such as a CMM starting with how it functions, why to use it, and how to operate it logically, concisely, clearly.
Communicates details of a product, a problem, an operation or a design with clarity, accuracy, and relevance.	With direction, identifies what may be needed to provide a problem-solving recommendation.	With minimal direction, develops a recommendation or a solution to a given problem.	Independently, synthesizes prior knowledge with new data to develop a recommendation or a solution to a given problem.		1- The CDP applies troubleshooting knowledge from past equipment experiences. Starts troubleshooting process of new equipment by performing similar troubleshooting steps to make further troubleshooting decisions.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