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HONORS THESIS

Automation and Distribution Center Labor Effectiveness: A Case Study of Operations Company X

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ABSTRACT

Distribution center automation has progressed rapidly in recent times, with substantial improvements in automated systems which improve worker efficiency. These improvements have enabled distribution centers to increase their total throughput, while lowering their labor cost-per-case. However, when a distribution center transitions from manual fulfillment to an automated warehouse execution system, there will be growing pains as the facility adapts. In this exploratory case study of Operations Company X, we observe one such facility that recently transitioned to use an automated warehouse management system. To best explore the happenings of this facility, an archival analysis of pre and post automation data was conducted for the years of 2017 and 2020 to observe changes in key performance indicators between those years. Next, a survey of over 90% of employees was conducted, as well as a series of interviews across different levels of managers at the facility. Using this three-pronged approach of observing what occurred at the facility, we can see a more complete picture of what happened. At this facility, employee fatigue was not increased due to the implementation of automation, likely due to the temporal differences between when automated work was accomplished and when employees needed to interact. Automation's perceived usefulness and perceived ease of use among employees were good predictors of automations propensity to improve employee performance. These findings highlighted the need for strong communication from managers to attain employee buy-in, and sufficient training to teach them how to use it for maximum effectiveness. Additionally, the implementation of automation led to a movement of work for employees from lower-skilled to higher-skilled positions, as automation created new positions at the facility. These new, higher-paying positions, such as seven ASRS attendant and the improved office clerk role, were largely filled by internal hiring of forklift drivers or pickers. Finally, automation caused a reduction in the tedious / repetitive nature of tasks within the facility, as those tasks were the easiest to automate and allow employees to focus their efforts on higher value-added roles.

INTRODUCTION

The employee is the driving force behind any company. While some see the widespread implementation of automation as a threat to the prospects of base-level employees, others see it as a catalyst which will ultimately increase labor demand. Whether automation reduces the necessity to employ as many people as before, or it creates more higher-skilled jobs, one thing remains true: What is best for the employee will be at the center of controversy regarding the use of automation for years to come.

This concept relates to a modern movement being hailed the 'Fourth Industrial Revolution', where automation is being used in conjunction with physical labor to boost efficiency and promote growth to elevate companies past their competition. The hallmark of the Fourth Industrial Revolution is autonomy to the point of extreme automation and hyper connectivity (Tan, 2017). For a distribution center (DC), automation seems like an attractive avenue to use to continue to innovate and improve their bottom line. As time goes on, the landscape of global supply chain operations will be reshaped, as the rise of big data and advanced analytical techniques force companies to need to adapt to survive (Reyes et al, 2020). However, it stands to be seen what the realized impact of automation is on the business-side of distribution centers, and what the employee's perspective is on this automation.

This paper presents a multi-tiered approach to answer that question: How can improvements in automated supply chain technology improve distribution center labor effectiveness. The primary purpose of distribution centers is to store goods, process products, de-aggregate vehicle loads, create SKU assortments, and assemble shipments (Higginson and Bookbinder, 2005). All of these tasks have been historically labor-intensive and require careful management of resources to effectively navigate day to day. If a firm were to adopt automation, a displacement effect would occur where that cost would move from a labor expense to a capital expense, where the added value of labor would be theoretically reduced as that task is done by machinery rather than employees (Acemoglu and Restrepo, 2019). For a distribution center, this causes a realized reduction in labor cost, at the expense of an upfront capital expense to implement the machinery.

For Operations Company X, a New England based third-party logistics firm, they found themselves in this situation in mid-2018. They manage a distribution center for Production Company Y, who desired to implement an automated warehouse execution system which they anticipated would reduce their cost of labor (specifically labor cost per case) and increase the volume that the DC would be able to process. Beginning in 2018, the construction of the automated Warehouse Management System (WMS) began, and that construction would continue until early-2020, when the system was finally completed to the point it was made fully operational. This system uses a combination of conveyor belts, pallet-carrying carts, cranes and reaching robots to compile and store pallets, then drop them into lanes directly in front of the truck receiving the orders.

To evaluate the impact of this transition from manual-fulfillment center to automated inventory process facility, an archival analysis was conducted of all shipments processed in 2017, the last year before the implementation, and 2020, the first year the automation became fully operational. Next, a survey of over 90% of employees working at the facility was conducted to determine their perception of the integration and efficiency of the automation in their workplace. Finally, a series of interviews was conducted among various levels of management within the facility to gather a more in-depth perspective of the things impacted by the automation within the facility. These three elements all sought to explore the direct impact of automation on labor effectiveness within the facility. Combining these quantitative and qualitative elements together for an individual facility provides an opportunity for a comprehensive case study.

By examining a facility which has adapted to and navigated through the implementation of an extreme form of automation, we can uncover important findings within labor effectiveness which will offer a basis of substantive data for future researchers to utilize to explore distribution center automation. This paper adds new knowledge and data to the pool of scholarly knowledge around the emerging field of the use of extensive automation within the context of distribution centers.

The structure of this paper begins with a review of literature relating to the concept distribution center automation and labor effectiveness, and how prior research inspired the hypotheses which this paper centers on. Next, it explores the methodology of the three aspects of research

conducted on the facility, the archival analysis, surveys, and interviews. Following those same three topics, it goes into the objective results gathered from the different types of study. Then, there is a discussion of the findings and implications that can be taken from them.

This paper contains several compelling findings. While the automation in the DC accomplished its primary objectives of reducing cost-per-case and increasing throughput, secondary metrics such as late % and shipping DPPM were worsened. Next, tasks which involved tedious and repetitive labor saw improvements in worker efficiency by removing some of the most 'tedious' aspects of them. The jobs of forklift drivers were improved by removing the task of 'consolidation' and pickers work was made less tedious by automating the process of picking a full tier of cases. Further, within the facility, the implementation of the automation caused a movement of work from lower-skilled to higher-skilled positions. The creation of the ASRS attendant position and the expanded role/quantity of office clerks, combined with internal promotions, caused previous forklift drivers and pickers to see improvements in salary and job duties.

A list of definitions of terms is included as Appendix A in the 'Appendices' section, located on page 82.

LITERATURE REVIEW

The use of automation to improve labor efficiency has been extensively studied and examined. A typical approach centers on the examination of automation to supplant manual labor in production facilities and model the impacts of this supersession on the workforce. An accurate model of automation has the potential to predict a given workforce's output, reduce the high cost of labor, and compensate for a limited labor supply (Gaimon, 1985). In more recent works, it has been argued that automation increases the number of jobs and the net labor demand (Acemoglu, 2019). By replacing low-wage jobs with automated machinery, it creates the opportunity for more openings in higher paying positions overseeing these machines. Employees who see their previous jobs made redundant by automation could apply for trade schools and learn to repair the machines they were replaced by (Yu, 2019).

While an en masse transition of low skill employees to trade schools to learn complicated robotics maintenance and repair is unlikely, perhaps what skills those employees already obtained can be beneficial. Some facility tasks are more difficult to automate than others, and too much automation can actually be inefficient for certain tasks (Parasuraman, 2004). A balance of manual labor and automation assistance may be most beneficial to boost facility productivity.

The nature of a distribution center is decidedly different than a production facility. A factory generates value by creating products from raw materials. The primary purpose of a distribution center is to store goods, process products, de-aggregate vehicle loads, create SKU assortments, and assemble shipments (Higginson and Bookbinder, 2005). The movement of goods within the distribution center and the ability to ship the products in a timely fashion is where value is generated (Murphy, 2011). This contrasts a production facility where the value proposition centers on the creation of those goods, not their movement and storage.

In today's age of rapid automation, manual labor is continually displaced. However, not all automation is equal in its *displacement effect*, or removing the need for labor, and its *reinstatement effect*, which increases the net labor share as well as labor demand (Acemoglu, 2019). Labor displacement can be realized in the development of more machine maintenance

positions or attendants to observe the operations of the robots. In fact, there is large demand for these highly-skilled employees who can operate the machinery (Yu, 2019).

The linkage of this machinery to one central hub can enable a controller to work more efficiently and diagnose issues as they arise (Bloem, 2014). Different types of augmentations to work that was previously achieved by manual labor can greatly increase efficiency. Romero, 2016, describes virtual operators, who deal with digital renderings, 'smarter' operators, who work with displays of live-updating data, and collaborative operators, who function as an extension of the machine and directly assist it in accomplishing a task. These different types of automative assistance positions can augment considerable additional value of labor for individual employees.

These new duties arising as types of 'Operator 4.0' require not only cooperative work with robots, but also work aided by machines if necessary (Romero, 2016). These aspects of 'extreme automation' and 'hyper connectivity' are hallmarks of what has been considered by some the 'Fourth Industrial Revolution' (Tan, 2017). This fundamental change in how automation used to function in facilities, and what it is capable of now, is essential to continual improvements of the optimal labor-automation mix. For a facility seeking to capitalize on these changes, understanding what distinguishes the fourth industrial revolution from the third can enable them to check if they are adapting in the right areas (Bloem, 2014).

Hypotheses Development

Work Type and Skill -> Labor Achievement

Historically, labor most suitable to be made redundant by automation is work which is an easily replicable, repeated process, such as positioning parts prior to being drilled. In the 1950s, when base level automation came to the Ford plant in Brook Park, an area of the assembly line which used to have 117 men to operate could instead be run by 25 (Meyers, 2002). More generally, a scenario where automation is most warranted is when a large workforce exists, there are low costs associated with maintaining automation, and the facility currently has a low level of automation (Gaimon, 1985). A distribution center with high staffing and exclusively floor

storage meets these criteria. To successfully automate a task, the task must be clearly defined and understood (Agutter, 2013). Logically, this task would only contain a few elements or be repetitive in nature. Limiting variety in the task can make it done in the same manner repeatedly and not require any thought to be accomplished.

Work in base-level, pacesetting tasks is likely to be the most suitable for improvement by automation. The intrinsic repetitive nature of these tasks potentially creates the availability for significant time savings and efficiency improvement. Further, the shift of these most basic tasks to be achieved by machines can raise the productivity of the entire facility. In raising the speed with which tasks are accomplished in one easily automated area of the facility, this has the potential to pressure manual laborers in other regions of the distribution center to work faster.

Thus, it can be theorized that:

H1. Automation increases worker efficiency the most in tedious or repetitive tasks.

H2. Automation has the potential to fatigue workers by raising the level of work for human operators to achieve.

Acceptance by Facility -> Worker Efficiency

For workers whose facilities adopt automation, it can be a learning experience. Throughout the transition process, it can be difficult for workers who previously did tasks entirely on their own to now work alongside automation. For tasks which the operator feels comfortable doing on their own, factors such as training, self-confidence using the automation, automation reliability, and prior experience with the automation play an important role (Riley, 1995). While Riley, 1995 is referring to the significantly higher-stakes of fly-by-wire automation, the comparison is adept at observing people who felt considerable confidence in their abilities and now must learn a new way to do a task.

For a facility which has transitioned from manual fulfillment to automated inventory management, it makes sense for workers to be skeptical of the new technology. They may feel usurped by robots and require additional convincing that the automation is a good thing. That is

why it is so important for workers whose roles change to receive part task training (PTT) when learning to use elements of automation (Gutzwiller, 2013). Their smooth adaption to their new work circumstances is critical to the efficiency of the transition of the facility.

Ultimately, worker efficiency is likely to be impacted by the workers perception of the automation, as well as how easy it is for them to pick up and use.

Thus, we propose the following:

H3. Automation's perceived usefulness has a positive relationship with worker efficiency.

H4. Automation's ease of use has a positive relationship with worker efficiency.

Displacement and Reinstatement Effect -> Movement of Labor

The displacement effect of automation is when capital takes over a task previously accomplished by labor, or when a job is made redundant by automation accomplishing the task easier (Acemoglu, 2019). This effect is very well documented, for example, with the development of the tractor displacing agricultural workers in the 20th century (Olmstead and Rhode, 2001). However, this effect is typically countered by a strong reinstatement effect, where work is brought back into a larger variety of tasks, which again changes the balance of tasks in favor of labor (Acemoglu, 2019). This concept of jobs being eliminated and brought back but in a different capacity relates strongly to not an elimination, but a movement of labor to different fields.

"Journalists and even expert commentators tend to overstate the extent of machine substitution for human labor and ignore the strong complementarities between automation and labor that increase productivity, raise earnings, and augment demand for labor." (Autor, 2015). Within this quote, Autor emphasizes how machinery substituting labor is exaggerated but rising earnings and augmenting additional labor is ignored. This sensationalism tends to give automation a negative perception while it very well could be positive and improve the quality of labor.

Testing these presuppositions of prior literature, the following hypothesis is brought forth:

H5. Automation causes a movement of work from low-skilled positions to higher-skilled positions.

Easy Scheduling and Planning -> Worker Efficiency

A critical element to the success of automation is the ability to manage the speed with which it must operate, and how much time it has to accomplish tasks. Further, managers must decide the speed with which to transition their facility from manual to automated labor. A 'radical' timing strategy, which involved a fast transition, or an 'evolutionary' or continuous timing strategy can both be effective depending on the circumstances (Gaimon, 1985). According to Gaimon, 1985, the competitiveness of the industry the firm is in is another important deciding factor.

Moreover, the demand environment for a firm deciding on automation is important to determining how efficient it will be. In a stable supply/demand environment, more extensive planning is possible and load management for an automated system is easier to achieve. Based off the nature of the products being managed by Operations Company X, their supply/demand environment is likely a stable process of functional products. This stable environment with predictable demand, low breakdowns, and longer lead times would be perfect for long-term planning and coordination (Lee, 2002). That type of environment would seem ideal for the successful implementation of automation. Therefore, the ability to monitor and mitigate the strain placed on automation by successful planning could improve its efficiency. With more a more predictable demand schedule, workers could be effectively allocated and be given the ideal level of work to be most efficient in conjunction with the automation.

Thus, the following hypothesis was formulated:

H6. Automation in a stable demand environment has a positive relationship with worker efficiency.

Hypotheses

H1. Automation increases worker efficiency the most in tedious or repetitive tasks.

H2. Automation has the potential to fatigue workers by raising the level of work for human operators to achieve.

H3. Automation's perceived usefulness has a positive relationship with worker efficiency.

H4. Automation's ease of use has a positive relationship with worker efficiency.

H5. Automation causes a movement of work from low-skilled positions to higher-skilled positions.

H6. Automation in a stable demand environment has a positive relationship with worker efficiency.

METHODOLOGY

This methodology section will consist of three subsections which relate to each of the three methodologies used to conduct research for this paper, the archival analysis, surveys, and interviews.

Archival Analysis Methodology

Shipment information from 2017 through 2020 was made available to be used in this study. This information was locked in an inefficient, day-by-day interface where the data was stored using three tables: Retail Sales, Food Service sales, and Mixed Shipments. This outdated storage method had no export function. The data had to be pulled from this interface by copying it three times from all three tables for each day before pasting it into a unified form in Excel. This data was compiled for the entire year of 2017 and 2020, as well as May through July of 2018 and 2019.

This quantitative data was gathered throughout the Summer of 2020 and in January of 2021. The data stored contained the information in Figure 1, which can be seen below.

Date	Load	First Stop	Carrier	Appt Time	Driver Dep	Driver In	Load Start	Load Stop	Plts In	Plts Out	Plt Pos	Loader	Elap	Earn	Var
Jan-2-2017	366-03	SUPERMARKET LOCATION	Production Company Y	11:00 PM	10:25 PM	9:00 PM	9:14 PM	10:25 PM	0	34	24	9939	71	58.7	-12.3

Figure 1 – Sample Cross Section of Archival Data Gathered

For each shipment, the above information was stored. The meanings of each term in the table are given on the next page, in Figure 2.

Date	The date the order was scheduled to be shipped
Load	The order number (Load # and Order # are interchangeable terms)
First Stop	The first destination the delivery truck is taking the shipment
Carrier	The company which was contracted to deliver the load to its destination
Appt Time	The time the truck was scheduled to arrive to pick up the order
Driver Dep	The time the truck left this facility with their shipment
Driver In	The time the driver of the truck arrived at the facility and loading the truck could commence
Load Start	The time that a loader was assigned to fill the truck which arrived with the order.
Load Stop	The time the loader finished placing the entirety of the order into the truck
Plts In	The number of pallets arriving on the truck
Plts Out	The number of pallets being shipped away from the facility in the truck
Plt Pos	The number of eligible pallet positions within the truck (Typically 24)
Loader	The I.D. number for the employee who loaded the truck
Elap	The number of minutes which elapsed between load start and load stop time.
Earn	The number of minutes it would be expected for this worker to take to complete this load
Var	The difference between how long the loader should have taken and how long they took
Comment	Where was the load shipped from? Are there any special conditions for this load? Was this truck held up due to Waiting on Product?

Figure 2 – Archival Column Term Definitions

This data was organized by date. For 2017, there were 5,847 rows of data. For 2020, there were 12,134 rows of data. Next, three additional columns were added to the sheet exploring three aspects which are critical to the analysis of the data, “Time to Completion”, “Minutes per Pallet”, and “Shipped Late?”. Their meanings are in Figure 3, on the next page.

Time to Completion	Calculates the difference between the arrival time of the truck and when the load was completed. Determines the amount of time the truck spent at the facility waiting for the load to be completed.
Minutes per Pallet	Using the 'Time to Completion' above, as well as the "Plts Out" column, determines how many minutes, on average, it took the loader to load one pallet.
Shipped Late?	Using rules implemented by Production Company Y, determines if the shipping contract was violated and the truck was shipped late. Determines if it took over two hours to load the truck from either the time the truck arrived, or the truck's appointment time, whichever was latest.

Figure 3 – Additional Column Descriptions

Next, data from a different source was considered. Several important Key Performance Indicators (KPIs) were provided for additional consideration. The KPIs supplied were labor cost, cost-per-case, and ship accuracy. These metrics are tracked on a weekly basis.

Based off interviews and discussions with Operations Company X employees, certain considerations were given to the dataset when calculating some values. For example, Production Company X has their own fleet of trucks for movement of product between their facilities, and these loads are typically pre-filled the day (or days) before the shipment is sent out. Therefore, when tracked in the system, accurate numbers for these loads are impossible. Typically, these numbers are tracked through scan gun activity and monitoring by the office clerk, however due to the spread out and preemptive nature of these loads, the numbers are not accurate. Therefore, this data has been excluded from the dataset regarding late loads and late percent.

Additionally, this facility utilizes a dock door locking mechanism where a claw grabs onto the bumper of the trailer and prevents it from moving while it is being loaded. This is so that forklifts moving in and out of a trailer do not cause the trailer to move. Within this dataset, smaller loads (less than three pallets) are often shipped in small trucks with lift gates which the locking mechanism cannot grab on to. Operations Company X's policy for this building is that if the truck cannot be properly hooked, forklifts cannot drive into the trailer. Therefore, a pallet

jack must be used to load these types of trucks with their pallets. The pallet jack is typically done by the truck driver themselves. Due to the unpredictable nature of loads this small, as well as the fact they are typically not loaded by Operations Company X staff, it would not be beneficial to look at loads involving less than three pallets when calculating late loads or late percent.

The data for the years of 2017 and 2020 was broken down by month into two tables for easier comparison. The tables included factors which will be important for the analysis of the data, including total shipped, number late, ship errors, ship cost, total cases moved, and cost per case.

Survey Methodology

To conduct the survey for this project, we first examined the hypotheses of the project to determine which areas would be most beneficial for us to focus on with our research. The hypothesis points identified whose points could best be resolved using a survey are below:

H1: *Automation increases worker efficiency the most in tedious or repetitive tasks.*

H2: Automation has the potential to fatigue workers by raising the level of work for human operators to achieve.

H3: Automation's perceived usefulness has a positive relationship with worker efficiency.

H4: Automation's ease of use has a positive relationship with worker efficiency.

These points were especially identified because the perception of the average employee is relevant to answering them. For H1, it would be useful to identify or substantiate the fact that employees at the facility feel their work is in fact tedious and repetitive. By cross referencing their job duties with their answers for this series of questions, we can begin to uncover their perception of the 'repetitiveness' of their work, and if automation improves it.

For H2, this hypothesis point is essentially exclusively answered through the use of this survey. Do the workers feel tired/worn out? Can it be proven their survey answers that the automation is the cause of this exhaustion?

In H3, we must first prove that the workers perceive the automation as "useful" before any progress can be made. Employee perception of automation is best explored by asking the employees themselves how they perceive the automation.

In a similar vein to H3, for H4, the best way to explore employee perception of ease of use is to ask them. In order to explore how ease of use impacts efficiency, first, do the workers perceive the automation to be easy to use?

Research Instrument

This research is focused on uncovering the impact of automation in a distribution center for Operations Company X. When modeling an appropriate survey, several factors were considered to properly explore the different elements automation impacts within the facility. A preliminary factor analysis model was constructed based on appropriate categories and data gathered from the above literature review. The basis for development and related references of the survey questionnaire items is enumerated in Figure 4.

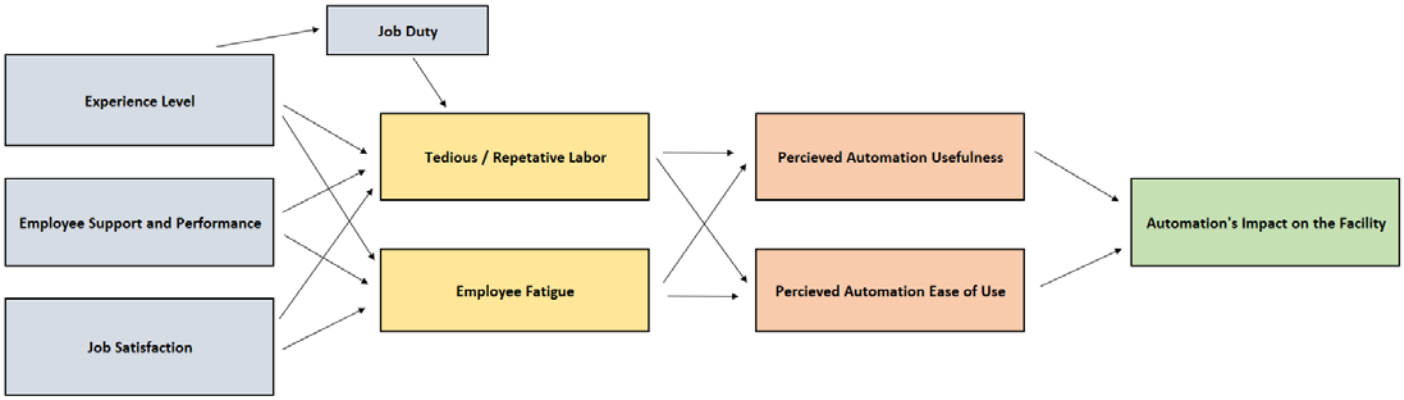


Figure 4 – Preliminary Factor Analysis Model

Questionnaire Instrument

We used an iterative process to develop the final measuring instrument for the study. This process began by evaluating the elements of the hypothesis present in the study which needed to be tested. These elements were extracted and reduced into simpler, arching categories which could be more easily evaluated. The categories identified for the study were different dimensions which could evaluate the impact of automation on the facility. These elements were then researched within peer reviewed articles to uncover potential questions which would be viable to use as measures of these factors, suitable for further analysis. After further evaluating the questions were suitable to measure the categories, a finalized list of 33 questions was developed and implemented.

To effectively measure the scores given by respondents to the survey, a six-point Likert scale was utilized anchored at (1 = Strongly Disagree) to (6 = Strongly Agree). The scale was used to

evaluate the extent to which a respondent agreed with the statement given. A Likert scale was chosen because it is commonly involved in research that employ questionnaires and has been effective in measuring employee job satisfaction (an element we are attempting to measure) in the past (De Silva, 2014). For some questions, such as demographics, a nominal measurement was used. For a single question, an ordinal one to ten scale was used (rating their quality of work in the previous four weeks). After deciding on the scale, we researched other successful academic surveys which have been able to accurately measure the attributes within our factor analysis model. The questions used, as well as the reference for their studies, are included below in Figure 5. The six demographics questions are not included on this chart and will be discussed later.

#	Scale Items	Reference
1	I have experienced that Operations Company X provides enough support for employees during peak periods.	(Borowska-Pietrzak, 2011)
2	I have sufficient professional knowledge to do my job at a high level	(Borowska-Pietrzak, 2011)
3	My closest manager motivates me through clear and constructive communication	(Borowska-Pietrzak, 2011)
4	How would you rate your overall job performance on the days you worked during the past four weeks?	(Okazaki et al, 2019)
5	I am given adequate information on how well I am performing at my job.	(Lambert et al, 2011)
6	I have an interesting and stimulating job.	(Borowska-Pietrzak, 2011)
7	I have enough variation in my job.	(Borowska-Pietrzak, 2011)
8	I look forward to changes within my work environment.	(Vakola & Nikolaou, 2005)
9	If a new organizational change program is initiated, I will emphatically show my agreement.	(Vakola & Nikolaou, 2005)
10	My work makes me feel mentally exhausted.	(Lheureux et al, 2017)
11	I feel tired when I get up in the morning and have to face another day of my job.	(Lheureux et al, 2017)
12	I have sufficient time to do my daily tasks.	(Borowska-Pietrzak, 2011)
13	I feel like I am working "too hard" in my job.	(Lheureux et al, 2017)
14	I feel exhausted at the end of my day.	(Lheureux et al, 2017)
15	Automation helps me be more efficient at my job.	(Venkatesh & Davis, 2000)
16	Automation reduces wasted time in my job.	(Venkatesh & Davis, 2000)
17	Using the automation in my job improves my productivity.	(Venkatesh & Davis, 2000)
18	My interaction with automation is clear and understandable.	(Venkatesh & Davis, 2000)
19	I find the automation useful in my job.	(Venkatesh & Davis, 2000)
20	Using the automation improves my effectiveness in my job.	(Venkatesh & Davis, 2000)
21	I find the automation to be easy to use.	(Venkatesh & Davis, 2000)
22	I find it easy to get the automation to do what I want it to do.	(Venkatesh & Davis, 2000)
23	I am very satisfied with my current job.	(Borowska-Pietrzak, 2011)
24	The expectations of my job have been fulfilled.	(Borowska-Pietrzak, 2011)
25	My job does not allow me much opportunity to make my own decisions.	(Lambert et al, 2011)
26	I value doing my work as well as possible.	(Borowska-Pietrzak, 2011)
27	There are good opportunities to find interesting and new challenges at Operations Company X.	(Borowska-Pietrzak, 2011)

Figure 5 – Survey Questions and References

Due to the nature of the group the survey was to be conducted on, the survey was available in both English as well as Spanish. The survey was translated into Spanish by Jane Rizzitano, a Spanish language professor at Framingham State University, and verified by Michael Gravier, professor at Bryant University and proficient speaker of Spanish.

After deciding on the questions to be included in the survey, an updated version of the factor analysis model was able to be created where the questions intended to measure each category could be attributed to their anticipated grouping. In Figure 6 on the next page, the questions have been grouped as such.

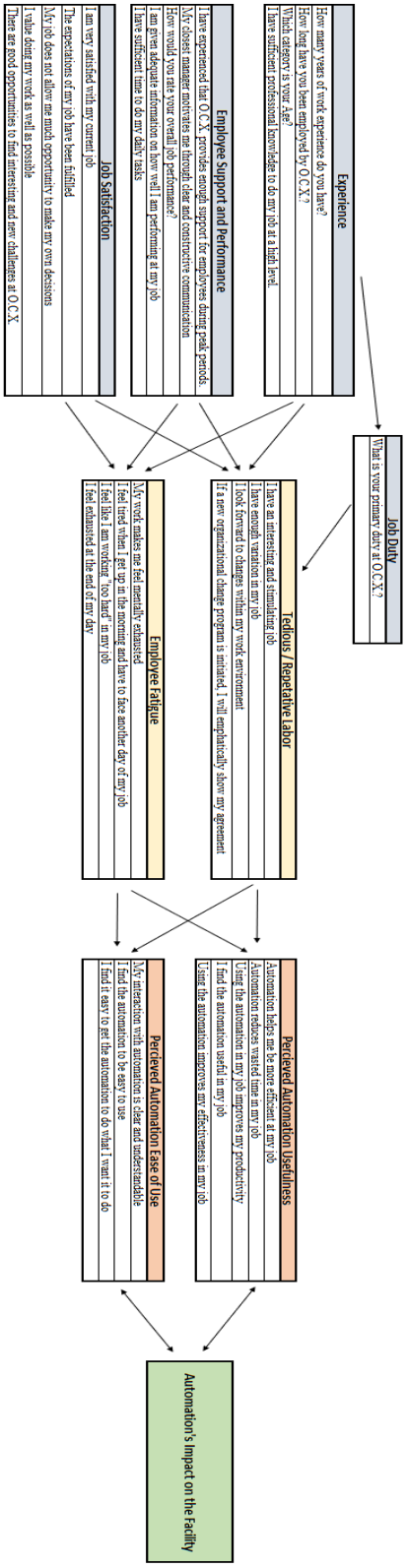


Figure 6 – Preliminary Factor Analysis Model with Anticipated Question Groupings

On 7/26/20, a copy of the finalized questionnaire was submitted to the Bryant University Internal Review Board to evaluate it for potential risks. Due to the multiple languages spoken by employees at Facility X, the survey was designed to be made available in both English and Spanish. After receiving approval from the Bryant Internal Review Board on 8/4/2020, the survey administration began at the facility.

Throughout the month of August 2020, all surveys were administered and collected. Of 61 eligible respondents within the facility, 57 were surveyed. Two surveys were rejected due to their several incomplete questions. This response rate of 90.2% of all eligible employees within the facility is high enough to be representative of the views of workers at the facility. The demographic distribution of the 55 usable responses – the gender distribution – shows that 85% of respondents were male, while 9% were female. 55% of respondents were Hispanic, while 29% of respondents were White. All survey demographic information can be seen in the Figure 7 below.

How long have you been employed by Operation Company X?		How many years of work experience do you have?	
Not Employed by O.C.X.	9.1%	0-5 years	21.8%
Less than 1 year	27.3%	5 - 10 years	20.0%
1 - 3 Years	20.0%	10 - 20 years	18.2%
4 - 6 years	23.6%	20 - 30 years	16.4%
More than 7 years	20.0%	30+ years	23.6%
How old are you?		What is your race?	
Prefer not to answer	3.6%	Asian	3.6%
21 - 29	12.7%	Black or African American	1.8%
30 - 39	30.9%	Hispanic	54.5%
40 - 49	21.8%	Multiple Races	1.8%
50 - 59	23.6%	Prefer not to answer	9.1%
60+	7.3%	White	29.1%
What is your Gender?			
Female	9.1%		
Male	85.5%		
Prefer not to answer	5.5%		

Figure 7 – Survey Demographic Information Table

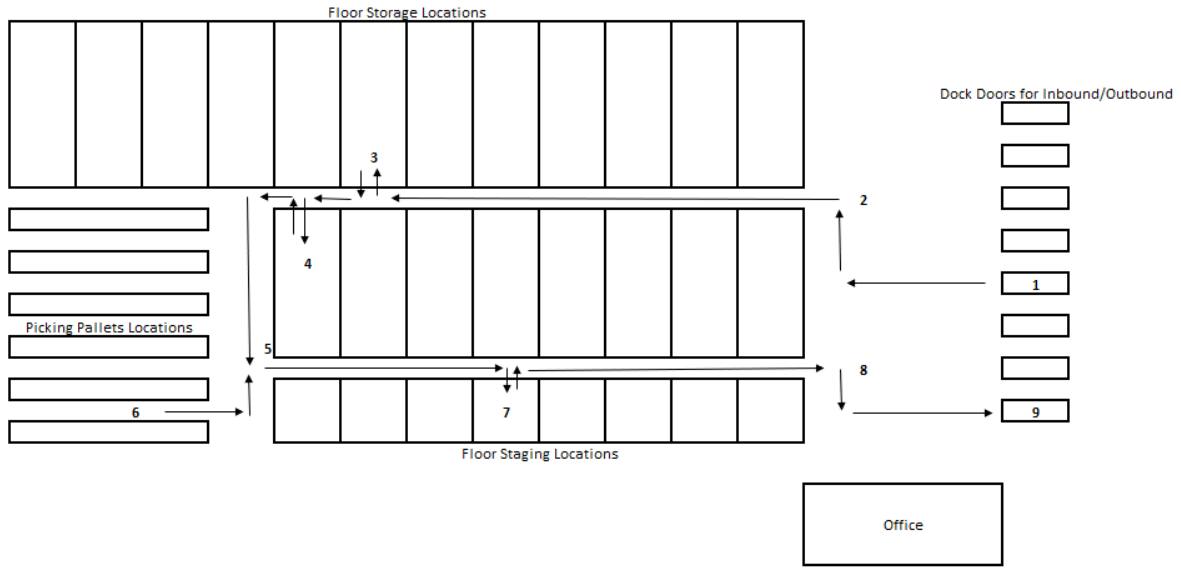
Interview Methodology

Five managerial candidates were selected to take part in an interview regarding the operations of the facility pre-instalment of the automation, to compare it to operations which took place post-automation implementation. Due to the impossibility of truly observing the operations of the facility in the past, to improve the understanding of operations, two diagrams were created. Two supervisors assisted in the creation of these diagrams which encapsulate the activities which occurred prior to automation, and after it became operational at the facility. This was done to understand what functions specifically changed due to the implementation at the facility.

Figure 8 is the flow of a pallet arriving, being stored at, then leaving the facility pre-automation.

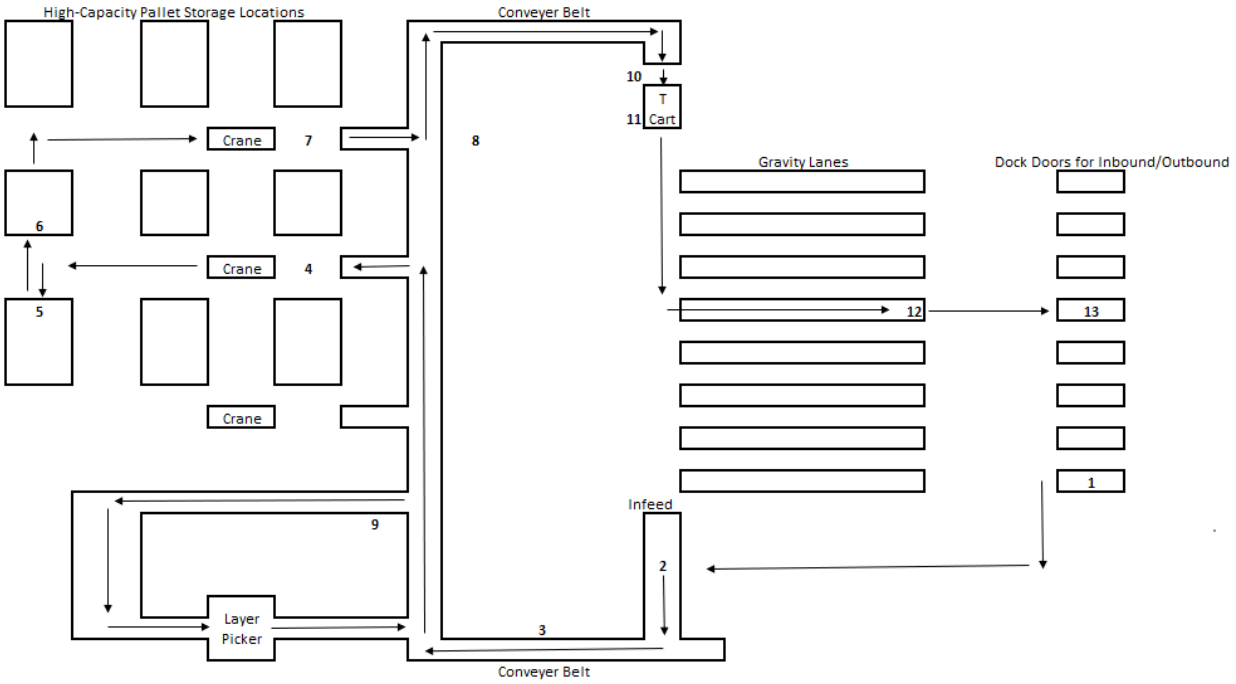
Figure 9 is the flow of a pallet arriving, being stored, and leaving post-automation.

Figure 8 - Pre-Automation Flow Model



Pallet Flow Diagram - Pre-Automation	
Step One	Trucks arrive from plant with finished goods
Step Two	Trucks are unloaded via forktruck and the driver searches the floor locations for an empty space - They will check locations where the item is already but if space is limited, they must find a new completely empty spot.
Step Three	Once an empty space is found, the forktruck driver unloads the pallets into a floor location.
Step Four	Another forktruck driver comes along later with the task of 'Consolidation' who tries to group together different locations with the same item to free up floor space. Additionally, they organize by FIFO.
Step Five	Once an order is received for outbound pallets, an office worker prints the labels and assigns the order to a forktruck driver. The forktruck driver then gathers the required pallets and brings them to a staging location.
Step Six	At the same time that a worker begins to stage the pallets for an order, a picker is assigned the task to create the partial pallets for the order.
Step Seven	All pallets required for an order are staged and prepped with labels for when the outbound truck arrives.
Step Eight	Once the outbound truck arrives, the forktruck driver drives back and forth between the staging location and outbound truck to move all the pallets into the truck.
Step Nine	After verifying the truck has been fully and correctly loaded, it is sent off with the pallets to its next location.

Figure 9 - Post-Automation Flow Model



Pallet Flow Diagram - Post-Automation	
Step One	Inbound deliveries of finished goods arrive from the production plant
Step Two	Pallets are unloaded from the inbound trucks via forktruck and placed onto the infeed conveyer belt where they are scanned into the WMS and enter the automated system
Step Three	Pallets continue along the conveyer belt into the system on their way to a storage location
Step Four	Pallets reach the multi-story high cranes which individually take pallets and deliver them to their storage location in the racking.
Step Five	Via crane, pallets reach their putaway location where they sit near other pallets of the same product.
Step Six	Pallets may be moved at a later time after their arrival in a process called "Rewarehousing" where the system consolidates different locations for the same product into larger spaces which can house all of that type of product
Step Seven	When an operator inputs an order requiring a specific pallet in storage, the machine sends a crane to retrive it and pull it down from the racking.
Step Eight	From here, the pallet can go in two directions. Either back towards the "Layer Picker" if less than a full pallet of the product is needed, or off towards the outfeed if an entire pallet of the product is required.
Step Nine	If the pallet goes back to the layer picker, the shrinkwrap around it is cut, and an industrial vaccume arm will remove the top layer of product on the pallet and place it on another partial pallet, where the machine can mix and match layers of required products for orders.
Step Ten	Pallets which have been through the layer picker and made into a partial pallet will join the full pallets heading to the queue to be automatically labled and sorted into gravity lanes by T-Carts
Step Eleven	Pallets are automatically placed onto a T-Cart, which drives the pallet down infront of the gravity lane in front of the desired door, and drops them onto it.
Step Twelve	Pallets are loaded one by one into the gravity lane until all the pallets required for an order have been queued infront of the desired door, awaiting the outbound truck's arrival.
Step Thirteen	Once the outbound truck arrives and is given the door across from the correct gravity feed, a fork truck will unload the pallets from the gravity feed into the outbound trailor. Once the order is filled and the quantity verified, the outbound truck will leave and bring the pallets to their next destination.

After the construction of these diagrams, certain areas of focus were uncovered to be relevant to explore further with the interviews. First, specific task differences and duties of employees was deemed to be necessary to explore. Next, situations the automated system currently excels/struggles with should be explored. Finally, areas which the automation is anticipated to improve and what went well with its implementation must be looked at.

The structure of the interviews was developed to be semi-structured, where the first question is asked of all respondents, and depending on the areas of interest which the respondent brings up, follow up questions are available below it.

The content of the interview questions is in Figure 10.

Automation Interview Questions

1. What was working at this facility like before automation?
   - → What was the available level of work like?
   - → What was the general attitude towards work?
   - → Were there distinctive problems with the pre-automation facility? What were they?
2. What sorts of tasks were present at this facility pre-automation, and what sorts of tasks exist exclusively post-automation?
   - → Has the quality or content of work changed in your eyes?
3. What situations does this automation seem to work best in?
   - → What situations does it struggle? Are these struggles expected to be a long-term drawback of the machine, or is there an imminent fix available?
4. It is my understanding there is a 'busy' and 'slow' season for this facility – Does the automation seem to be able to keep up with the 'busy' season? Does it feel like overkill in the slow season?
   - → Does automation allow for less workers to be staffed in the slow season? Does it allow for less to be staffed in the 'busy' season?
5. How has automation effected the output for this entire facility? How has it effected the available level of work for employees to do?
   - → Does it ever feel like the physical employees cannot keep up with all the work available? What are the most important KPIs used at this facility? Has automation improved them?
6. How have expectations for this machine effected the work environment here?
   - → Has automation met these expectations? Is it able to meet these expectations soon?
7. How has the quality of staffing positions here changed due to automation?
   - → Have you noticed more high-quality positions available, such as supervisors, management, attendants? Has hiring been more internal to capitalize on lower-level worker familiarity with this automated system?
   - → Has automation caused you to look for different qualifications for potential new employees, or focus training on different sets of skills?
8. How satisfied are you with the execution of how this automation system was installed?
   - → How do you get support when you have a problem with this system? How were you trained to use this system? Who at this facility receives this training?
9. What is the biggest issue in the way of the efficiency of this facility?
   - → Does automation do anything to resolve this? How does this issue impact automation?
10. How has automation impacted your job?
    - → What advice would you give to another facility think of using a similar automated system?

Figure 10 – Interview Questions

After constructing the set of interview question, five potential respondents were selected from the facility to be interviewed. All of them consented to the interview and signed a strict-anonymity form. The interviews were designed to take roughly a half an hour to forty-five minutes and be taken in a one-on-one environment without distractions.

Question responses were tracked exactly as stated on paper, with a pencil and clipboard at the time of the interview. Respondents were asked to slow down or repeat answers for the sake of maintaining the integrity of a precise set of notes. Immediately after the interview, these notes were translated into Microsoft Excel in a format more conducive to be analyzed later.

RESULTS

This results section will consist of three subsections which relate to each of the different methods used, the archival analysis, surveys, and interviews.

Archival Analysis Results

Results were drawn from the archival data through the comparison of the 2017 monthly numbers with the 2020 numbers. There were eight categories considered, Total Shipped, Number of Late Loads, Late Percent, Average Time per Pallet, Ship DPPM, Labor Cost, Total Cases Moved, and Cost per Case. While substantive numbers would be best to show in this case to specifically address elements of the impact of automation, Operations Company X has expressed it would prefer any writeups to not release comprehensive tracking of business-critical information, such as Late Percent, Time per Pallet, Labor cost or Total Cases Moved. However, DPPM is acceptable to disclose.

Due to their incredible cooperation to supply access to their database of information, it is acceptable to follow their request. For the following section, numbers will be referred to as a percentage change from pre- to post- automation numbers in 2017 and 2020. For example, for January's data relating to shipped quantity, a percentage of positive 67% means that the quantity of shipped pallets leaving the facility increased by 67% looking at January 2017 and January 2020. While positive percentages indicate an increase in the number for their respective months, a negative percent is indicative that the number was lower in 2020 than 2017.

For this data, an unfortunate combination of lapse by Operations Company X management and the COVID-19 pandemic caused for several important categories to not be properly tracked between January 2020 and May 2020. Labor Cost, Cost per Case, and Total Cases Moved were not tracked for the five months stretch from January to May 2020, and comparison cannot be performed. Due to the irregular nature of the numbers in other, complete data tables, it would be inappropriate to attempt to extrapolate these numbers as well. Therefore, for this dataset, those months will remain blank.

When calculating the percentages used in the tables below, the following formula in Figure 11 was used. This was to give the best impression of the increase from 2017 to 2020 in the values.

((2020 Month X Value - 2017 Month X Value) / 2017 Month X Value)
(Change from 2017 to 2020) / (2017 Value)

Figure 11 – Percentage Formula

Total Shipped Quantity

The total shipped quantity refers to the number of outbound shipments which were sent out of the facility for their respective month. It is most compelling to look at the data regarding outbound shipments because the speed with which Operations Company X can get trucks in and out of their facility relates to how efficient they are.

One of the primary stated purposes of the automation's implementation was to increase the throughput of the facility, specifically pointing at a desire to increase the quantity of pallets it can ship.

Figure 12 shows the increase in shipped quantity by month between 2017 and 2020.

Change in Total Shipped Quantity from 2017 to 2020											
January	February	March	April	May	June	July	August	September	October	November	December
66.84%	76.52%	68.87%	59.53%	61.78%	105.48%	146.08%	131.73%	222.91%	216.92%	178.82%	113.07%

Figure 12 – Change in Quantity Shipped

In Figure 12 above, for the months of January through May, you can observe a very solid increase in shipped quantity by roughly 67% per month. However, starting in June, roughly six months after the automation began being used more extensively, the increase in throughput notably increases. For the remainder of 2020, the total shipped quantity was up an average of 159% over the 2017 numbers. These numbers are largely buoyed by incredibly impressive

performances for the facility in September and October, where the facilities' shipped quantity was up 222.91% and 216.92%, respectively.

In the interpretation of these numbers, the inherent seasonality of products supplied by the facility cannot be ignored. Figure 13 translates the percentage of the total shipped quantity for the following months relative to the total quantity for the year.

	January	February	March	April	May	June	July	August	September	October	November	December
2017	9.6%	7.9%	9.8%	9.4%	14.2%	10.6%	7.2%	7.8%	5.5%	5.6%	5.5%	6.8%
2020	7.8%	6.7%	8.0%	7.2%	11.1%	10.5%	8.5%	8.7%	8.6%	8.5%	7.4%	7.0%

Figure 13 – Change in Percent of Quantity Shipped

For Figure 13, it represents the percentage of the total shipped quantity for each month of the year as it related to the total shipped for that year. Notably, the month of May and June seem to have an elevated percentage of the total shipments within that month relative to the whole year. This lines up with what was expected due to the seasonal nature of the products supplied. One other notable fluctuation is that the peak shipment month of May has a peak 2.9% lower in 2020 than 2017, emphasizing the more even distribution of shipments across all months now.

In fact, the months which witnessed some of the larger increases in total shipped quantity experienced the largest increases in total-yearly throughput increasing for that month. September and October, our two largest increases in Total Shipped Quantity percent, had the largest increases in percentage of total for the year of any months. September and October witnessed their share of the yearly shipped quantity increase by 64% and 66%, respectively.

While this stark change in shipment scheduling tendencies cannot be ignored, it also does not make up for the entirety of the difference for those months. Even making allowances for the increase in quantity due to scheduling differences, there is still an increase in shipped quantity for those months which is anticipated to have been caused by automation.

Number of Late Loads

The number of late loads for each respective month relates to how many shipments did not leave within their permitted window and violated elements of the shipping contract signed by Operations Company X. A late load is defined as a load which took greater than two hours to ship from either the appointment time, or truck arrival time, whichever was latest.

For Figure 14, we can observe the change in total number of late loads between 2017 and 2020. Due to the increase in total shipped quantity, this chart is not anticipated to be overwhelmingly helpful in determining the impact of automation, as an increase in total shipped quantity would be expected to create an increase in total late shipped, regardless of automation.

Change in Number of Late Loads from 2017 to 2020											
January	February	March	April	May	June	July	August	September	October	November	December
233.72%	284.13%	162.92%	194.23%	70.05%	309.26%	247.92%	156.12%	314.04%	282.50%	144.68%	209.09%

Figure 14 – Change in Number of Late Loads

As can be seen, the number of late loads increased significantly between 2017 and 2020. In fact, outside of the relatively low 70% increase for the month of May, every other month witnessed an average of a roughly 230%. This means that, for example, if August has 100 late loads, an increase of 156% is equivalent to a 2020 late load number of 256.

The 309% increase for the month of June is particularly interesting, as it emphasizes a significant increase in late loads which is beyond what could possibly be simply accounted for by the increase in shipped quantity.

For Operations Company X, the 70% increase for the month of May is a clear outlier, but it is due to an outrageously high late percent in 2017 rather than an impressive performance in May 2020. Referencing Figure 13 again, with the percentage of total shipped quantity broken down by allocation across months, the month of May at 14.2% is almost 4% higher than any other month. Clearly, Operations Company X experienced particularly uneven truck scheduling which caused an incredible increase in late loads for that month compared to their average month. The lower peak May figure for 2020 and more dispersed totals for later months could possible be due to this incredibly spike in late shipments for May 2017.

Monthly Late Percent

The monthly late percent accounts more for the increase in shipping quantity rather than the prior section, which measured more just the impact of the increase in shipped quantity. By comparing percentages, we can get a clearer picture of the state of the facility for each month relative to how many loads needed to be shipped that month. Figure 15 shows the change in late percent from 2017 to 2020.

Change in Month Late Percent from 2017 to 2020											
January	February	March	April	May	June	July	August	September	October	November	December
100.02%	117.61%	55.69%	84.44%	5.11%	99.17%	41.38%	10.53%	28.22%	20.69%	-12.24%	45.07%

Figure 15- Change in Late Percent

Most interesting in this graph is the presence of the first clear improvement in a positive category beyond shipped quantity for the post-automation facility. November of 2020 had a late percent 12.24% lower than the corresponding month in 2017.

While the first half of the year looks as though there is a notably higher increase, this is contrasted by the second half of the year where the late percent finally begins to get back under control and, accounting for the increase in throughput, become more what would be anticipated.

Again, the month of May looks particularly impressive due to only a 5% increase in late percent. Being surrounded by April, with 84.44% late and June with 99.17% late increase makes it appear to be a massive anomaly, which is accurate. However, remember that the reason for this number is likely not due to an improvement in 2020, but rather the massive quantity of shipments occurring in May of 2017 which caused a large spike in late percent and late load count for that month.

Average Time per Pallet

The average time per pallet is how long, in minutes, it took for the person responsible for loading the outbound orders to move a pallet from the staging area into the truck. This statistic looks at how long it took for the order to be completed after the truck “arrived” or its appointment, whichever is later, and adjusted based on the size (in # of pallets) the order was.

Essentially, it considered that based on when the truck was 'on the clock' to be shipped out, how long it took per pallet for the shipment to occur. Figure 16 shows the change in time to ship outbound pallets from 2017 to 2020, by month.

Change in Average Time per Pallet from 2017 to 2020											
January	February	March	April	May	June	July	August	September	October	November	December
42.72%	36.90%	20.84%	87.13%	32.50%	60.58%	50.06%	20.13%	25.68%	13.82%	13.13%	21.35%

Figure 16 – Change in Time per Pallet

The average time per pallet follows a similar trend to the late percent, as it takes relatively longer early in the year, then the numbers begin to settle down later in the year closer to the old, pre-automation percentages.

Ship DPPM

Ship DPPM considers the number of orders shipped as well as the number of shipping errors within that quantity of orders. For the following Figure 17, the row for 2017 can be compared with the corresponding numbers for 2020.

	Change in Ship DPPM from 2017 to 2020											
	January	February	March	April	May	June	July	August	September	October	November	December
2017	3979	0	1267	1221	957	0	2535	2963	1414	0	0	5563
2020	4665	7612	3214	4938	2799	1706	2032	2472	0	858	1136	0

Figure 17 – Change in Ship DPPM

Labor Cost

Labor cost looks at how much it cost for all of the employees within the facility to be paid for that particular month. According to the interviews conducted, the relative number of employees in the facility between 2017 and 2020 is very similar. Therefor, some of this percentage change is due to inflation, rising wages, and more expensive or higher skilled labor being performed post-automation as opposed to pre-automation.

Figure 18 shows the percent change in cost of labor between 2017 and 2020.

Change in Labor Cost from 2017 to 2020											
January	February	March	April	May	June	July	August	September	October	November	December
N/A	N/A	N/A	N/A	N/A	26.37%	8.10%	34.98%	11.44%	9.93%	10.60%	48.32%

Figure 18 – Change in Cost of Labor

Labor cost did increase from 2017 to 2020, however not in the same proportion to the percentage increase of throughput for the facility. Outside of spikes in June, August, and December, the labor cost actually remained relatively stable. This is actually surprising in July, September, October and November as a larger percentage of the total number of shipments for the year was conducted in those months in 2020 than 2017.

Total Cases Moved

The total cases moved considers a category of product not accounted for in the other prior sections of this analysis, which are the inbound shipments of product. This category is the combination of the total number of cases inbound for the facility as well as outbound. Figure 19 shows the increase in the number of cases moved between 2017 and 2020.

Change in Total Cases Moved from 2017 to 2020											
January	February	March	April	May	June	July	August	September	October	November	December
N/A	N/A	N/A	N/A	N/A	38.64%	50.95%	72.09%	109.67%	59.17%	68.03%	83.14%

Figure 19 – Percent Change in Total Cases Moved

For the months available to analyze, this chart shows a clear increase in the number of cases processed by the facility in 2020 compared to 2017. However, there are several difficulties interpreting the data. The nature of 2020 must be taken into account, where fluctuations due to the COVID-19 pandemic undoubtably influenced the quantity of total cases moved. Further, rebalancing the throughput to smooth the peak in May seems to have also reduced the bump at the beginning of the busy season, and increases the quantity of cases moved into August and September.

Cost per Case

The cost per case for the facility considers the cost of labor as well as the number of cases processed. The cost per case purely considers how much it cost, in labor, to move each case of

product throughout the facility for the products duration there. This is one category, similar to shipped quantity, that was expected to be most positively impacted by the implementation of automation. Figure 20 shows the change in cost per case between 2017 and 2020 by month.

Change in Cost per Case from 2017 to 2020											
January	February	March	April	May	June	July	August	September	October	November	December
N/A	N/A	N/A	N/A	N/A	-9.67%	-29.70%	-21.87%	-39.28%	-28.71%	-37.55%	-14.95%

Figure 20 – Change in Cost per Case

For the months available, cost per case is down an average of roughly 26%. Cost per case is down as much as 39.28% in September. Based off other data presented, such as late percent, time per pallet, and labor cost, it may be surprising to see the cost per case is down. However, it is worth mentioning that Late % and time per pallet consider only outbound shipments, while cost per case considers the full life cycle of inbound and outbound for cases within the facility. A large increase in throughput in conjunction with slightly less efficient time per pallet is offset by considerable improvements in efficiency for inbound cases arriving off trucks.

Survey Results

Data Analysis

Principal axis factoring was run to identify the number of factors present within the data. These factors were chosen based on loadings, and likelihood of significance was determined with the help of eigenvalues and a scree plot. This data was analyzed, and the number of factors was chosen to best give an overview of the impact of automation on the facility, as well as to reduce the number of variables to into more important categories to simplify the dataset. A maximum likelihood factor extraction was then run to distinguish these significant factors for subsequent analysis. Validity and reliability were tested using the loadings of values within factor matrix.

Results

Prior to conducting the exploratory factor analysis (EFA), the dataset was tested for base-level assumptions of suitability. Tests conducted included the creation of an appropriate correlation matrix and verifying the absence of outliers, constancy of variables, and linearity. Next, four basic statistical tests were conducted on the dataset, as follows.

First, a visual inspection of the dataset was conducted to examine the correlation matrix of the scale items. Plenty of items had correlation values greater than 0.30, which suggested the possibility the dataset had structure, and EFA was appropriate. Second, a Bartlett's test of sphericity was conducted. The purpose of this was to assess the overall significance of the correlation matrix. The SPSS output on this test confirmed that the data was significant past the .001 level, indicating a good fit for a possible factor analysis (Bagozzi et al, 1991).

Third, the Kaiser-Meyer-Olkin test was used. This test measures sampling adequacy, with values ranging from 0 to 1. A value closer to one is desirable, as it means a variable is able to be predicted (without error) by the other variables within the dataset. A value of less than .5 indicates it is unlikely the dataset would be suitable for EFA. Our dataset had a sampling-adequacy score of .648, which is above the .5 threshold for this test, and EFA would likely be beneficial (Hair et al. 2010).

Fourth, the sample size for this dataset was examined. 55 responses out of 61 possible members is greater than 90% of the population of the facility, which is likely to give a complete view of sentiment within the facility. Further, it meets the criteria for five or more subjects per variable, with seven anticipated variables (requiring a minimum of 45 respondents) when we have 55 respondents (Hair et al, 2010). 55 respondents is above the well-defined minimum required of 50 to conduct EFA. Regardless, stringent standards have mostly disappeared from necessity in these types of models (Osborne and Costello, 2004).

Having completed these four tests, it is likely exploratory factor analysis would be effective on this dataset.

The goal of an exploratory factor analysis is to produce the least number of factors that can sufficiently explain the variables within a dataset. Due to this, variables have a tendency to 'stick together', or can be grouped together, based on high factor loadings which likely measure the same underlying constructs.

Using SPSS version 26, the 27-item dataset for the impact of automation on the facility was subjected to principal component analysis, which was set to look for factors with an eigenvalue greater than one. This PCA identified ten factors within the dataset containing eigenvalues higher than one. The following table displays the initial findings of the component analysis. Figure 21 is the scree plot for this dataset. Observing Figure 21, there are two possible locations for an inflection point on the scree plot, after the 5^{th} variable or after the 10^{th} variable. After careful consideration of the variables and loadings present in factors 1-5 and 6-10, it is desirable to limit the dataset to five factors to extract the most meaningful associations within the many variables.

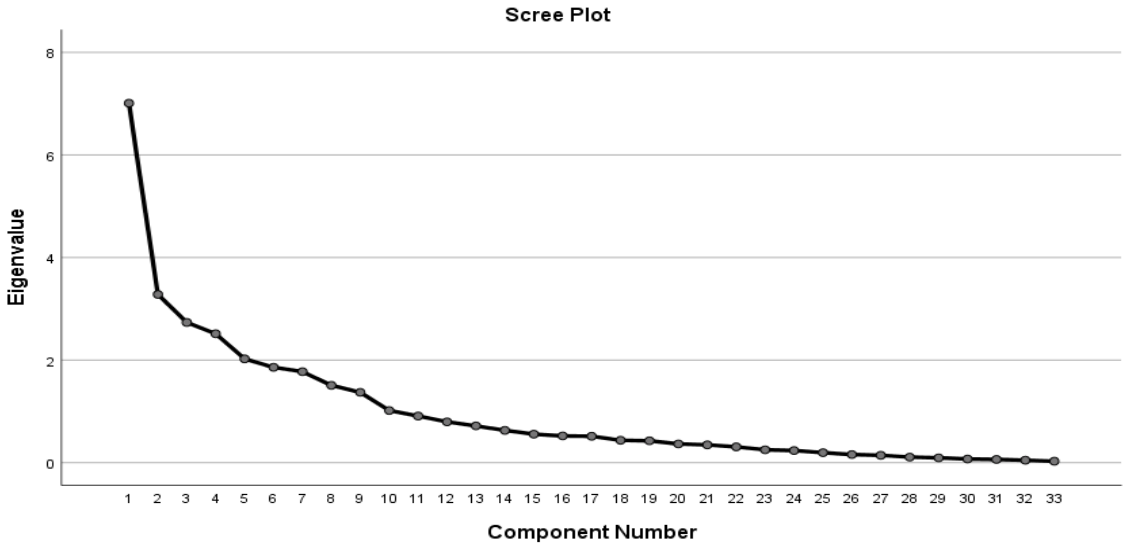


Figure 21 – Scree Plot for PCA

Then, the factor analysis was re-run for the maximum likelihood extraction method, and a limit of five factor was placed on the dataset. In Figure 22 below, you can observe the respective eigen values and % of variance explained for these five factors.

Total Variance Explained									
Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.008	21.238	21.238	6.356	19.26	19.26	4.248	12.874	12.874
2	3.281	9.943	31.18	2.434	7.376	26.636	3.676	11.14	24.014
3	2.733	8.283	39.464	2.731	8.277	34.913	2.669	8.087	32.101
4	2.513	7.616	47.079	2.047	6.203	41.116	2.321	7.033	39.134
5	2.024	6.133	53.212	1.485	4.5	45.616	2.139	6.482	45.616

Figure 22 – Total Variance Explained Chart

Next, we must look at the loadings for the factors and which questions in the survey seemed to be measuring a unified trait. The loadings for the factors in the rotated factor matrix have been included in Figure 23, on the next page.

Figure 23 – Rotated Factor Matrix with Factor Loadings

Rotated Factor Matrix					
Question	Factor				
	1	2	3	4	5
I have enough variation in my job	0.809	0.166			-0.129
I value doing my work as well as possible	0.805		0.166	0.195	-0.154
I have an interesting and stimulating job.	0.675	0.341	-0.203	-0.114	0.119
I am very satisfied with my current job	0.593	0.192	-0.281		
If a new organizational change program is initiated, I will emphatically show my agreement	0.56			-0.127	
The expectations of my job have been fulfilled	0.556	0.309		0.191	-0.126
I am given adequate information on how well I am performing at my job	0.447	0.212	-0.128		
There are good opportunities to find interesting and new challenges at OCX	0.418	0.332	-0.384		0.294
My interaction with automation is clear and understandable	0.39	0.19			0.153
I have sufficient time to do my daily tasks	0.354	0.259		-0.343	-0.13
I have experienced that OCX provides enough support for employees during peak periods	0.323	0.297	-0.252	0.109	
Automation helps me be more efficient at my job	0.199	0.832			0.129
Using the automation in my job improves my productivity	0.244	0.808			
I find the automation useful in my job	0.361	0.784		-0.209	
Using the automation improves my effectiveness in my job	0.298	0.675	0.103		0.204
My closest manager motivates me through clear and constructive communication	0.129	0.416	-0.231		-0.179
I feel exhausted at the end of my day		-0.103	0.717		
My work makes me feel mentally exhausted	-0.125		0.716	0.206	0.12
I feel like I am working "too hard" in my job		-0.149	0.713		0.116
I feel tired when I get up in the morning and have to face another day of my job	-0.25	0.149	0.501		
I look forward to changes within my work environment			0.161		0.102
Which of the following categories includes your age	-0.155	-0.168	-0.293	0.831	-0.168
How many years of work experience do you have			0.281	0.76	
How long have you been employed by OCX			0.147	0.694	
I have sufficient professional knowledge to do my job at a high level			0.215	0.317	0.124
I find the automation to be easy to use	0.261	0.219			0.729
I find it easy to get the automation to do what I want it to do	0.353	0.319		0.126	0.727
Automation reduces wasted time in my job		0.429			-0.489
What is your primary duty at OCX	0.209			0.114	-0.483
My job allows me much opportunity to make my own decisions	0.119		-0.186		-0.269
Extraction Method: Maximum Likelihood. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 6 iterations.					

From the examination of the items with loadings containing the highest pattern coefficients, as well as their meaning in measuring the impact of automation, the 30 items seem to load onto the five factors determined. These five factors lined up with some of the anticipated categories from the original factor analysis model. However, certain factors did not align as anticipated. Figure 24 is the new exploratory factor analysis model. It includes only the factors which were identified from the maximum likelihood factor analysis and is based off the groupings which were found.

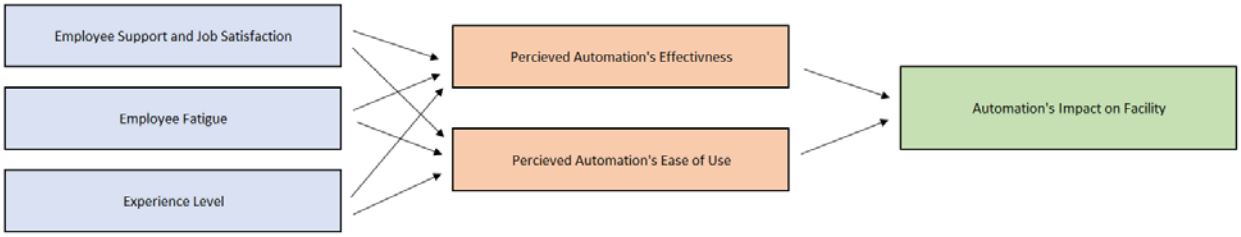


Figure 24 – Revised Exploratory Factor Model

There are a few key differences between this new graph and the hypothetical one proposed. First, the factor examining tedious/repetitive labor is now absent. The answers for questions regarding this factor all had strong loadings with the questions relating to Job Satisfaction and Employee Support. Within this dataset, the tedious/repetitive nature of work is intrinsically tied to job satisfaction and performance. Hence, these categories which all loaded on the same factor have been combined into “Employee Support and Job Satisfaction”.

Next, with the removal of tedious/repetitive labor, the factors of “Employee Support and Job Satisfaction”, “Employee Fatigue” and “Experience Level” all seemed to directly interact with automation’s ease of use and efficiency. Therefore, these factors have been shown in the new diagram to flow into these categories, which ultimately measure automation’s impact on the facility.

Factor One – Job Satisfaction and Labor Quality

Based off the factor loadings identified within the maximum likelihood factor analysis, the first factor can be categorized as “Employee Support and Job Satisfaction”. Figure 25 is the table of which questions were included inside this category and how they loaded together.

Factor One – Job Satisfaction and Labor Quality	
Question	Factor Loading
I have enough variation in my job	0.809
I value doing my work as well as possible	0.805
I have an interesting and stimulating job .	0.675
I am very satisfied with my current job	0.593
If a new organizational change program is initiated, I will emphatically show my agreement	0.560
The expectations of my job have been fulfilled	0.556
I am given adequate information on how well I am performing at my job	0.447
There are good opportunities to find interesting and new challenges at Barrett	0.418
My interaction with automation is clear and understandable	0.390

Figure 25 – Factor One Question Loadings

These questions were a cumulation of several different categories. Since the maximum likelihood analysis was set to five factors when the survey was initially designed with eight in mind, some mixing and merging of categories was going to happen. Some were expected to have merged together, while there were also some surprises. In the area of anticipated merges, it was encouraging to see tedious/repetitive labor and job satisfaction merge. Two of the most prominent questions within these categories, “I have enough variation in my job”, and “I value doing my work as well as possible” were the two questions with the highest loadings.

Of the four questions initially intended to measure tedious/repetitive labor, three of them are in this category. For job satisfaction, of the five questions initial questions, four of them are in this combined category as well.

Next, a question relating to employee support and performance was combined in. The question “I am given adequate information on how well I am performing my job” fell into this category, as well as the automation ease of use question “My interaction with automation is clear and understandable”. These two paint a little more of an interesting picture of this factor which was identified, as it shows the relationship of job and labor satisfaction with automation ease of use and employee support from management.

Factor Two – Automation's Effectiveness

Factor two was identified based off of the four strongest factor loadings, which all related to the construct of automation's perceived usefulness. The final strong loading, for the question regarding "My closest manager motivates me…" was included due to the interesting dynamic it exposes, how the perceived usefulness is closely tied to the quality of communication received by the employee's manager. The chart entitled Figure 26 has each question and the factor loadings of them, respectively.

Factor Two – Automation's Effectiveness	
Question	Factor Loading
Automation helps me be more efficient at my job	0.832
Using the automation in my job improves my productivity	0.808
I find the automation useful in my job	0.784
Using the automation improves my effectiveness in my job	0.675
My closest manager motivates me through clear and constructive communication	0.416

Figure 26 – Factor Two Question Loadings

Factor Three – Employee Fatigue

This factor aligned perfectly with how these questions were anticipated to stick together. Each of these questions were anticipated to measure employee fatigue, so it is promising they grouped together in such a definitive fashion. Figure 27 is the questions and their respective loadings.

Factor Three – Employee Fatigue	
Question	Factor Loading
I feel exhausted at the end of my day	0.717
My work makes me feel mentally exhausted	0.716
I feel like I am working "too hard" in my job	0.713
I feel tired when I get up in the morning and have to face another day of my job	0.501

Figure 27 – Factor Three Question Loadings

Factor Four – Level of Experience

In a similar fashion to factor three, this factor had the questions load together exactly as they were originally anticipated to. The loading for the fourth question included was not as strong as would be ideal, but still strong enough so show the positive relationship between these factors. Figure 28 includes the questions and their respective loadings.

Factor Four – Level of Experience	
Question	Factor Loading
Which of the following categories includes your age	0.831
How many years of work experience do you have	0.76
How long have you been employed by Barrett Distribution	0.694
I have sufficient professional knowledge to do my job at a high level	0.317

Figure 28 – Factor Four Question Loadings

Factor Five – Automation's Ease of Use

In the hypothetical model, three questions were supposed to measure Automation's ease of use. However, the question "My interaction with automation is clear and understandable" actually had the strongest loading on factor one, with employee support / job satisfaction.

The other two factors describing automation's ease of use did sufficiently load with each other in the fifth factor, as can be seen in Figure 29. Also curious is the negative relationship for these questions with automation reducing wasted time. While the construct of "Automation's ease of use" is included within this factor, there is also an inherent negative relationship with the automation being easy to use, however that not reducing wasted time. Perhaps this factor includes some element of the automation being easy to use but not beneficial.

Factor Five – Automation's Ease of Use	
Question	Factor Loading
I find the automation to be easy to use	0.729
I find it easy to get the automation to do what I want it to do	0.727
Automation reduces wasted time in my job	-0.489

Figure 29 – Factor Five Question Loadings

Correlation within Dataset

After having refined the model to confirm things stuck together in the anticipated fashion, a series of Pearson bivariate correlations were run in SPSS to search for significant trends within the data. One concern was the sample size of the data used for this case, however seeing as it is meant only to be representative of trends within Operation Company X's facility and the sample is greater than 90% of employees in the facility, the trends within this survey are meaningful.

The entire Pearson correlation table is too large to fit entirely within this document, however specific sections of it have been extracted.

Correlation relating to perceived usefulness and efficiency.

An important distinction is made here between efficiency and effectiveness. Efficiency relates to using resources in an optimal way, while effectiveness refers to the degree to which something produces optimal results. As it relates to usefulness, effectiveness highlights the ability of the automation to be useful to the employees in accomplishing their tasks. Useful automation has been hypothesized to lend itself to more efficient work by employees.

The following table compares two questions measuring attributes of 'perceived usefulness' with impact on efficiency. The questions measuring perceived usefulness are 'I find the automation useful in my job' and 'Using the automation improves my effectiveness in my job'.

The answers to those questions are compared to questions measuring efficiency, which are 'Automation helps me be more efficient at my job' and 'Using the Automation in my job improves my productivity'. The inherent positive connotations between these questions only aids in the analysis of the findings – Whether they agree or disagree, similar responses across these questions highlight increased ties between perceived usefulness and efficiency within this dataset. Figure 30 shows the correlation table.

Within the table, all questions are correlated at a level significant at the .01 level, and the correlation values are generally high. The questions 'Automation helps me be more efficient at my job' and 'I find the automation useful in my job' are correlated at a score of .694.

Correlations

		Automation helps me be more efficient at my job	Using the automation in my job improves my productivity	I find the automation useful in my job	Using the automation improves my effectiveness in my job
Automation helps me be more efficient at my job	Pearson Correlation	1	.730**	.694**	.705**
	Sig. (2-tailed)		.000	.000	.000
	N	55	55	55	55
Using the automation in my job improves my productivity	Pearson Correlation	.730**	1	.787**	.474**
	Sig. (2-tailed)	.000		.000	.000
	N	55	55	55	55
I find the automation useful in my job	Pearson Correlation	.694**	.787**	1	.641**
	Sig. (2-tailed)	.000	.000		.000
	N	55	55	55	55
Using the automation improves my effectiveness in my job	Pearson Correlation	.705**	.474**	.641**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	55	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 30 – Perceived Usefulness Correlation

Correlation relating to ease of use and efficiency.

This question focuses on the ease-of-use employees experience with the automation, compared to those same efficiency questions. Ease of use looks at how easy the automation is for employees to use, as well as the relationship between 'clear and understandable' interaction with the automation lending itself to improved job productivity.

The questions measuring ease of use are 'My interaction with automation is clear and understandable', 'I find the automation to be easy to use', and 'I find it easy to get the automation to do what I want it to'. The questions measuring efficiency are 'Automation helps me be more efficient at my job' and 'Using the Automation in my job improves my productivity'. Figure 31 is the table correlating these questions.

Correlations

		Automation helps me be more efficient at my job	Using the automation in my job improves my productivity	My interaction with automation is clear and understandable	I find the automation to be easy to use	I find it easy to get the automation to do what I want it to do
Automation helps me be more efficient at my job	Pearson Correlation	1	.730**	.151	.322*	.411**
	Sig. (2-tailed)		.000	.270	.016	.002
	N	55	55	55	55	55
Using the automation in my job improves my productivity	Pearson Correlation	.730**	1	.400**	.190	.360**
	Sig. (2-tailed)	.000		.003	.164	.007
	N	55	55	55	55	55
My interaction with automation is clear and understandable	Pearson Correlation	.151	.400**	1	.317*	.367**
	Sig. (2-tailed)	.270	.003		.018	.006
	N	55	55	55	55	55
I find the automation to be easy to use	Pearson Correlation	.322*	.190	.317*	1	.680**
	Sig. (2-tailed)	.016	.164	.018		.000
	N	55	55	55	55	55
I find it easy to get the automation to do what I want it to do	Pearson Correlation	.411**	.360**	.367**	.680**	1
	Sig. (2-tailed)	.002	.007	.006	.000	
	N	55	55	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 31 – Perceived Ease of Use Correlation

One of the most important things to first point out is that the questions ‘Automation helps me be more efficient at my job’ and ‘My interaction with automation is clear and understandable’ are not significantly correlated. Beyond that, clear and understandable interaction is correlated .400 with ‘Automation in my job improves my productivity’. Next, the question ‘I find it easy to get the automation to do what I want it to’ is correlated to .411 with the question ‘Automation helps me be more efficient at my job’.

Interview Results

A series of interviews was conducted regarding the use and transition of automation into Company X's facility. Five people were interviewed from a range of backgrounds at different levels of management within Company X. The people interviewed represent a diverse combination of supervisors and managers within the organization, to give insight into all automation-related activities within the facility. Refer to Figure 10 from the methodology section for a breakdown of the specific questions and follow up questions which were asked.

Question One: *Working at the facility prior to automation - Distinct problems.*

This question regarding pre-automation problems received a variety of answers, but there was consensus that automation improved the put away process by both saving time and reducing human error. Respondent One focused on the difficulty of executing the strict FIFO inventory protocol with only floor locations, and the facility operating near maximum capacity. This sentiment was echoed in another interview, where Respondent Five said, "In the busy season, space was a massive issue… We used to start picking for the 10:00 AM load when it was already 10:00 AM sometimes - It was a mess." With little to no space to stage outbound orders, it was incredibly difficult to properly execute the labor-intensive picking process.

Building on this sentiment of the difficulty finding space, 80% of the respondents specifically named "The Put away Process" and "Consolidation" as two of the largest concerns prior to the implementation of automation. Sentiment was strong that the implementation of automation helped 'improve' this shortcoming of the facility, Respondent One elaborated, "Human error was a fairly prominent issue in this put away process. With the automation methodically checking and putting stuff away now, that error has been completely eliminated."

Respondent Four agreed that the automation improved the put away process but lamented the fact that verification of inbound inventory had also been eliminated: "If things get labeled wrong at the plant, there is no verification process to ensure it is the right item. Our infeeders just mindlessly put the pallets from the trucks onto the conveyers." This highlights an increased level

of dependence on the automation technology, as well as an increase in the required trust at different levels of the supply chain due to the automation. If a product receives the wrong license plate / barcode at the production plant, inbound forklift drivers are not specifically checking or scanning each pallet themselves.

Question Two*: Tasks which existed prior to automation, which are no longer needed.*

Extending question one, this question sought to identify specific tasks which had changed. Similar to question one, the task of "consolidation" was named in every interview conducted. "Consolidation" was best explained by Respondent One in the interviews as, "When extra product arrives, often all the product (especially for popular items) cannot fit in one individual spot, so the employee would need to drive out and find another close spot on the floor to place the item. This led to some strange layouts and spreads of items… so constant consolidation was necessary. If the product was new, and the lane was not full, the old product had to all be pulled out, with the new items then placed behind. Then the older stock is put back in front." With the implementation of automation, this task was replaced by the fully-automated task of "rewarehousing", where the system rotates in the new inventory automatically, and employees do not need to do anything for it. This saves a lot of labor hours at the facility, as they used to "devote 80-120 hours a week to (consolidation)". Respondent Two noted it used to be a huge labor sink and is pleased that the task does not exist anymore.

Other tasks which have changed significantly are cycle counting full pallets and auditing putaways. Cycle counting full pallets was mentioned in two of the interviews as a critical point – pallets within the high-capacity storage racks of the automation do not have to be cycle counted at all now, outside of routine verification during the yearly inventory. Only partial pallets being used for picking get audited and cycle counted by inventory now.

For outbound shipments, the prep work has shortened as well. According to Respondent Five, "A big part of why loading is better is all the space - All the pallets get dropped in the lane in front of the right door, which is great. There used to be a lot more mis-shipments because orders

would be staged in two or more locations and loaders just wouldn't find all the pallets." With the automation, around the scheduled shipping time an office employee is able to easily tell the automation which orders to drop. The system then stages the order in gravity feeds directly in front of the door where the truck has backed in. This saves a lot of time staging the order prior to the trucks arrival and allows the loads to be completed in a timelier fashion as well by shortening the drive time from the staging area to the loading door. The pallets are now only 15 feet from the truck they are being put into.

Finally, one job that has changed is the office clerk position. Before, it was almost exclusively checking in the truck drivers and printing labels to stick on to loads that needed to get staged. Respondent Four commented: "The clerk position is really much higher level - they are more like an office coordinator, not a clerk." They now must directly interact with the interface for the automation to compile and drop orders, as well as troubleshoot difficulties and check for shorts. The office clerk position is now much more technical and requires very dependable employees.

Question Three: *Situations and areas where the automation excels, and struggles.*

This question tried to identify specific use cases or situations where the automation was especially efficient and worthwhile. On the flip side, the second part of the question asked about situations where the automation struggled, and if that was an anticipated long-term drawback or if a fix was imminent.

Labor prep time improvements were mentioned in 60% of interviews, with two interviews specifically stating the improved putaways process as the automation's best contribution. Accuracy improvements and labor reduction were named as other key areas that the automation improves. As for automation struggles, a high volume of missions (large quantity of things the automation has to do) was named as a difficulty in three of the five interviews.

Respondent One immediately identified the improved put away process when goods arrive at the facility as an area where the automation excels, but also elaborated the layer picker device's

particular importance to both time-saving and worker health, explaining, “The layer picker getting a lot of those full-tier partials out of the way is pretty useful. It really takes away time from pickers having to move full tiers over onto pallets, and they can really focus on just the small, incomplete layers that the (layer) picker cannot do.” They then explained that the task of moving full tiers of cases from one pallet to another was an especially time-consuming task, and with an abundance of orders with ‘full tier’ picks, the workers could get tired moving so many cases and boxes. With the layer picker device doing a lot of the heavy lifting, the pickers can now focus on smaller picks for incomplete tiers of cases, which is faster for them to complete and easier on their backs.

This sentiment was echoed by Respondent Two, elaborating, “Picking volume has seen a lot of improvement. 40% of picks are now being done by the layer picker. We anticipate this number to continue to increase slightly. This has been seen in a reduction in staffing.” With 40% of the most labor-intensive, difficult picks now being handled by the layer picker, the automation allowed for a reduction in staffing while increasing the pick productivity. When large quantities of picks flood the facility, the automation enables them to better handle the majority of the orders and empowers employees to manage their picking workflow.

Respondent Three identified a different area of the facility as most strongly impacted, with the same result, explaining “The automation works best in getting orders down to you. One hour order prep time, if all goes well, versus three to four hours before of searching for stuff. The loading should also go quick with all the stuff staged in front of doors. We are now able to load faster and with less people.” When it comes to staging the orders, the automation is considerably more efficient at identifying the pallets to drop and placing them directly in front of the door in a timely manner. Additionally, by staging the orders directly in front of the doors where the order will be fulfilled, there is less driving time between going from the staging areas to the bay doors into the trucks. As long as the trucks arrive at their scheduled times, and the prep work is accomplished prior to the truck’s arrival, the automation makes the entire process go much more smoothly.

Respondent Five stated, “We can unload a truck in 15 minutes rather than 45-60 minutes, because now the guys just drop the pallets into the infeed conveyer belt and don't have to drive or search for a spot or anything.” This saves a lot of time on the front end for operations, and they can rotate through the doors for inbound deliveries much faster, with less drivers.

As for situations or areas the machine struggles in, responses were varied but Respondent Four had another strong answer, explaining, “High volume gives the automation a lot of trouble. Guys gotta wait for pallets to drop and come out rather than being able to just work harder and faster themselves.” While the automation largely enables faster activities in all areas, when things go wrong and pallets are delayed coming out of the machine, work essentially comes to a halt. In the past, if an order had to get shipped out of the facility immediately, a supervisor could throw a few workers on it and get it accomplished faster. With the automation, if 90% of the order is staged but a few pallets, for whatever reason, did not properly drop onto the lane in front of the door, no amount of rush will make the machine work faster. If the conveyer belts are all already full with other pallets and the machine is swamped with other missions to accomplish, it can easily take 45 minutes+ for the required pallet to drop. This can cause otherwise unnecessary late loads and work stoppages which impact the entire day.

Respondent One goes more in detail into difficulties of the machine slowing down, saying, “The automation does seem to struggle when the facility gets up to full capacity. When that back racking area starts to get pretty full and it does not have time to rewarehouse often enough because the facility is busy, the machine sometimes has to dig to find those pallets they need to send out. Rewarehousing is great as prep work, but it really gets in the way when we are trying to ship stuff out quickly or dropping product when the truck has already arrived. When you only have so many cranes or carts, the machine has to move pallets for the rewarehousing, infeed, outfeed... it really just can't do it all with the time pressure... This is a big known issue of the automation that it does not work well at full capacity.” When the machine’s racking begins to get full and orders pile up, the automation has to rewarehouse on the fly in the middle of the day. This process is especially time consuming for the cranes, and results in the typical quick activities of the automation being dragged out considerably longer. If the rewarehousing is not

allowed to be done at all, it can be even worse in the long run. With FIFO principles, the machine can have to dig up to seven or eight pallets deep into the racking to get the pallet with the desired expiration date – and then, the removed product is put in another location separated from other pallets of that same product. This causes the capacity concerns to snowball until the cranes must move pallets unreasonably far away to dig out pallets or properly rewarehouse.

Question Four: *Busy/Slow Season – Can the automation keep up?*

This question centers on the idea that this facility has some months/seasons in the year when it is especially busy and other times when business is slower. During the busy season, the automation has been pushed to its limits. In the slow season, the automation has plenty of time to prepare and can operate comfortably with less total missions to encumber the machine.

Generally, four of the five respondents said the automation struggled in the busy season. Respondent Four digressed and said it could handle busy days, but the design was "horrible". He did not, however, comment on the general busy season which sees an overall increase in quantity of shipments for a prolonged period.

For the slow season, sentiment was decisive that it was not "overkill" and was able to keep busy and stay on top of everything at an acceptable capacity. Respondents One and Three both argued that the automation in fact worked better when it was slower, and that was the best-use times for the machine. Respondent Five took a decidedly contrarian stance, stating that the automation could not keep up in the busy season and furthermore, "From my view, the volume of the facility hardly warrants such a massive machine." He did not believe the facility should have been automated at all and felt it did not have enough volume to require any automation. In his view, simply hiring more employees to drive forklifts would have been a more effective way to handle rising throughput volume.

Respondent One discussed one of the largest areas of concern in the busy season: "Faults in the system can be a HUGE concern in the busy season. There are two types of problems with the

automation, Faults and Mechanical issues. A fault is when something is wrong or impacting the automations efficiency, but it should be able to be easily resolved by an on-site attendant. A mechanical issue is a much larger problem. For those, we have to contact the company which built this machine, and this causes a huge loss in productivity. Honestly, the entire day could get shut down or grind to a halt depending on where the mechanical issue is. Their response time can sometimes be very frustrating." If something mechanical breaks and there is no on-site replacement part available, the entire facility can potentially grind to a halt, depending on where the issue is, and how bad it is. Generally, this increases risk of lost time at the facility compared to a non-automated facility. An entire lost day can be incredibly expensive.

Question Five: *How automation has affected output and impact on important KPIs.*

This question tried to uncover the general effect automation has had on the facility as a whole. Asking about general impact to output sought to uncover if the automation has generally been beneficial. By asking how automation has impacted key performance indicators, we can try to learn which aspects are most impacted or influenced by the machine (automation).

Four of the five respondents agreed that the automation generally empowered the facility to greater output – Respondent One disagreed strongly. Interestingly, all five of the respondents listed a different KPI as most important to the judgement of the function of the facility. The KPI's chosen all were most important for the area of business where the respondents worked, or the areas they were responsible for.

The KPIs listed were picking and shipping accuracy, total outbound loads, late load percent, safety, inventory accuracy, throughput, and cost per case.

Respondent One claimed that automation did not improve the output or any KPIs in the following quote: "Like, if it were just that easy, with everything dropped in a timely manner, it is good. But it isn't. Automation has not improved our ability to do more outbounds. Pre automation, we were much faster shipping stuff out… Without this automation, we could get

stuff out quicker and could always ship stuff out in a timely fashion… Automation has not removed the ability for employees to make potentially damaging shortcuts." In this quote, the supervisor is showing a lot of frustration about incomplete orders and pallets being selected to drop, but not dropping correctly. If everything worked as it was supposed to, they agreed that the system would work much better. However, at the time of the interview, it was not working correctly. This supervisor also shows a lot of confidence in the abilities of the facility pre-automation, and a level of comfort and understanding of pre-automation operations far greater than for the automated facility.

However, the other four respondents did not echo this sentiment by Respondent One. Respondent Three stated, "The output of the facility is improved by automation. It just wouldn't have enough storage if not for the automation. My understanding is that output has doubled due to automation." Respondent Four agreed, simply stating, "The automation has increased the facility throughput. There's more work, done with less labor." Following this trend, Respondent Five stated, "Automation has helped streamline several processes, like the picking loads. It has decreased the amount of time it takes to get a load out the door."

As for critical Key Performance Indicators, Respondent Two had a very thoughtful answer, explaining, "The most important KPIs are cost per case shipped, SRM downtime, and accuracy for inventory and shipping. The late load percentage is a good KPI for us to use to gauge how we are doing, but it is not really that costly if it is high. So, it will not really crush the customer. Ontime delivery is good, and the goal of course is a low late percentage, but not costly enough to crush the customer like some of these other ones. Cost per case is more important that late percentage. Detention time is a concern, but not as much as cost per case. Safety is also key, and the reduction in some of this repetitive labor is good - There has been a noticeable reduction in injuries. The automation seems to have done it." While addressing some of the KPIs which other respondents listed, Respondent Two explained their mindset for which metrics were the most critical. Using the perspective of which underperforming KPIs are crushing to the customer and which KPIs are better for internal regulation, they were able to focus in on cost per case shipped, SRM downtime and inventory/shipping accuracy as legitimately mission critical, while some

others such as late percentage and detention time are not nearly as harmful to the bottom line as some other respondents claimed.

Question Six: *Automation's effects on the work environment, specifically due to raised expectations.*

In this section of the interviews, questions regarding the expectations of the machine were posed to the supervisors. The purpose was to uncover how the expectations had been disseminated among various levels of management, and how that 'added pressure' impacted the facility as a whole.

Respondent One addressed many key points immediately in their answer, explaining "Yes, there's definitely higher expectations for the facility. The customer comes here pretty frequently, and they love giving tours with corporate office staff. The facility pretty much always has to be tour ready. Further, to get the ROI that the customer is expecting, staffing has been continually cut significantly. The automation allows for this leaner staffing, but the facility is barely getting by it seems like. We had 25 forklift driver's pre-automation per-shift, now we have 13." With the heavy increase in volume, it is surprising the facility has cut or reassigned half the forklift drivers. Further, due to the nature of Company X as a third party logistics firm, they need to keep the facility especially tidy and neat because corporate tours come to the facility frequently to check on the progress and examine the massive machines. With the automation comes the expectation of a quick turnaround time to see substantive ROI and get a return on investment. One of the best ways to do that is to schedule increasingly lean staffing, which seems to be pushing the facility to the verge.

Respondent Two seemed to agree with Respondent One, stating, "They (the customer) are trying to show the benefit of the automation by keeping labor costs down. This is due to pressure on us from our client. The expectation hasn't been passed down to employees - It is on management to make it happen. The automation is new, and there are lots of eyes on it. The eyes will not stay on it forever. We do however always have to keep the facility tour ready! It does kind of increase

stress. This responsibility has increased the level of stress/pressure." Furthering the point that the facility needs to be tour ready, Respondent Two notably claims the responsibility has been placed mostly on management and has not been passed down to the employees. They also believe that this expectation and attention will not last forever, and it is only as significant as it is due to how recent the implementation was. The customer wants to see quick ROI as proof they made the right decision by automating. The fastest way to improve ROI is to cut staffing and become as lean as possible.

Respondent Four had another interesting quote, explaining "So far, the machine has not met the expectation. I do not think we are at 100% though. We have the expectation the machine can do more. The people who sold us the machine so far oversold its capabilities." While the facility has recently started fully relying on the automation, it is still ramping up and in a state of transition. The capabilities of the machine working with the facility are still not "100%" in tune quite yet, and it is believed the machine will be more efficient once the small kinks are worked out and employees are more comfortable with the machine.

Question Seven: *Quality of Staffing Positions.*

This question tried to uncover if the quality of available staffing positions had changed due to the implementation of automation. There was general sentiment that the number of positions had been reduced overall, and that number of total positions had been suppressed relative to the increase in throughput of the facility. However, there was also strong agreement that the overall quality of positions had in fact increased. 60% of respondents mentioned that the creation of the ASRS attendant role was a 'higher level' position which only now exists pre-automation. Further, the role of the office clerk has grown and, according to Respondent Four, their position is now more of an "Office Coordinator".

Respondent Four further explained, "Promotion wise, the attendants, on my shift anyway, are all internal hires. The managers have been external hires. Everyone expected to be ready to be a supervisor or something was not interested or not really ready. For new qualifications, it depends

on the job. If you're an attendant, you can't be scared of heights. Do you know Excel. Stuff like that. The bar was pretty low pre-automation… Now we are looking at a lot more stuff." Familiarity with the machine does play some role in deciding who to promote to the higher level work. For hourly pay roles such as the attendant, they get paid more than the standard forklift driver, and that role is seen as a job that forklift drivers can work towards.

Respondent Five agreed, stating, "Quality of positions has improved. Solid raises if they are good with the automation for the seven new ASRS attendant positions. Guys who get promoted must have a more mechanical aptitude."

Respondent One stated, "It definitely gave some of our higher-performing workers a chance for better pay or whatever, but it definitely was not exclusively internal hires. Recently though new attendants have been mostly internal though. There is some value in hiring guys who are already a little familiar with the machine. Nowadays, for the office clerk position, supervisor role, and obviously the attendants, new skills are considered more important than before. Things like computer skills, communication, and possibly mechanical skills or knowledge are definitely more important now than pre-automation." In essence, Respondent One agrees with respondents Four and Five, and also adds that new skills are now important that were not really considered before automation. Specifically, computer skills and mechanical skills and knowledge to analyze readouts from the machine or make repairs.

Question Eight: *Satisfaction with the installation of the automated system and training to use it*

In this question, 60% of respondents expressed frustration around the training they received to use the automation, and 80% have a problem with the external support offered by the company. Specifically, with the external support, a common theme was the fact that it often 'lacks urgency'.

Respondent Five has an interesting story about the automation support's lack of urgency: "The two on-site employees from the automation installers are never much help. We have had

instances where stuff wouldn't move, we would call them, and even though they claimed 24/7 support, there was no haste. I remember one instance when I called in the night, the guy coming over sounded grumpy on the phone and said he needed to shower first. He then showed up an hour later than he said he would and had breakfast and a coffee with him. He then started to shoot the sh*t with the guys in the office when he did arrive. Our facility had been at a complete standstill with thousands upon thousands of dollars of productivity being lost. We were helpless. And these guys take their sweet time. I sent an email to the entire facility after this calling them useless, and instead of getting in trouble I got commended by the boss for calling it like I saw it." You want support for your mid-eight figure machine to be much faster than that, and the response time from the installation firm is not where it should be.

Respondent Five then goes on to explain another key point about why the installing company is still so important in doing specific repairs and the always on-site attendants cannot make all the repairs: "New people typically shadow attendants. They learn the basics, but the guys from the main company seemed to have felt threatened and they did not want to give up any of their secrets. Without strict training, everyone wants to feel valuable and they don't teach everything they know. Nobody wants to give up their secrets." This is clearly a big issue, without transparent training to learn how to make all the necessary repairs in place, new attendants must learn by shadowing experienced attendants. In order to protect job security, the experienced attendants never teach everything they know. That goes for the automation's parent company too, as Respondent Five claims they deliberately withhold some information so that they are the only ones who can make specific repairs.

Respondent Two best summed up the issues with training, stating, "The training was nil. It just wasn't good. Some of the guys did not get any training at all. It should have been better."

Respondent One stated, "We all kind of had to learn the new system on the fly while still running the facility using the old system. We got training for one week which showed the current employees some basic stuff, like how to drop pallets or manage the infeed. Very basic. The training was bare minimum. I don't think it was for enough time... It was not enough. They haven't given us more training really since."

Respondent Three stated, “In my view, the attendants likely do not have enough training, depending on which attendant we are talking about. For me personally, I received limited training to learn the automation. I had to learn on the fly and fight it out on my own. The automation definitely would have been easier to use if I had received any kind of formal training.”

Question Nine: *The biggest issue in the way of efficiency at the facility.*

This question was pretty evenly split. Two respondents stated the employees were the biggest issue in the way, two stated the issue was the ‘little bugs’ in the automation, and one said poor training was the biggest obstacle.

Respondent Three firmly believed that the biggest issue was the employees at the facility. He stated, “The employees are the biggest issue in the way of efficiency here. Everyone is just coming in and doing what they want to do. If everyone came in here and wanted to work, I mean really wanted to work, they would be a LOT more efficient. They all don't think the money is what they want it to be. Automation makes this issue of the employees worse. Nobody likes the robots, and the workers don't think they should have to work as hard as they do.” In this observation, it is clear he believes the workforce is unhappy with the automation and they are not giving their best effort due to this. It is worth noting that this interview was conducted relatively recently after raises were given out, and many of the hourly employees were unhappy with the amount they received. Their work ethic and attitude was likely impacted by this.

Respondent Four thought the automation itself was the biggest issue, stating, “The biggest issue for efficiency is the little bugs in the automation. Why isn’t this order at 100%? Why didn't this one pallet drop properly? Why didn't it drop the first time? The automation is the issue - it just is not programmed quite right now.” These issues are pretty expected for a system that is still working out the bugs and trying to reach optimal efficiency. Small errors derailing entire shipments are a big issue, and things not working right the first time – despite correct input from human operators – is undoubtably very frustrating.

Question Ten: How *Automation has impacted work.*

The predominant takeaway from the interviews on automation is that their day-to-day operations now involve more work with computers, specifically referring to reports and monitoring the status of the automation. 60% of workers reported that the implementation of automation made their job more difficult, while one respondent was adamant that the automation made their job more enjoyable.

One of the respondents who felt their job became more difficult was Respondent One, who stated, “The automation has made more reporting for me to look through and more computer things to do. I've been doing a lot more detailed work.” They then went on to explain they still have to do the standard monitoring labor they were doing prior to automation, except now they also have to comb through various reports to check and confirm the work is actually being done in a timely fashion.

Respondent Two had a different mindset when it came to the automation, not viewing it as more difficult, but rather an opportunity and a new challenge. They explained, “My job is more enjoyable due to the automation! I enjoy the learning and always having something new. I enjoy the challenge. What I really like is that this is the test plant, and we can learn here and set up the next facility for success. This automation is new for everyone. There are not a ton of resources for everyone. The training is hard. There are literally only two systems like this in our entire geographical area.” While Respondent Two acknowledged some of the struggles, such as with training and how it is a new experience for everyone, they seem to have embraced a more positive mindset about the situation. While it would be easy to categorize the automation as more difficult, this respondent has reframed the changes as a positive challenge, later going so far as to say he appreciated being entrusted to have such an important position working at the facility. It is clear Respondent Two is thinking bigger picture, while some of the other respondents thought about the question on more of a day-to-day basis.

Respondent Four answered the question in a notable way, beginning a discussion of how the staffing had been impacted due to the automation: “It was more stress for me and more hours at

first… Pre-auto, I had two supervisors, Now, only one… The facility does seem it is a little too lean now, but I also just lost another 3 people. Then some days it feels like our staffing is fine. If I can just replace the few employees I just lost, I think staffing would be fine. The facility can operate." While confessing that staffing would probably be alright if they could just get back the employees they lost, the extremely lean nature of the facility due to automation gives little margin for error. With increasing importance on each employee, when workers leave or call out, supervisors and managers must get creative with the distribution of labor to make everything work. Prior to the automation, the staffing at the facility felt much more comfortable; however now with so many eyes on the facility, they are forced to be lean to the point that any absences can notably impact the amount of work they get done.

Table of Responses

Figure 32 is a table of the responses gathered. Opinions held by three or more respondents were included in the "Consensus" column. Notable dissent or different opinions are in the "Disagreement / Alternate Views" column. Finally, meaningful quotes which either emphasize the perspectives of the "Consensus" column or stand out as interesting have been included in the "Notable Answers" column.

Appendix B highlights a revealing quote which helps weave together the idea that the facility was continually improving throughout 2020 with their use of automation.

Figure 32 – Interviewee Response Table

Interview Response Table			
Question	Consensus Responses	Dissent / Alternate Views	Notable Answers
1	Less fork truck drivers now, similar total # of employees. Everything took longer to put away before, now it is faster. There was never enough space before. Better verification process prior to automation with employees having to check everything.	Respondent Five claimed there were less total employees' post-automation than pre-automation.	**Respondent One**: "Prior to Automation, it definitely took longer to put everything away". **Respondent Four**: "Space was always an issue pre-automation". **Respondent Five**: "(Pre-automation) if you needed a pallet, you took a minute and drove over and got the pallet. Now (post-automation), we have these big hour-long delays waiting for one pallet".
2	Consolidation task does not exist anymore - It has been replaced by automated rewarehousing. There is a lot more space due to the automation - Storage capacity is way up. No more cycle counting full pallets.	None	**Respondent Two**: "Consolidating was a just labor sink for us and a big issue before - We would have to devote 80-120 hours a week to it. Now, we don't do that at all anymore". **Respondent Four**: "The clerk position is really much higher level - They are more like an office coordinator, not a clerk".
3	High-volume gives the automation trouble. When the facility is near storage capacity, things start to slow down. When the machine does not have time to do prep work, it can go very poorly. Machine works best in getting orders down to you and reducing staging prep time and offloading trucks. Picking is much faster now and less taxing on employees.	Respondent Four says November 2019 was a big struggle. The thing that hurts the automation's efficiency the most is untrained employees trying to use it.	**Respondent One**: "When you only have so many cranes or carts, the machine has to move pallets for the rewarehousing, infeed, outfeed... it really just can't do it all with the time pressure". **Respondent Two**: "Picking volume has seen a lot of improvement. 30-40% of picks are now being done by the layer picker". **Respondent Five**: "We can unload a truck in 15 minutes rather than 45-60 minutes, because now the guys just drop the pallets into the infeed conveyer belt and don't have to drive or search for a spot or anything. It definitely helps turning over trucks".
4	Automation cannot keep up in the busy season so far. It gets overwhelmed by too many missions and slows down significantly. It also does not feel like overkill in the slow season.	Respondent Four disagreed that the automation could not keep up in the busy times, saying he thought it could. Respondent Five felt that the volume of the facility did not warrant such a large machine.	**Respondent Three**: "Once we get a lot of loads, things go to sh*t". **Respondent Five**: "From my view, the volume of the facility hardly warrants such a massive machine".
5	Automation has had a positive impact on facility output - There would not have been enough storage before. Employees do not seem to be worked too hard. Safety is an important KPI automation has helped with.	Respondents seemed to list the most important KPIs based on their area of the facility, including picking/shipping accuracy, late %, cost per case, count of outbound loads, and inventory accuracy.	**Respondent Two**: "No, employees are not worked too hard by the automation. Employees are not necessarily asked to do more... The automation definitely struggled (so far). Only 5 months in, and we have made a lot of tweaks".
6	There is pressure from the customer onto the managers of Operations Company X. This increase in pressure has not been passed down to the individual employees.	Respondent Three felt that the base level workers thought the automation was unreliable and makes mistakes too frequently.	**Respondent Two**: "To get the ROI that the customer is expecting, staffing has been continually cut significantly. The automation allows for this more lean staffing, but the facility is barely getting by it seems like. We had 25 forklift drivers pre-automation per-shift, now we have 13".
7	Office Clerk role has changed and become more difficult. Less fork truck drivers in the facility. New job positions opened up, "ASRS Attendant", mostly internal promotions to those positions managing the automation. Work in general is less busy work. Workers here are now expected to be more technologically literate.	Respondent Four felt that promotions for ASRS attendants was almost exclusively internal, while Respondent One felt it was more 50/50. Respondent Three disagreed that there were any different qualifications to work at the facility.	**Respondent One**: "The hiring of the new machine attendants was pretty much 50/50 internal and external. It gave some of our higher-performing workers a chance for better pay... Recently though new attendants have been mostly internal". **Respondent Five**: "Quality of positions has improved. Solid raises if workers are good with the automation for the seven new ASRS attendant positions. Guys who get promoted must have a more mechanical aptitude".

8	Very basic or poor training for employees when it came to using the automation. Transition period was difficult. Support from installers was not particularly robust. Helpdesk from installation company lacks urgency with issues.	Respondent Four was happy with how the automation was installed and thought the process went very smooth.	**Respondent One**: "The training was bare minimum... I don't think it was for enough time... It was not enough. They haven't given us more training really since". **Respondent Five**: "The guys from the main company seemed to have felt threatened and they didn't want to give up any of their secrets. Without strict training, everyone wants to feel valuable, and they don't teach everything they know. Nobody wants to give up their secrets (for how to fix certain issues with the automation).
9	The biggest issue in the way of efficiency here is the employees - Poor training and attitude.	Respondents One and Four disagreed that the employees were the main problem, saying bugs/errors with the automation were the main issue. Respondent Two felt being so lean also hurt the efficiency in the facility.	**Respondent One**: "The biggest issue in the way of efficiency is when things go wrong with the automation with like big mechanical faults. One big issue derails the entire day... There is just no plan B". **Respondent Five**: "The biggest issue in the way of efficiency is the attitude of the employees on the floor. They are unhappy with pay. Their pay is right in line with the average, but their attitude is terrible. They had that same mindset pre-automation too... Bad attitude sets employees into only strictly doing their jobs and not wanting to be adaptable".
10	Work now involves more looking at reports and using a computer. Automation made work more difficult at first, but it is starting to become easier / more enjoyable.	Respondent Three continued to stress the point that a few uncooperative employees at the facility really slowed everything down.	**Respondent Three**: "My whole job is automation. Half my job is watching people, and the other half is watching the robots and those who watch the robots". **Respondent Four**: "It was more stress for me and more hours at first. Now that I know the system, I like it. My shift has got so efficient at getting trailers out the door".

DISCUSSION

The cumulation of knowledge from these three data sources can give a more complete view into what happened within Operations Company X during their transition and implementation of automation. The archival analysis of shipment data will be used as a backbone of stringent fact when considering the elements of the hypothesis. The survey administered will provide a combination of objective as well as more qualitative reasoning behind what the facility is experiencing, as well as the perspective from the common employee. Finally, interviews conducted upon upper management at the facility will give insights into further trends and reasoning behind what has been observed in the archival work and through the survey.

Hypothesis Discussion

Hypothesis One

H1. Automation increases worker efficiency the most in tedious or repetitive tasks.

This hypothesis point has elements supporting it from several of the research elements conducted. First, in the archival analysis, we were able to observe that efficiency had in fact increased at the facility, with throughput doubling and the labor cost per case dropping 15.6%. From the survey, some data supported this hypothesis while other aspects of the data did not support the hypothesis, which will be discussed below. Finally, through the interviews which were conducted, we dug into the nature of tasks which had seen their work change due to the automation, and which tasks had seen substantive improvements in efficiency by removing some of the tedious / repetitive elements.

One reason this hypothesis point was difficult to evaluate was due to the challenging nature of defining which worker is defined as ‘accountable’ for the completion of labor. While this automated inventory system did seemingly see the largest increases in efficiency for tedious/repetitive *tasks*, the nature of work accomplished by specific employees doing the tasks shifted as the facility became automated. Certain tasks that were once accomplished by one

group of employees was instead accomplished by the work of another employee in an automated area of the facility.

Rather than defining a task such that it must be accomplished by a specific type of employee, by looking at it from the perspective of net man-hours spent to accomplish, this finding becomes clear. For example, from the interviews, we learned the labor changed for a forklift driver to accomplish the task of completing an outbound load. Prior to automation, it took an office worker 5-10 minutes to print the labels for the order and it took roughly one to two hours for the forklift driver to then go around the facility and collect all the required pallets into a staging area. Finally, once the truck arrived, it then took another hour to verify the order was completed and move the pallets from the staging area into the truck.

After the automation, the office worker would still spend 5-10 minutes preparing the load, however now this prep work included the task of staging. The office clerk would spend the same amount of time working on the load but save the forklift driver almost two hours because they did not have to drive around and find the pallets themselves. Further, the order was staged into gravity lanes directly in front of the door it was shipping out of, so the act of loading the truck was more efficient as well. In this example, the blurring of tasks between different job descriptions shows why it was difficult to specifically address this hypothesis through the use of the survey.

In the survey, we had anticipated the ability to sort average Likert scale scores across employees with different job descriptions. For example, to explore the question “Using the automation improves my effectiveness in my job” and comparing the average score for a ‘forklift driver’ versus an ‘office employee’. However, after conducting the interviews, it was clear that such a clear-cut distinction could not be made across different occupations within the facility. The implementation of automation was so engrained in the nature of labor that duties, especially for tedious/repetitive tasks, changed hands frequently.

From the interviews, one key finding was that the removal of the task of ‘Consolidation’ was critical to reducing the number of employees required at the facility who drove forklifts. Prior to

automation, this task was accomplished by 2-3 forklift drivers, “80-120 man hours a week’, who would drive around and move pallets into groupings of similar products. However, with the implementation of automation, this task has been replaced by an automated function named “Rewarehousing”, where at night (or as needed) the machine runs completely by itself to automatically sort pallets by likeness. This task can also be manually forced by the office clerk if needed. This ultimately improves the quality of labor and instead allows the forklift driver who would have to spend his day driving around and moving pallets back and forth to instead do a task with a clearer value add, such as loading a truck.

Hypothesis Two

H2. Automation has the potential to fatigue workers by raising the level of work for human operators to achieve.

This hypothesis was tested in several capacities, and all of them proved mostly untrue for this facility. The archival analysis was not particularly helpful for resolving this point, however by observing the average time per pallet, we can see that it failed to be reduced to a level that would imply an extreme increase in speed of labor. The average time per pallet increased after automation – A very surprising finding. Next, from the interviews, by observing the average scores for fatigue-related questions, we concluded the workers were not self-reporting extreme levels of exhaustion or tiredness. Finally, through the interviews, managers gave their perspective that workers did not seem to be getting worked too hard. With these findings in mind, we concluded it was unlikely this hypothesis had enough evidence to support it.

Average time-per-pallet for outbound orders increased from 4.19 minutes to 5.63 minutes, an increase of 34.5 percent. This was due to more difficulties reassigning workers and busy truck scheduling times. This increase in time per outbound pallet does not suggest by itself that the level of work has been raised to a level which would fatigue workers.

Management did a good job of managing the tasks employees had to achieve in their day, and the level of work accomplished never seemed to cross the threshold for workers to become exhausted trying to keep up with the automation. This was further proven with the results from

the survey, which was conducted, where all levels of employees reported not feeling overworked or excessively tired beyond what would have been expected for a typical facility. Figure 33 is a table of 'fatigue' related questions and their average Likert scale scores.

#	Question	Mean	Median	Mode
13	My work makes me feel mentally exhausted	3.44	4	6
14	I feel tired when I get up in the morning and have to face another day of my job	2.93	3	1
15	I do not have sufficient time to do my daily tasks	2.18	2	1
16	I feel like I am working "too hard" in my job	3.8	4	4
17	I feel exhausted at the end of my day	3.85	4	4

Figure 33 – Fatigue Questions Table

This table shows the mean (average), median, and mode for the five questions relating to fatigue. Questions 14 and 15 both have mean scores below three, which implies slight disagreement. Questions 13, 16, and 17 have scores above three, but below four, which was the weight for agreeance; for these questions, although a positive trend does exist, it is not strong enough to imply fatigue is likely to be an issue at the facility.

This analysis is furthered by similarly reviewing the median values for these questions. The median values are all around the mean scores, although for questions 13,16 and 17 we do see the median values are 4, signifying 'Slightly Agree'. Question 14's median value is 'Slightly Disagree', while question 15 had much stronger sentiment, with a median value of two, signifying 'Moderately Disagree'.

After analyzing the mode of these questions responses, this finding became clearer. For questions 14 and 15, the most common answer was 'Strongly Disagree', implying fatigue or being overworked is likely not an issue in the perspective of these employees. Questions 16 and 17 again showed slight agreeance, with the most common response being 'Slightly Agree'. Finally, question 13 had a more interesting finding, with the most common answer being 'Strongly Agree'. For this question, fourteen respondents chose 'Strongly Agree' while thirteen chose 'Slightly Agree'. However, as can be seen from the fairly neutral mean score, there were also ten and nine respondents who selected 'Strongly Disagree' and 'Moderately Disagree',

respectively. This question was fairly polarizing in nature. Attempting to segment question 13 by job was similarly inconclusive, as responses remained spread out among different job descriptions.

The reason for this was likely due to the separation of work between automated tasks and human labor. While specific tasks were broken up into different elements, the human employees never had to work alongside the automation for any prolonged periods. The human employee would complete their parts of a task, then the automation would do their parts, then the human would work again. This lack of overlap between duties occurring concurrently likely enabled the human workers to operate at a pace they were comfortable with.

Even so, one duty which had concurrent elements to it failed to notably overwork employees. As was learned from the interviews, infeeding pallets requires the automation to scan / accept new inventory onto a conveyer belt into its system. Forklift drivers will continually infeed their pallets into the system once a spot opens on the conveyor belt. This failed to push human operators to levels of exhaustion for a couple reasons, but mainly because the humans were allowed to operate slower than the automation to still accomplish the task, and because when it did get incredibly busy, the infeed would logjam and slow down. During very busy times, human operators would actually wish the automation was able to work *faster* as it struggled to work through capacity constraints with many pallets being infed at the same time.

Further looking into the lack of extensive exhaustion from workers operating alongside the automation, when an outbound order was missing a pallet, workers still wished the automation could move faster. This type of automation is different from other styles in that work is accomplished efficiently due to forethought and preparation rather than purely speed. The automation is efficient because it enables work to be accomplished prior to the truck arriving, or order needing to be ready. From a speed standpoint, the pallets actually move slower than if it was an employee carrying a pallet on a forklift. This was a point of frustration widely documented throughout the interview process, as managers remembered how forklift drivers would often lament it would have taken them ‘like a minute’ to drive down and grab the pallet and complete the order. Instead, the one pallet remaining to be picked would be stuck in a queue

on a conveyer belt where it would slowly work its way down to the door after almost an hour – way slower and more inefficient than before. This 'lack of a plan B' as it was described does an effective job of explaining why workers are probably not getting exhausted working with the automation – It is slow but relentless. It works best when you select and drop the orders required for the next day the night before, and then once you arrive that next day, the pallets are all in their proper places.

Hypothesis Three

H3. Automation's perceived usefulness has a positive relationship with worker efficiency.

This hypothesis was primarily explored with the survey of employees at the facility, although several answers from interview respondents will also be considered. The data collected would seem to support this hypothesis. Perceived usefulness of the automation was compared to reported improvement in efficiency to uncover how the workers felt about the automation. The interaction between these two elements of the survey is depicted in Figure 30.

Correlations

		Automation helps me be more efficient at my job	Using the automation in my job improves my productivity	I find the automation useful in my job	Using the automation improves my effectiveness in my job
Automation helps me be more efficient at my job	Pearson Correlation	1	.730**	.694**	.705**
	Sig. (2-tailed)		.000	.000	.000
	N	55	55	55	55
Using the automation in my job improves my productivity	Pearson Correlation	.730**	1	.787**	.474**
	Sig. (2-tailed)	.000		.000	.000
	N	55	55	55	55
I find the automation useful in my job	Pearson Correlation	.694**	.787**	1	.641**
	Sig. (2-tailed)	.000	.000		.000
	N	55	55	55	55
Using the automation improves my effectiveness in my job	Pearson Correlation	.705**	.474**	.641**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	55	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 30 – Perceived Usefulness Correlations

Strong correlations exist between these attributes of usefulness and efficiency. These correlation scores show the close relationship between these aspects of automation. The question

'Automation helps me be more efficient at my job' has high Pearson correlation scores with the two questions relating to automation's perceived usefulness with a correlation of .694 and .705, respectfully, with 'I find the automation useful in my job' and 'Using the automation improves my effectiveness in my job'.

These findings align with the interviews which were conducted, as management reported employee attitude towards the adoption of the automation did impact how effective they were using it. If the workers considered the automation a waste of time, they would drag their feet and often complain about having to learn to use the new system or not being paid enough to deal with these new duties.

It was phrased best by respondent three, explaining "Automation makes this issue of the employees (complaining) worse. Nobody likes the robots, and the workers don't think they should have to work as hard as they do". This negative sentiment has a corresponding negative performance between those employees and the automated system.

This is elaborated by Respondent Five, stating "Bad attitude sets employees into only strictly doing their jobs and not wanting to be adaptable. Big picture, they are setting stuff back". While not specifically commenting on the automation, his intent with his statement is clear: Frustrated employees who perceive the automation to be a threat begin to shut down or stick strictly to their job duty and deliberately not be adaptable. For workers who have a positive perception of the automation, the reverse is true, where workers who wholeheartedly use the automation and are adaptable to the change are made more efficient by the automation.

The perception of usefulness for the automation relates strongly to the communication the employees received from management on the purpose of the automated system. Generally, poor communication on the substantive abilities and purpose of the automation caused negative employee sentiment which hurt productivity. For employees who fully understood the system and what it was intended to do, it was more effective in boosting their productivity.

Hypothesis Four

H4. Automation's ease of use has a positive relationship with worker efficiency.

This hypothesis was primarily explored with the survey of employees at the facility. The interviews were also used to discuss the presence of training at the facility as it applies to ease of use. Ultimately, there seemed to be evidence supporting this hypothesis. Ease of use related to the training employees received on how to use the automation, and higher ease-of-use scores is hypothesized to relate to higher 'automation helps efficiency' scores. Workers who feel more comfortable using the automation in turn feel the automation is more useful in boosting their efficiency. Figure 31 shows this relationship between several questions between these two categories.

Correlations

		Automation helps me be more efficient at my job	Using the automation in my job improves my productivity	My interaction with automation is clear and understandable	I find the automation to be easy to use	I find it easy to get the automation to do what I want it to do
Automation helps me be more efficient at my job	Pearson Correlation	1	.730**	.151	.322*	.411**
	Sig. (2-tailed)		.000	.270	.016	.002
	N	55	55	55	55	55
Using the automation in my job improves my productivity	Pearson Correlation	.730**	1	.400**	.190	.360**
	Sig. (2-tailed)	.000		.003	.164	.007
	N	55	55	55	55	55
My interaction with automation is clear and understandable	Pearson Correlation	.151	.400**	1	.317*	.367**
	Sig. (2-tailed)	.270	.003		.018	.006
	N	55	55	55	55	55
I find the automation to be easy to use	Pearson Correlation	.322*	.190	.317*	1	.680**
	Sig. (2-tailed)	.016	.164	.018		.000
	N	55	55	55	55	55
I find it easy to get the automation to do what I want it to do	Pearson Correlation	.411**	.360**	.367**	.680**	1
	Sig. (2-tailed)	.002	.007	.006	.000	
	N	55	55	55	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 31 – Perceived Ease of Use Correlations

While not all attributes of efficiency and ease of use directly relate, several connections do exist within the dataset – The strongest connections are between 'My interaction with automation is clear and understandable' and 'Using the automation in my job improves my productivity', with a Pearson Correlation of .400. Further, the questions 'I find it easy to get the automation to do what I want it to do' and 'Automation helps me be more efficient at my job' have a Pearson correlation score of .411.

This data echoes the sentiment of the interview respondents. Poor training was expressed as a difficulty throughout the interviews, and the employees who worked best with the automation were the ones who had been trained to use it.

According to Respondent Two, "The training was "Nil". It just wasn't good. Some of the guys did not get any training at all. It should have been better… A big part of the issue is unfortunately the company we worked with. They are clearly spread thin, and they do not have all the training programs and materials quite perfected yet". This quote paints a pretty bleak picture of the training for the automation and may explain part of why ease of use scores are so closely tied to workers efficiency. Early in the use of the automation, workers are less efficient as they are forced to learn 'on the fly'. With poor training, it is not that the employees will never become proficient using the automation, however it just takes longer to get there.

This sentiment was echoed by Respondent One "We all kind of had to learn the new system on the fly while still running the facility mostly using the old one. We got training for one week which showed the current employees some pretty basic stuff, like how to drop pallets or manage the infeed. Very basic. The training was bare minimum. I don't think it was for enough time… It was not enough. They haven't given us more training really since". This quote finally drives home the relationship between ease of use and worker efficiency. It is critical that employees are comfortable using the automation for them to be most effective. 'Bare-Minimum' training is not enough when it comes to such a complex machine, and poor training will cause a lag time between implementation and most efficient use as workers get comfortable using it.

Hypothesis Five

H5. Automation causes a movement of work from lower skilled positions to higher skilled positions.

For this element of the project, it was difficult to measure using archival or survey data – So this hypothesis was primarily supported using the interviews. However, one survey question did provide some level of insight. The question 'There are good opportunities to find interesting and new challenges at Operations Company X.' provided some perspective into this, as sentiment remained very positive that there were good opportunities for them within the company. Figure 34 represents a graph of the responses for this question.

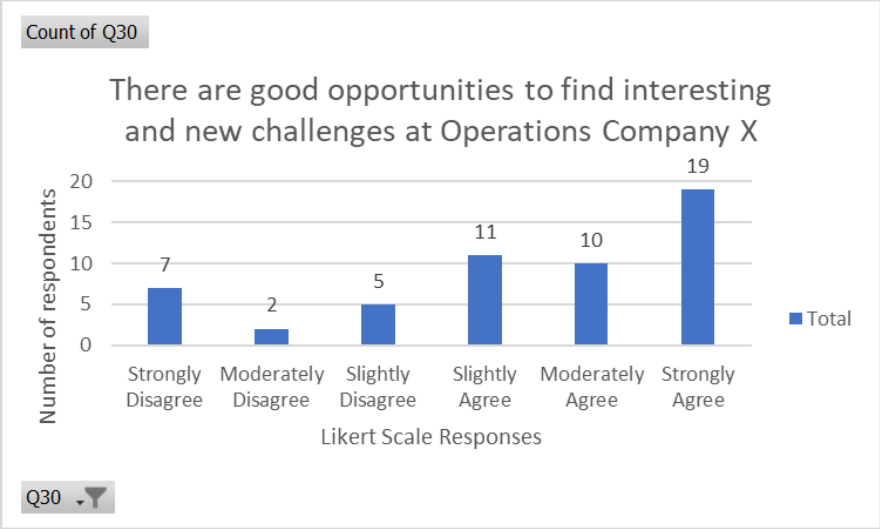


Figure 34 – Question Thirty Response Graph

While it is reassuring that workers feel confident that they have good opportunities for 'interesting and new challenges', it does not within itself resolve the hypothesis, which specifically relates to the implementation of automation. Thankfully, the interview question seven did adequately answer this question. It has been attached as Figure 35.

7. How has the quality of staffing positions here changed due to automation?
   - ➔ Have you noticed more high-quality positions available, such as supervisors, management, attendants? Has hiring been more internal to capitalize on lower-level worker familiarity with this automated system?
   - ➔ Has automation caused you to look for different qualifications for potential new employees, or focus training on different sets of skills?

Figure 35 – Interview Question Seven

Responses to this question were decisive, as the consensus for this question was that staffing positions had improved, and the more advanced 'automation' staffing positions had been mostly internal hires.

Respondent Five may have stated it best, explaining "Quality of positions has improved. Solid raises if workers are good with the automation for the seven new ASRS attendant positions. Guys who get promoted must have a more mechanical aptitude".

Furthering this point, Respondent Four discussed the promotions caused for the attendant position due to the automation's implementation "Promotion wise, the attendants, on my shift anyway, are all internal hires".

Piecing in Respondent One's perspective, they explain "Prior to the automation, it seemed like there was more manual and labor-intensive work. There was a new group of positions made after the automation came to the facility too, the machine attendants… The hiring of the new machine attendants was pretty much 50/50 internal and external. It definitely gave some of our higher-performing workers a chance for better pay… Recently though new attendants have been mostly internal. There is some value in hiring guys who are already a little familiar with the machine".

This alone would seem to begin to confirm the hypothesis, however there is another category of employee who was strongly impacted by the implementation of the automation: the office clerk.

According to Respondent Four, "The clerk position is really much higher level - They are more like an office coordinator, not a clerk". This quote emphasizes the increase in expectations for the office clerks. Further, the phrasing 'higher level' helps to give insight into the perception and quality of work that these office employees are conducting.

Respondent Two furthered this perspective, confirming the shift in the nature of work for office clerks "The position that has seen the most change due to automation are office coordinators. They handle some inventory control tasks now. They work with two systems – it is a lot more complicated".

Due to the implementation of the automation, there are also more office coordinator positions available. The job used to be conducted by one employee per shift, however two more openings (one additional per shift) appeared in the office for workers to manage the day-to-day operations of the automation. These hires were also mostly internal, as workers who were comfortable withing with the machinery throughout the transition period were ideal candidates for promotion.

Ultimately, using this facility as a case study, the evidence would suggest that there was a movement of work from lower skilled to higher skilled positions due to automation. Further, the workers who populated those higher skilled positions were predominantly internal hires.

Hypothesis Six

H6. Automation in a stable demand environment has a positive relationship with worker efficiency.

While it was theorized at first that this hypothesis would be able to be reasonably answered with the archival data intended to be gathered from this project, it is difficult to accredit a stable demand environment to a positive relationship with worker efficiency. Interview evidence was collected which would imply that the best operating conditions for the automation are during the slower season for the facility, when demand is more level and consistent. Further, evidence was collected that seemed to show the automation worked best with ample lead time to plan. This would suggest that a stable demand environment, which allows for the most lead time to plan out / schedule orders would have a positive relationship with worker efficiency.

Unfortunately, while these findings were promising, without substantial proof of heightened worker efficiency statistics due to more consistent patterns of demand, it is hard to confirm that this relationship is proven to exist within the facility. There are various hints which imply it, but the archival data gathered was throughout a COVID-19 ravaged 2020 became almost unusable for this purpose. Unseasonal / atypical demand fluctuations occurred throughout the year, which

were managed in an appropriate fashion to not negatively impact the facility. However, they did make it impossible to characterize the demand for the facility as ‘stable’.

There were too many factors to consider that blurred any potential resolution to this hypothesis. Aside from concerns from COVID-19, a facility which so recently implemented an automated system such as this one is not suitable for efficiency to be attributed to the nature of demand it experiences. Most fluctuations in efficiency would be due to workers becoming more comfortable with using the automation as well as less downtime due to ironing out bugs / errors in the system itself. The facility was not yet mature enough for a study of the impact of its demand environment to occur. Without confidence in the continuation of a typical, stable facility demand environment, this hypothesis can be neither proven nor disproven.

This may be one area where future research would be promising, as evidence did begin to point to this conclusion. In a future study, a comprehensive review of the demand environment for the facility, in conjunction with tracking of employee efficiency statistics for that same time length, would begin to answer this question. Learning from this study, before attempting to attribute changes in efficiency with the stability of demand, it should be confirmed that ‘all else remains equal’, or that the scheduling and quantity of shipments would be the only independent variables.

Additional Findings

While this case study is undoubtably not fully representative of what all distribution centers may experience in the transition to an automated WMS system, it can be used as an interesting window into a distribution center to learn from and observe what they experienced. In large part, their transition from manual fulfillment to automated inventory management achieved what they were trying to do. Their stated goals were to increase facility throughput and lower cost per case, and that is what they accomplished. Facility throughput increased by 108% (over doubling), and cost per case was reduced by almost 16%.

However, in striving to achieve these goals, several other key metrics were impacted and damaged -- at least in the short term. Average late percent increased by 46% from 2017 into 2020, although it seemed to be coming under control later in the year. Further, the average labor cost per month increased by roughly 24%, and yearly ship errors increased substantially from twelve to thirty-two. Worsening matters, average time per outbound pallet increased by almost 35%, which would seem to imply the failure of the implementation. However, this metric of average time per outbound pallet is deceptive, as the increase in throughput forced the workers to have to be more pragmatic when deciding which orders to load first, and generally more loads were completed closer to the end of their 2-hour window rather than earlier. In order to suppress the rising late load percent, management had to be more selective about when workers were reassigned from other duties to assist in shipping out orders. This only compounded with issues relating to the rising expectations on the facility. Operations Company X managers faced continually rising pressure to operate more and more lean to see more significant ROI from the automation's implementation – This forced the facility to operate on the edge of being understaffed, and potentially infringed on the workers realized efficiency. When the facility is continually too busy to get all the work done, there becomes a certain level of desensitization to late orders which seemingly cannot be helped.

From the perspective of several members of management at the facility, employee attitude and lack of training played a role in this increase in time per outbound pallet. While some workers were incredibly efficient, a few 'Bad Apples' managed to lower the mood and cause numerous

problems during the transition. This highlighted the need for careful management of staffing throughout the transition, as employees who are unhappy with the way the changes occurred or unsatisfied with the transition can cause widespread moral and efficiency problems.

A likely explanation for unhappy employees was due to poor training on the use and purpose of the automation. While limited training days were available when the automation was first being installed in 2018, turnover is relatively high for forklift drivers, and there was never more advanced training beyond base-level shadowing for these new workers. While this would have been acceptable for the most part, the required qualifications for forklift drivers changed while their pay did not. The best and most qualified pickers and forklift drivers were internally promoted to the newly created ASRS attendant positions, while those who were less technologically qualified remained as the new crop of top forklift drivers. While the automation is undoubtably a positive for those who received a promotion (and subsequent raise), for those that did not, the question remains the reasoning for why they were not promoted – and that is lack of mechanical knowledge and technological literacy. Once these forklift drivers began needing to interact with the automated system and have their forklifts equipped with tablets / new scanners, they were the most probable population within the entire facility to feel uncomfortable with these changes. This only compounded with the lack of extensive retraining or education to alleviate these concerns.

Increases in efficiency remained inconsistent across the entire facility, where some tasks were improved more than others. For pickers, the use of the layer picker enabled them to no longer need to move full tiers of pallets when picking, which greatly increased their efficiency. Additionally, for forklift drivers emptying out inbound trucks, their travel time reduced significantly as they simply had to drop the pallets on the conveniently placed infeed conveyor belt, which caused a reduction in time to break down a truck as high as 75%, according to interview Respondent Five. For forklift drivers who had to load trucks, they were no longer responsible for staging orders at all, which also potentially reduced their time to complete an order from as high as three hours to one hour or less.

Improvements in safety were also a notable finding, as having less forklifts driving all over the facility lends itself to less injuries as a direct result of automating. Further, the layer picker taking over the movement of full product tiers from pickers enabled them to move less total weight per pick, as the heaviest elements were now handled by the automation. This reduced strain on employee's backs and arms. Additionally, due to thicker plastic wrapping and higher quality pallets being needed to survive moving along the conveyor belt, these stronger pallets broke less frequently, and when they did break, it was in an unmanned area of the storage where there were no employees to be hit by falling product.

Although not a finding which was necessarily sought out, a poor policy relating to the scheduling and loading of trucks at the facility was hurting efficiency. For example, if a truck was scheduled to arrive at 8:00 AM and arrived at 8:00 AM, it was placed into a queue with the other trucks who had an 8:00 AM appointment time. However, if the truck who was scheduled for 8:00 AM arrived at 12:00 noon, rather than being placed in the queue with trucks scheduled for 12:00 noon, it jumped the line and was next-up to be unloaded. This incentivized trucks to arrive late for their appointments so that they would not have to wait around the yard as long.

Once this was corrected so that trucks arriving late were instead 'fit in' rather than receiving priority, the cascading effects of trucks missing their appointments was reduced. Rather than the trucks arriving late causing other subsequent trucks to be late, only that one truck was late, and they were forced to wait around for an opening.

CONCLUSION

The research questions for this paper all centered on the impact of automation on a facility who had transitioned from a manual fulfillment facility to an automated warehouse execution system. This study has shown that while automation was effective in accomplishing the primary objectives of improving facility throughput and lowering cost per case, it damaged secondary metrics such as percent of late shipments and shipping DPPM. As it applies to tedious or repetitive tasks, the implementation of automation was effective in eliminating them and enabling employees to focus their energies on more value-added functions.

Further, this implementation of automation did not appear to fatigue the workers at the facility. Due to the separation of work completed by robots and by humans, a temporal disparity exists which enables work to be accomplished at a different pace across the facility. The automation works at the consistent, unrelenting speed it needs to so that it can prep for human labor at a later time. Then, once manual labor is needed, there is minimal-to-no direct interaction between the machinery that would force the employees to work faster than they are comfortable with. This subsequent increase in the overall work to be accomplished at the facility is further offset by the elimination of the most tedious elements of labor, which causes a general neutral shift where employees are no more fatigued working at the automated facility than at a manual fulfillment facility.

From the perspective of workers at the facility, the perceived usefulness of the automation and ease of use were both reasonable predictors of how those workers efficiency would be affected. For workers who had a more positive perception of the automation, and perceived the automation as easier to use, they also reported higher efficiency scores. This emphasized the importance of clear communication from management to get early employee buy in, and the importance of sufficient, recurring training for the use of the automation.

At the facility in question, automation also caused a movement of work from lower skilled to higher skilled positions. The creation of an entirely new position working with the automation, the ASRS attendant, was filled by mostly internal hired of forklift drivers and pickers, enabling them the opportunity for more advancement and better pay. Further, tasks such as office clerk

became more numerous and higher level, again enabling more internal upwards movement for preexisting employees and higher quality of labor.

In conjunction with safety improvements, the implementation of the automation was a success, with the most harmed metrics showing signs of improvement as the facility grows more used to using the automation. The late shipped percent, which had been up by 77% in the first half of 2020, was only up 21% in the back half of 2020, and showed signs of returning to pre-automation levels. Ultimately, this case study gave a fantastic window into a facility which had only recently adopted automation. The cumulation of all three research instruments, the archival analysis, survey, and interviews, gave a comprehensive insight into the happenings at the facility.

Research Limitations and Future Research

Given the case-study and exploratory nature of this study, these findings are not necessarily applicable to every facility who is considering the implementation of automation. Data collection for the archival analysis only looked at two years, 2017 and 2020, and valuable information which occurred during the construction and early transition to automation was lost. The depressed metrics which were present in 2020 were likely even more damaged in prior years when areas of the facility were closed, and the machinery was actively being built.

The survey being conducted was only 55 valid respondents, while being representative of the facility in question, is not nearly a high enough number to even begin to project the perceptions of the generalized distribution center worker. This sample size problem persisted with the interviews, as five interviews all from the same facility who have similar experiences cannot speak to larger industry trends. Interviews across multiple different facilities who had implemented automation would be required to speak to larger trends with higher confidence of them.

The literature review was used to develop the hypotheses, survey questions, and interview questions, however a more extensive analysis may provide different areas of focus. As the field of automation in distribution centers is so fast-moving, another study conducted now would

likely see the implementation of the automation take a different path and use different technologies and controls to streamline the process further.

Future research would likely have more luck considering the sixth hypothesis of this project, that a stable demand environment is beneficial to efficiency with automation. At the time of this research, the implementation of the automation was too recent to attribute any changes in observed efficiency to the environment of demand. A more mature facility would need to be researched to fully explore this relationship.

It may be interesting to further explore the relationship between management decisions in a transition from manual fulfillment to automated inventory management. The clarity of communication with employees and level of training they receive were both identified as potentially important aspects of an automation implementation for this study. Examining these aspects across multiple facilities in different situations could discover, ways that companies can reduce transition paints and mitigate risks associated with automating.

APPENDICES

Appendix A – Table of Relevant Terms

Definitions of Terms:	
"The Automation"	This refers to the entire automated system of conveyer belts, T-Carts and cranes which enable pallets to move throughout the facility without constant human interaction.
"The Customer"	This refers to the customer who has contracted Company X to operate their facility for them. As the third-party logistics firm, Company X does not own any of the goods in the facility, or even the facility itself. The facility and product are owned by the customer, who also operate the plant.
ASRS Attendant	These are employees who work for Company X and are responsible for maintaining the automation within the facility. They can typically fix and resolve basic problems and faults, as well as perform normal maintenance. ASRS stands for 'Automated Storage and Retrieval System'.
Consolidation	A specific task that an employee was assigned to do for a day. They would drive a fork truck around the facility and match up different locations with the same product, then consolidate those multiple locations into one location to hold all of the same product.
Conveyer Belt	A belt which exists internally inside the automation, it allows for pallets to move in a controlled manner from one location to another. Contains motors to control the speed and direction that pallets move. Contains multiple sensors to allow the constant tracking of pallets and their locations in the facility.
Crane	A several-story tall crane which is capable of operating 100% autonomously or be overridden by an operator. It has space to take one pallet at a time and a small robot with tracks on it. The crane carries the pallet down to the correct row and lifts the pallet up to the correct height, then the robot the pallet sits on drives it out to the correct position deep into the racking.
Fault	A basic error or issue with the automation. Can be resolved by an ASRS attendant. For example, a pallet falls off the conveyer belt or some product gets loose. Further, it can be standard maintenance or basic misreads.
FIFO	First In, First Out. For food products, it is important to cycle completely through old inventory before shipping out items with a later expiration date.
Gravity Feed	An angled lane which the T-Cart drops a pallet onto. Loaded from the back, it slowly allows the pallet to roll down from the back to the front of the lane where it can be removed. Operates as a queue which can hold all the pallets for a particular order.
High-Capacity Storage Locations	Potentially six rack locations high and up to eight rack locations deep, these locations can only be accessed via the crane within the automated system.
Inbound	A truck or pallet of goods which has not yet been scanned into the WMS system and is not currently tracked by the facility. Location is known as "Infeed Pool" prior to being placed into the Infeed when the location begins to be substantively tracked. An inbound truck brings new finished goods to the facility.
Infeed	A conveyer belt where a fork truck driver places inbound pallets. The pallets enter the WMS here and are scanned, measured, and centered prior to being allowed to enter the automated system. The pallets must pass a series of tests before being allowed to enter the system, and if they fail, they will be rejected and given a code for the changes required before the pallet will be accepted.
KPI	Key Performance Indicator. Refers to metrics which Company X tracks that monitor efficiency and effectiveness in various capacities and tracks their progress towards goals and improvements.
Layer Picker	An important element of the automated system which reduces manual labor required. Full pallets go in, and a vacuum arm can remove the entire top tier of product off of the pallet before placing it onto another empty pallet, before shrink wrapping it and prepping it for shipment. Enables the automation to deal in less than full pallet loads, but not smaller than one tier of a product.
Manager	A level of job which an employee has, they are responsible for higher-level planning as well as monitoring supervisors and important business functions.
Mechanical Issue	An issue with the automation which is uncommon or unexpected. This is more serious than a fault, where an important part seriously malfunctions or breaks and cannot be fixed quickly be standard Company X employees on-site. Examples include critical springs or gears snapping on the cranes, or expensive parts being damaged for which there are no easily accessible replacements.

Mission	A mission is a task within the automated system for a specific pallet. An example of a mission for a pallet is for it to be moved from its storage location to a gravity feed to prepare for a shipment. The automation interprets a mission as a task it must accomplish by moving a pallet. Missions can have different priorities depending on how quickly they must be accomplished.
Outbound	Pallets which are currently in the automated system but in the process of leaving, typically staged in a gravity feed awaiting a truck which will ship them off to their next destination. An outbound truck is receiving finished goods from this facility and bringing them elsewhere.
Partial Pallet	A partial pallet is a pallet which has been prepared either by manual pickers or the layer picker and contains less than a typical pallet load of a product.
Post-Automation	This term refers to the facility after the implementation of automation.
Pre-Automation	This term refers to the facility prior to the implementation of automation when inventory was managed manually.
Rewarehousing	An example of a specific task which the automated system can undertake to reorganize the high-capacity storage locations to better follow FIFO principals or sort the same product near other lanes of that same product. This task specifically replaced the old manual task of consolidation.
Supervisor	An employee whose job is to monitor base-level employees. They typically are responsible for a specific area of the facility or are accountable for making sure a specific operation runs smoothly. They do some higher-level reporting and tasks, but report directly to managers.
T-Cart	A small, automated cart on a set of tracks which runs forward and backwards along a row of gravity lanes. It receives pallets from a conveyer belt and drops them into a gravity feed.

Appendix B – Respondent Three January 2021 Quote

"I really noticed us start to turn a corner last July or August. We got rid of a few bad apple employees and I took charge of making sure loads got handed out quicker... Early last year (2020) and how we have been now (January 2021) is night and day. We are really cooking now."

❑- Respondent Three, January 2021

Change in Month Late Percent from 2017 to 2020											
January	February	March	April	May	June	July	August	September	October	November	December
100.02%	117.61%	55.69%	84.44%	5.11%	99.17%	41.38%	10.53%	28.22%	20.69%	-12.24%	45.07%

77% Increase 22% Increase

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