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Analysis of Container Shipments for USTRANSCOM

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ANALYSIS OF CONTAINER SHIPMENTS FOR USTRANSCOM

THESIS

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Abstract

USTRANSCOM (United States Transportation Command) sends containers to various overseas destinations, mainly commercial container shipping companies. Delivering the containers to the destinations on time is important to support the United States (US) Forces deployed in foreign countries. This study analyzes container shipment records for two years from 2019 to 2021 and prepares insights for USTRANSCOM. This study utilizes descriptive statistics, data visualization, and one-way analysis of variance (ANOVA). According to the records, almost half of the containers (41.25%) were delivered late for one day or longer. The container with the longest delay took 408 days. Major reasons for delays included port staging and related issues, delivery scheduling, incremental weather, missing documents, customs issues, COVID-19, and so on. One-way ANOVA results revealed that shipments to the Republic of Korea (ROK) took longer than any other country in the USINDOPACOM region, which was statistically significant. In addition, when only delayed containers to ROK were selected, the mean delay days were 6.92 days with a standard deviation of 17.078, which showed high variability. Although most delayed shipments have been approved by USTRANSCOM, it is critical for USTRANSCOM to understand delays for planning shipments to the destinations.

Acknowledgments

I would like to express my sincere appreciation to my faculty advisor, Dr. Seong-Jong Joo, for his guidance and support throughout this thesis effort. His continual guidance and patience were truly appreciated. In addition, I am grateful to Dr. Lunday for supporting my thesis with the USTRANSCOM fund and serving as a committee member. I dedicate this thesis to both my mother and beautiful wife. Their continual support, understanding, and wonderful love made all this possible.

John N. Campos y Campos, TSgt, USAF

Table of Contents

Page

List of Figures

List of Tables

ANALYSIS OF CONTAINER SHIPMENTS FOR USTRANSCOM

I. Introduction

Chapter Overview

This chapter presents the background and purpose of this study of the United States Transportation Command (USTRANSCOM) use of containers for logistics purposes. In addition, it provides the justification for this study, the scope guiding this study, limitations, and assumptions. Lastly, it summarizes the research focus of the study on containers.

Background

The containerization revolution created an opportunity for the United States military to enhance military operations in different regions across the globe. In addition, the delivery of containers provides a massive logistical advantage during global campaigns against adversaries (McGowan, 2005). The United States military has utilized containerization for over 50 years. The containerization revolution started in the 1950s, impacting businesses and trade around the globe. The surge of commercial containerization gave a way to improve foreign exchange and expedite intermodal cargo movement. All modes of transportation upgraded to carry larger capacities due to the increasing demand across the nation. The United States military did not overlook the growing build-up and productivity gained by utilizing containerization (Cudahy, 2006). The capacity to safely move assets quickly from the mainland to anywhere in the world created an opportunity for them to enhance military power and be involved in global campaigns (Weaver, 2010; Preston, 2013). Historically, the United States military utilized containerization for multiple purposes in conflicts such as the Vietnam War, Operation Desert Shield in 1990, Desert Storm in 1991, Operation Iraqi Freedom, and Operation Enduring Freedom.

The multi-echelon inventory management solutions have increased shipping materials from CONUS locations to deployed installations (Weaver, 2010). As conflicts escalate, container demand increases, putting pressure on supply chains and creating unexpected delays.

Limitations and assumptions

The major limitations of this study were the lack of data about the actual effects of the delay on current operations across different locations. In addition, due to the complexity of analyzing large data sets with shipping and receiving records, the scope of this research will focus its analysis on consignee countries within USINDOPACOM. Sample sizes can produce accurate results when data is interconnected, exact, and accurate (Schoot et al., 2015). Due to the way the data was recorded, multiple data sets provided by USTRANSCOM had correlations but failed to connect. There was no connection between the reasons for delays and shipment records data sets. This study could present better recommendations by knowing and understanding the effects of the reasons for the delay on current operations.

Research Questions

This study will answer three main questions on container shipping records by utilizing descriptive statistics and one-way ANOVA using IBM SPSS 27 (IBM, 2020).

RQ1: What is the proportion of on-time delivery and delayed shipments?

RQ2: Are there any differences in delivery time by destination?

RQ3: What is the major reason for the delay?

This study employed descriptive analysis and one-way Analysis of Variance (ANOVA), statistical tools to analyze shipping records from the United States to allied countries into the United States Indo-Pacific Command (USINDOPACOM).

Research Focus

Less expensive and effective shipping modes such as commercial sea liner and shuttle ships have become a trend for shipping military containers by both military contractors and organizations. The service ports to commercial and military companies have evolved throughout the years, continually improving their operations to prevent loss or delays. Delays cause a rise in prices due to the need for warehousing, rail transportation, drayage, demurrages, and truck transportation outside the cargo port. Another critical factor is the relationship between the port and the region they serve, as ports impact the economy and way of life of the local region or area of service. This study identifies major delays and reasons for the delay to consignee countries to give recommendations that help decision-makers minimize delays.

II. Literature Review

Chapter Overview

This literature review begins by presenting a layout of the fundamental knowledge of how military container delays and stoppages can breach contractual agreements. Also, it presents a brief explanation of external factors that affect seaports and transportation operations.

Late arrivals in a transshipment container terminal

A close examination of multiple sources of scientific literature affirmed numerous issues related to the transportation and delivery of containers across ports. Analyses of likely emerging stoppage could revamp delivery times to the port, resulting in expedited delivery of cargo to the customer. Cargo delays are a constraint during the cargo transportation process. The delay can result in the non-compliance of contractual agreements and potentially lead to mission failure. Pani et al. (2014) conducted a study on Transshipment Container Terminal in which they found multiple external factors contribute to the late delivery of assets to the port terminal. The arrival day to the cargo terminal is a relevant factor affecting delayed delivery of cargo, i.e., cargo arriving over the weekend will get delayed more than cargo arriving during the week. The research concluded that better data management could improve port operations management, maximizing its competitive advantage by preparing the right equipment and closely monitoring cargo ships.

Effects of cargo delivery and employment

Seo & Park (2018) identify an interesting link regarding the effects of cargo delivery and the country's employment at the port-regional area workers. The study employed economic theories of employment within models. The results indicated that the establishment of quayside ports was closely related to the origin and rise of cities. Port cities became more relevant as they turned into one of the primary trading sources for merchants. In addition, these trades and sales introduced much wealth into the local economies (Merk, 2013). Historically, seaports were linked to the backcountry areas with small populations and lower salaries. However, the evolution of seaports and increasing supply and demand across Asia has produced unprecedented growth. The port of Busan in the Republic of Korea is one of those regions in which government investment has increased the enterprise, enabling the region to become the largest port in South Korea. The actions taken by the South Korean Government encouraged multiple changes to port laws, forecast of intense competition, preparation for uncertainty, and improvement of port connectedness (Seo & Park, 2018).

The impact of delays across the regions depends on multiple factors, including topographic situation, location, season, and time. Merk (2013) analyzed the direct relationship between the supply chain's effects on large cities and the direct link to port cities. Their analysis utilized direct value added to identify the impact of port cities. Inland, large cities depend on ports as they depend on the goods to be delivered to satisfy the increasing demand. Additionally, ports contribute to the global markets and economy of the countries (Merk, 2013).

Specific ports might have a limited capacity with crane scheduling and availability. Choo et al. (2010) discussed; container terminals met multiple constraints. Constraints related to the port configuration are a well-known issue mentioned by multiple theory authors. Their study investigated solving the issue by implementing mixed integer-linear programming (MIP) and heuristic techniques to address constant delays on the port operations' quayside and landside. Typically, ports can handle up to 2,000 containers, operating multiple container boats simultaneously. In addition to the download quay, crane ports possess large cargo yards in which they store containers up to 20 stacks. With extensive operations, delays can occur as ships' arrival can be dynamic depending on multiple factors out of control from the port authorities (Gharehgozli et al., 2007).

Global Containerization

The global containerization of cargo for maritime movement is not a new concept for the military (McGowan, 2005: 205). The Department of Defense has utilized containerization for over 50 years. The containerization revolution started in the United States in the 1950s, impacting how commercial and military conduct business and trade around the globe (Cudahy, 2006). The surge of commercial containerization gave way to improvements in foreign exchange and faster intermodal cargo movements. In addition, it has increased dependence on Chinese products and the rise of that country to economic world power. All modes of transportation upgraded to carry larger capacities of containers due to the increasing demand across the nation. The United States did not overlook the increasing build-up and productivity of utilizing containers. Changes worldwide resulted in the increase of capacity to safely move assets to anywhere in the world. Many others followed suit, as is the case with many countries in Asia (Cudahy, 2006: 207).

Chen et al. (2007) discuss how information sharing, market variable demand, and supply chain changes are important factors that constraint the effective delivery of goods. They utilized data envelopment analysis to analyze linear efficiency measures of the rapid changes of demand and business environment. These changes required supply chains to become more efficient and effective at data sharing to increase their performance. Before ordering and delivering goods, managers need to have complete knowledge of complex supply chain management to ensure costs can be kept as low as possible. Multiechelon inventory management models provide a full view of inventory control activities across the entire supply chain. Also, forecast accuracy is an important factor for predicting both trends and decision-making.

Upon reviewing the literature, multiple researchers observed several gaps related to statistical data about shipment delays. Statistical analysis with exact data can be used with one-way ANOVA to present real-world decision-making.

Summary

The literature review examined the great potential of cargo containerization. In addition, it reviewed the most notable indicators affecting ports, such as efficiency and effects of seaports in quayside towns. Lastly, global economic powers currently utilize transportation to deliver larger quantities of cargo and project power.

III. Methodology

Chapter Overview

This section describes the sources utilized to obtain the data. In addition, this section presents both an in-depth explanation of the analysis of the methods conducted on the data set and a description of significant variables related to containers shipped to consignees.

Data Collection

This study analyzed container shipping data records provided by the United States Transportation Command (USTRANSCOM) from 2019 to 2021. The data includes the number of containers delivered to military installations in six major combat commands (MAJCOM). The data sets were categorized by destinations to identify the overall frequency, percentage, valid percentage, cumulative percentage, mean, and kurtosis.

Statistical Methods and Graphical Representation

This study examined destination shipping records using descriptive statistics to identify delivery time differences among destinations. In addition, the execution of the analysis on the data collected served to identify major delays across different countries. The process took place in two phases. First, the exploratory phase calculates frequency, percentage, valid percentage, cumulative percentage, and means of shipments delivered to all ports. The second part, the inferential phase, confirmed that the calculations performed in the first step were the correct method to analyze the data. During the inferential phase, the researcher identified conclusions and significant differences according to the evidence drawn from the data (Myers et al., 2010: 14-16).

In addition, histogram charts were utilized to group data into bins for visual analysis. Histograms are a common graphical representation of the quantitative data acquired. The histogram data from the number of delayed days were placed on the horizontal axis to represent the measure of each bin. The frequency measurements were placed on the vertical axis for each bin. The most relevant part of using histograms is representing a lack of symmetry and skewness according to normal distribution. Histograms can be skewed to the left when the tail exhibited distribution extended further to the left than the right. Additionally, the data set can be skewed to the right when the tail of the exhibited distribution extends further to the right than the left. An example of this type of histogram would be for data representing the number of delays; a higher number of on-time shipments would create skewness in the right tail.

The following list presents an itemized list of relevant statistical terms utilized in the descriptive analysis.

- N: The number of cases in the total sample.
- Minimum (Min): The minimum observed score.
- Maximum (Max): The maximum observed score.
- Alpha (α): Statistical significance.
- Mean (x): Average of a data set.
- Grand Mean ($\bar{x}$): Average of the means.
- Mean (μ): The arithmetic average of a variable.
- Variance (σ^2): A measure of the variability of scores on the squared-metric of the variable.
- Standard error (SE): A measure of statistical accuracy of an estimate.

- Standard deviation (σ): A measure of how spread out numbers are and the amount of variability of scores.
- Confidence intervals: Represent a range of plausible values of the true population parameters.

One-way Analysis of Variance

One-way ANOVA compares the statistical significance between means of populations of three or more groups. One-way ANOVA provides results to identify whether the average effects of delay are similar across different destinations. For this study, the variables utilized are the delivery destination (independent variable) and the number of days delayed (dependent variable).

During this part of the analysis, inferential statistics were computed to draw conclusions from statistical significance indices—the tests utilized to generalize from a sample to analyze characteristics of the population. During this study, the one-way ANOVA utilized was $\alpha = 0.05$. The analysis helped determine the relationships between dependent and independent variables with the selected α level. Furthermore, one-way ANOVA computes the degrees of freedom—the assumptions underlying the ANOVA measures of importance and power of the significance test. One-way ANOVA utilizes *F*-statistics to determine how different variables are one from another between groups and within groups (Meenakshi et al., 2021; Myers et al., 2010).

$$F = \frac{MS_{Between}}{MS_{Within}} \quad (1)$$

where,
MS between is the average sum of squares between groups;
MS within is the average sum of squared within groups.

The degrees of freedom (df) served to convert the sum of squares (SS) to mean squares (MS) by dividing the SS with their associated df. The sum of squares between was calculated directly with the following formula.

$$SS_{Factor} = \sum_{k}^{n} n_k(\bar{x}_k - \bar{x})^2 \tag{2}$$

where,
n: is the total sample size;
$\bar{x}_k$: is the sample mean;
$\bar{x}$: is the grand mean of the group.

The sum of squares within was calculated directly with the formula below.

$$SS_{residual} = \sum k \sum_{i}^{n}(x_{ik} - \bar{x}_k)^2 \tag{3}$$

The total sum of squares was calculated with the following formula.

$$SS_{total} = \sum_{k}^{a} \sum_{i}^{n}(x_{ik} - \bar{x})^2 \tag{4}$$

Mean square is the ratio of a sum of squares to degrees of freedom (Myers et al., 2010).

$$MS = \frac{SS_{Between}}{df_{Between}} \tag{5}$$

where,
SS between is the spread between individual values;
df are the degrees of freedom.

Post-hoc Tukey's method was performed after completing the one-way ANOVA. The post-hoc was conducted to analyze statistical significance among all groups. Tukey's method is the most common for comparing all groups from the one-way ANOVA results. The examples computed during this study represented three groups that required six comparisons to cover all combinations of groups. Furthermore, a harmonic mean was utilized during this comparison to calculate the groups' average. This method equalized the weights of each data point. For example, Japan (2) has a larger number of shipments, while Elsewhere (3) has a lower number of shipments. The harmonic mean calculation was computed by dividing the number of values from the data groups by the sum of reciprocals of each value in the groups (Clark & James, 2019).

The distribution of delayed shipments was similar to a Poisson distribution. As such, this study performed a goodness-of-fit test for South Korea delay data. The goodness-to-fit test helped determine how well the distributions of on-time and delayed shipments fitted the observed data. Next, a goodness-of-fit test was performed with a negative binomial model. The negative binomial model was selected because it does not assume an equal mean and variance like the Poisson chi-square test (Osgood, 2000; Paternoster & Brame, 1997; Staudte, 2020).

Summary

This chapter discussed sampling processes, methods, and preliminary data analyses. The study utilized descriptive statistics and one-way ANOVA using IBM SPSS 27 (IBM, 2020). First, the descriptive analysis was focused on explaining the graphics and number mechanics. The methodology outlined steps for the data collection process. In addition, explaining the analysis of observed patterns from frequency, percentages, valid percentage, cumulative percentage, and means.

IV. Results and Discussion

Chapter Overview

This chapter summarizes the results found from the data analysis. This study addresses each investigative question with descriptive analysis and one-way ANOVA. This researcher obtained the shipment delay record from the data set, then computed a detailed explanation of the efficiency scores obtained from SPSS. This process resulted in indices of statistical significance.

Descriptive Analysis

The data set included shipping records for destinations or seaports in six MAJCOMs: USAFRICOM, USCENTCOM, USEUCOM, USSOUTHCOM, and USINDOPACOM. The total number of shipments from 2019 to 2021 was 13,372. From the data set, the MAJCOM with the highest frequency of shipments by consignee was USINDOPACOM. Hence, the focus of the analysis will be USINDOPACOM, with a total of 12,811 (95.80 percent) shipments from the United States to destinations within that region.

Table 1 shows shipping records by destinations for shipment from the United States to USINDOPACOM. There are 11 countries in this region with shipping data records. Among the countries under USINDOPACOM, Japan (JA) and South Korea (KS) are major consignees with the highest delivery frequency and percentage. Other countries within USINDOPACOM are not relevant as they represented only a low number of shipping records. The busiest port in the USINDOPACOM was Japan, with 6,612 shipments or 51.6 percent of the shipments. The second busiest port was South Korea, with 4,867 shipments representing 38.0 percent of the total shipments. As a result, these two countries are the major consignees of containers within the USINDOPACOM region.

Table 1. Shipping Record by Consignee Country

CONSIGNEE COUNTRY					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	AQ	79	0.6	0.6	0.6
	GQ	329	2.6	2.6	3.2
	HI	28	0.2	0.2	3.4
	IO	98	0.8	0.8	4.2
	JA	6,612	51.6	51.6	55.8
	KS	4,867	38.0	38.0	93.8
	MG	168	1.3	1.3	95.1
	OK	433	3.4	3.4	98.5
	RP	56	0.4	0.4	98.9
	SN	64	0.5	0.5	99.4
	TH	77	0.6	0.6	100.0
	Total	12,811	100.00	100.00	

Figure 1 demonstrates the shipping frequency distribution of cargo within USINDOPACOM. The original data set contained the North Atlantic Treaty Organization (NATO) country codes to each destination within USINDOPACOM. Figure 1 shows the frequency of shipments by increasing the orange color contrast when more shipments are delivered to that location. The ports with the most visible contrast were Japan and South Korea, with 89.6 percent of the total cumulative shipments delivered.

Figure 1. Shipping Frequency by Consignee Country

Table 2 shows the descriptive statistics of the data and analyzes the number of days delayed for all cases. First, the total number of container shipments into USINDOPACOM was 12,811. The range statistics present the difference between the highest value of 306 and the lowest value of 0. The mean statistics represent the data set's average of 3.57, with a standard deviation almost three times the mean with 11.163. The skewness of days delayed data was found to be 570.999, indicating that the distribution was right-skewed.

Table 2. Descriptive Statistics All Cases

Descriptive Statistics							
	N	Range	Min	Max	Mean	Std. Deviation	Kurtosis
No Days Delayed	12,811	306	0	306	3.57	11.163	570.999

Figure 2 presents a histogram for all shipments into USINDOPACOM. The histogram is directly related to Table 1, presenting the same data. The tallest rectangle represents the highest frequency distribution. The graph contains the total data sample of 12,811 shipments with a mean of 3.57. The graph presents a noticeable sample skewed right due to 7,528 or 58.75 percent of shipments delivered on time.

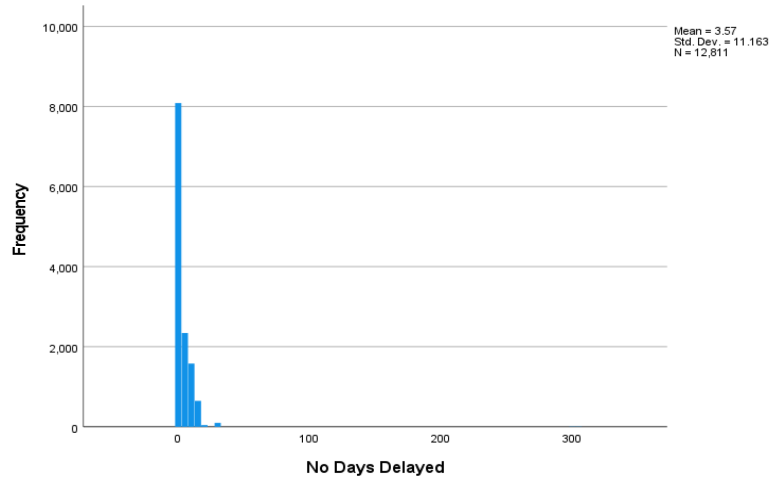

Figure 2. All Cases

Figure 3 shows the number of days delayed greater than zero, which includes 5,283 shipments or 41.24 percent of the total shipments. The mean is 8.65, with a standard deviation of 16.071. Like Figure 2, the sample is skewed to the right. The threshold value greater than zero was selected because shipments arriving on time outweighed the delay data, changing the way the histogram is presented.

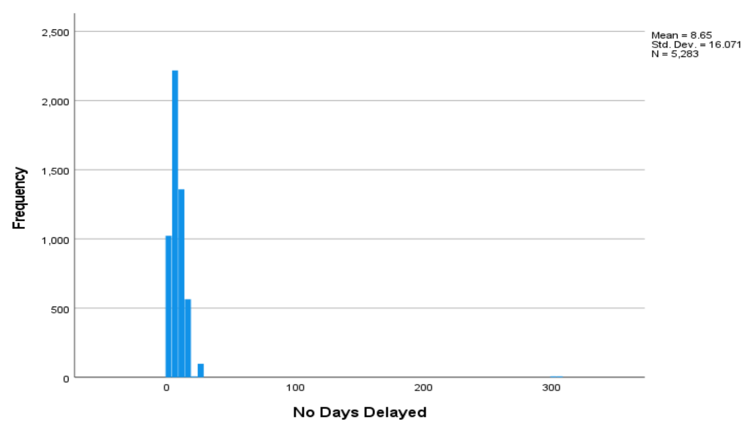

Figure 3. Number of Days Delayed Greater than Zero

Figure 4 represents the number of days delayed greater than five. The threshold value greater than five days was selected because typically shipments in this range would arrive within a week of the required delivery date. The sample of delayed shipments arriving five days after the delivery date was 3,097 or 25.17 percent. The histogram presented an increase in the mean to 12.33 and almost twice the standard deviation of 20.166. In addition, multiple shipments delayed over 300 days are evident, which stretches the tail away from the center.

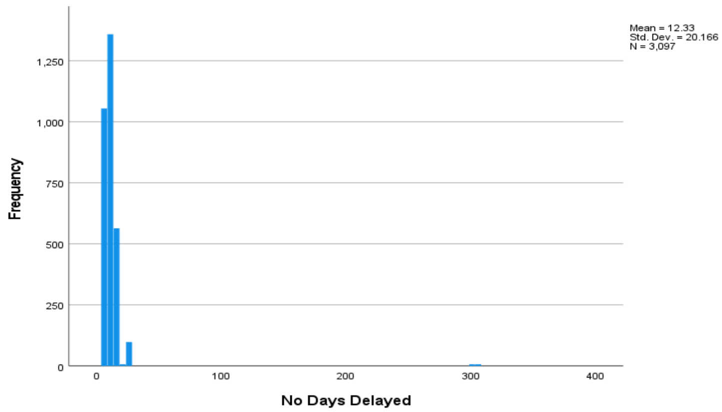

Figure 4. Number of Days Delayed Greater than Five

Figure 5 shows the number of days that shipments are delayed greater than 21. From 112 data samples, the mean changed to 62.5, and the standard deviations to 91.691. The sample skewed right due to what looks like multiple outlier shipments with delays over 300 days.

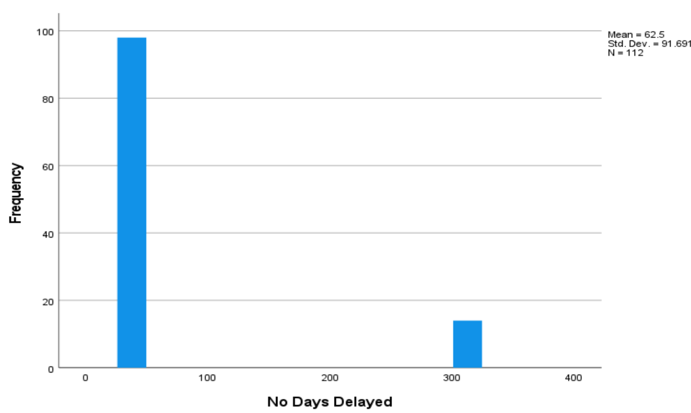

Figure 5. Number of Days Delayed Greater than Twenty-One

Data sets were classified into three groups by assigning one (1) for South Korea, two (2) for Japan, and three (3) for the remaining countries. This classification by destination country allows computation of the highest shipping delays recorded for all shipments. Table 3 demonstrates the mean delivery days by groups. Mean shipping delay in days for South Korea (1) is the largest at 6.92, followed by elsewhere (3) at 2.25, and Japan (2) at 1.36. This comparison helps visualize the data and suggests that further analysis is required for the South Korea records.

Table 3. Mean Number of Delay Days by Destination All Cases

Descriptive Statistics							
No Days Delayed							
	N	Mean	Std. Deviation	95% Confidence Interval for Mean		Min	Max
				Lower Bound	Upper Bound		
1 (S. Korea)	4,867	6.92	17.078	6.44	7.40	0	306
2 (Japan)	6,612	1.36	2.980	1.29	1.43	0	20
3 (Elsewhere)	1,332	2.25	4.683	2.00	2.50	0	16
Total	12,811	3.57	11.163	3.37	3.76	0	306

According to Table 3, South Korea had the highest mean delay, making it suitable for further analysis. Table 4 presents the descriptive analysis of the delay data for shipments into South Korea. First, the total number of container shipments into South Korea was 4,867. The maximum value was 306, and the minimum was zero (0). The mean of the data set was 6.92. Next is the standard deviation of 17.078, almost three times greater than the mean. Lastly, kurtosis of delay data was found to be 260.883, indicating that the distribution was more heavy-tailed compared to the normal distribution.

Table 4. Descriptive Statistics South Korea Only

Descriptive Statistics							
	N	Range	Min	Max	Mean	Std. Deviation	Kurtosis
No Days Delayed	4867	306	0	306	6.92	17.078	260.883

Figure 6 visually represents the number of days delayed for all cases, which totals 4,867 shipment samples into South Korea. The mean was 6.92, and the standard deviation was 19.443. Notice that the sample is skewed asymmetrically to the right.

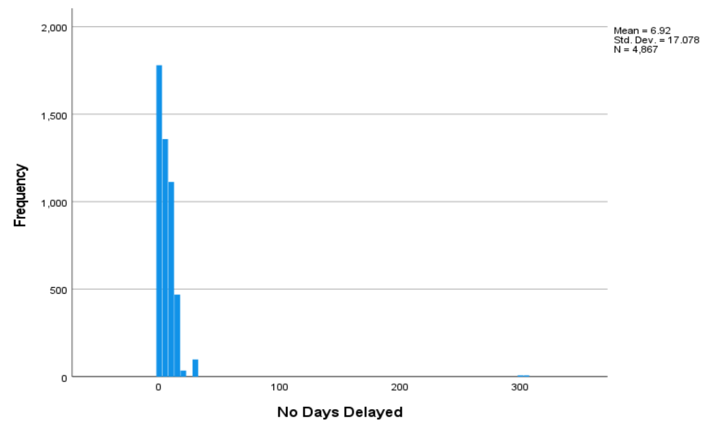

Figure 6. All Cases (South Korea)

Figure 7 presents a visual representation of the number of days delayed greater than 0 into South Korea. The selection of this threshold changes the histogram to represent 67.17 percent delayed shipments. For South Korea, the mean changes from 6.92 to a higher 10.31 and a standard deviation of 19.985. Notice that the sample is positively skewed.

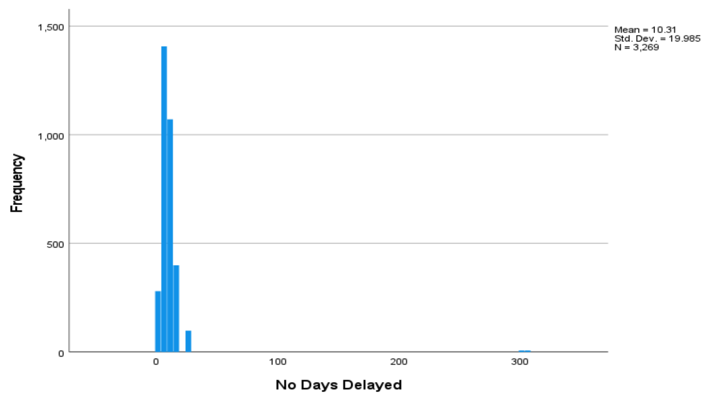

Figure 7. Number of Days Delayed Greater than Zero (South Korea)

Figure 8 represents the number of days delayed greater than five days into South Korea. This threshold was selected because 2,282 or 46.89 percent shipments were delayed longer than five days. The mean increased to 13.11, and the standard deviation changed to 23,359.

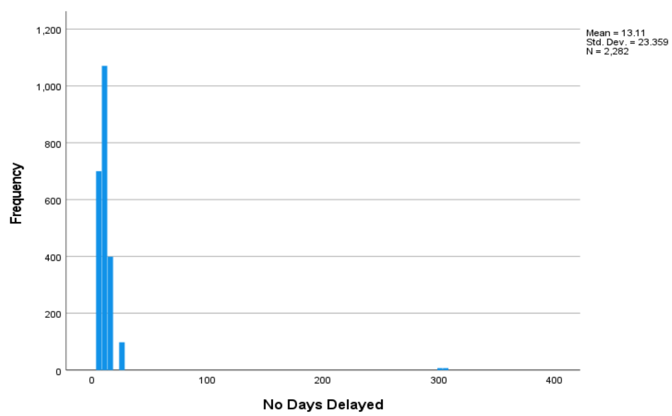

Figure 8. Number of Days Delayed Greater than Five (South Korea)

Figure 9 presents 112 or 2.30 percent of shipments delayed for over 21 days entering South Korea. The mean changes to 91.691 because multiple shipments arrived over 300 days late.

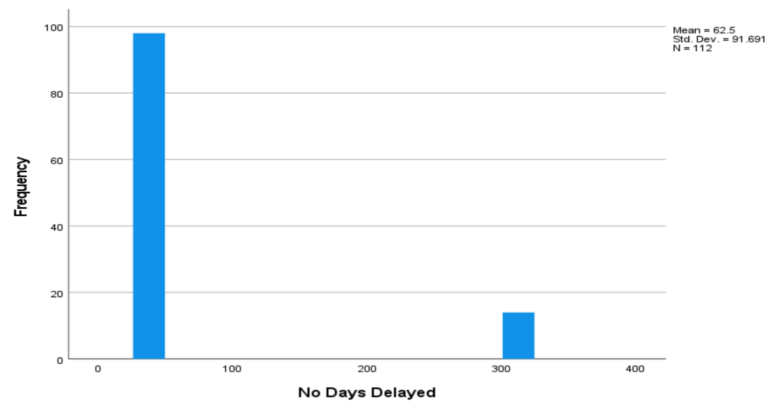

Figure 9. Number of Days Delayed Greater than Twenty-One (South Korea)

Data for South Korea only are fitted to probability distributions using an R package, "fitdistrplus" in R (R Core Team, 2020; Delignette-Muller, 2015). Table 5 shows results of data fitting using Poisson and negative binomial probability distributions. The mean for both destributions such as lambda (λ) for Poisson and mu (μ) for negative binomial are 6.922. According AIC (Akaike's Information Criterion), the negative binomial distribution is superior to the Poisson distribution. Using these results, the probability of on-time or late deliveries can be computed. The code for data fitting can be found in Appendix A.

Table 5. Data Fitting (South Korea)

	Observed counts	Poisson	Negative Binomial
<= 0	1598	4.796560e+00	1272.06643
<= 2	182	1.481259e+02	999.80598
<= 3	98	2.651773e+02	319.08827
<= 4	392	4.589114e+02	260.23869
<= 5	315	6.353476e+02	218.36168
<= 6	189	7.330147e+02	186.64628
<= 7	364	7.248818e+02	161.62710
<= 8	147	6.272343e+02	141.31889
<= 9	217	4.824361e+02	124.48538
<= 10	154	3.339584e+02	110.30747
<= 11	378	2.101611e+02	98.21588
<= 12	217	1.212338e+02	87.79964

<= 13	105	6.455543e+01	78.75275
<= 15	112	4.665012e+01	134.72524
<= 16	140	6.373106e+00	57.73440
<= 17	112	2.595104e+00	52.27684
<= 28	133	1.547493e+00	342.01785
> 28	14	1.638462e-06	221.53123
Goodness-of-fit criteria			
		Poisson	Binomial Negative
Akaike's Information Criterion		70128.43	28385.71
Bayesian Information Criterion		70134.92	28398.69

One Way ANOVA Results.

Table 6 presents the result of one-way ANOVA among three groups with all cases of shipment delay. The researcher computed a one-way ANOVA to determine whether the delay was significantly related to the destination country. The results indicated that delays were statistically significant at $\alpha = 0.01$, indicating that at least one group is different from the others.

Table 6. Delay by Destination for All Cases

No Days Delayed					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	89262.338	2	44631.169	379.284	0.000
Within Groups	1507143.816	12808	117.672		
Total	1596406.154	12810			

The mean delay difference between Japan and South Korea was significant at $\alpha=$ 0.05. Tables 7 and 8 exhibit post-hoc comparisons using Tukey's HSD method for all cases. The use of Tukey HSD comparisons allowed the evaluation of the delays among the three bins. The results indicated that the difference between other countries and South Korea was statistically significant at α = 0.01.

Table 7. Post Hoc for All Cases

No Days Delayed				
Tukey HSD[a,b]				
Consignee Country	N	Subset for alpha = 0.05		
		Japan	Others	South Korea
2 (Japan)	6,612	1.36		
3 (Elsewhere)	1,332		2.25	
1 (South Korea)	4,867			6.92
Sig.		1.000	1.000	1.000
Means for groups in homogeneous subsets are displayed.				
a. Uses Harmonic Mean Sample Size = 2708.911.				
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.				

The computed means indicated statistical significance in the multiple comparisons. More specifically, South Korea was the region with the most delays. The difference between South Korea (1) and Japan (2) is statistically significant at α= 0.01. The computed mean difference was 5.560 with a 95 percent confidence interval of (5.08, 6.04). In addition, the difference between South Korea (1) and Elsewhere (3) was statistically significant at α = 0.01. The computed mean difference was 4.675 with a 95 percent confidence interval of (3.89, 5.46). Lastly, the group sizes were unequal; hence, Tukey's test utilized a harmonic mean sample size of 2708.911 to give equal weight to each data point.

Table 8. Post Hoc Multiple Comparison for All Cases

Multiple Comparisons						
Dependent Variable: No Days Delayed						
Tukey HSD						
(I) Consignee Country	(J) Consignee Country	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1 (S. Korea)	2	5.560*	0.205	0.000	5.08	6.04
	3	4.675*	0.335	0.000	3.89	5.46
2 (Japan)	1	-5.560*	0.205	0.000	-6.04	-5.08
	3	-0.886*	0.326	0.018	-1.65	-0.12
3 (Elsewhere)	1	-4.675*	0.335	0.000	-5.46	-3.89
	2	0.886*	0.326	0.018	0.12	1.65
*. The mean difference is significant at the 0.05 level.						

Table 9 presents the mean number of delays greater than zero by destination. This comparison visualizes the change in the means by not taking into account on-time delivery. Mean shipping delay in days for South Korea was the largest with 10.31 and 19.987 standard deviations. South Korea received 3,269 or 61.80 percent of the shipments delayed. The computed results formulated a 95 percent confidence interval of (9.62, 10.99). The next highest was other countries (Elsewhere) with 400 delayed shipments. The mean was 7.49, and the standard deviation was 5.818. Lastly, Japan received 1,614 or 30.50 percent of the delayed shipments. The mean for Japan was 5.58, and the standard deviation was 3.584. The data serve to construct a 95 percent confidence interval of (5.40, 5.75).

Table 9. Mean Number of Delay Days by Destination

Descriptive Statistics							
No Days Delayed							
	N	Mean	Std. Deviation	95% Confidence Interval for Mean		Min	Max
				Lower Bound	Upper Bound		
1 (S. Korea)	3,269	10.31	19.985	9.62	10.99	1	306
2 (Japan)	1,614	5.58	3.584	5.40	5.75	1	20
3 (Elsewhere)	400	7.49	5.818	6.91	8.06	1	16
Total	5,283	8.65	16.071	8.22	9.08	1	306

Table 10 presents the one-way ANOVA results among three groups for shipment delays greater than zero. The results indicated that the difference between other countries and South Korea was statistically significant at $\alpha = 0.01$.

Table 10. Delay by Destination Greater than Zero

ANOVA					
No Days Delayed					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	24728.513	2	12364.256	48.738	0.000
Within Groups	1339479.743	5280	253.689		
Total	1364208.256	5282			

Table 11, similar to the previous Tukey's HSD comparison, the following table presents shipments delayed greater than zero. The results indicated that the difference between other countries and South Korea is statistically significant at $\alpha = 0.01$. It is important to mention that the mean delay for South Korea has changed from 6.92 to a higher 10.31. This change indicates that the change in the data affected the central tendency.

Table 11. Post Hoc Comparison for Delay Greater than Zero

No Days Delayed				
Tukey HSD[a,b]				
Consignee Country	N	Subset for α = 0.05		
		Japan	Others	South Korea
2 (Japan)	1,614	5.58		
3 (Elsewhere)	400		7.49	
1 (South Korea)	3,269			10.31
Sig.		1.000	1.000	1.000
Means for groups in homogeneous subsets are displayed.				
a. Uses Harmonic Mean Sample Size = 875.789.				
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.				

South Korea continues with the trend of most delays. The difference between South Korea (1) and Japan (2) is statistically significant at α= 0.01. The computed mean difference was 4.727 with a 95 percent confidence interval of (3.59, 5.86).

In addition, the difference between South Korea (1) and Elsewhere (3) was statistically significant at α= 0.01. The mean difference calculated was 2.821 with a 95 percent confidence interval of (0.84, 4.80). Harmonic mean averages the multiples of the three selected groups, and it gives equal weight to each data point. The multiple comparisons during Tukey's HSD test utilized the harmonic mean of 875.789.

Table 12. Post Hoc Comparison for Delay Greater than Zero

Multiple Comparisons					
Dependent Variable: No Days Delayed					
Tukey HSD					
(I) Consignee Country			Std. Error	Sig.	95% Confidence Interval

	(J) Consignee Country	Mean Difference (I-J)			Lower Bound	Upper Bound
1 (South Korea)	2	4.727*	0.485	0.000	3.59	5.86
	3	2.821*	0.844	0.002	0.84	4.80
2 (Japan)	1	-4.727*	0.485	0.000	-5.86	-3.59
	3	-1.906	0.890	0.082	-3.99	0.18
3 (Elsewhere)	1	-2.821*	0.844	0.002	-4.80	-0.84
	2	1.906	0.890	0.082	-0.18	3.99
*. The mean difference is significant at the 0.05 level.						

The computed number of days delayed using grouping represents the delay performed in Table 13. The first category, on-time delivery, shows that 7,528 or 58.75 percent of shipments arrived on time. Furthermore, the second category was the delayed shipments in different bins greater than zero. All categories of delayed shipments amounted to 5,283, or 41.2 percent late by at least one day or more. Lastly, 112 or 0.8 percent of shipments were 28 days or more late. Although the late shipments were mostly authorized by USTRANSCOM, it is necessary to minimize late shipments in general.

Table 13. Number of Days Delayed All Cases

Delay (Days)	0	1 - 7	8 - 14	15 - 20	≥ 28	Total
Count	7,528 (58.80%)	2,901 (22.6%)	1,713 (13.40%)	557 (4.40%)	112 (0.8%)	12,811 (100%)

Table 14 captures the delay reasons for containers shipped by USTRANSCOM. There are 21 reasons for cargo delay, including inclement weather, customs, holiday, port staging issues, cargo configurations, and others. The "end delay" category had the highest count, with 2,071 or 40.3 percent of shipments delayed. The definition of end delay consists of an approved transaction set in which every carrier submits a request when the delay starts. If the request is approved, the transaction can be submitted when the delay ends – hence the "end delay" records. The second and third delay reasons were port staging with 1,428 (28 percent) and released from staging with 1,027 (20 percent). However, since the two categories were port staging-related issues, it would be accurate to blend both categories and say that 2,455 or 47 percent of delays were due to staging issues.

Table 14. Delay Reasons

Delay Reason	Frequency	Percent	Valid Percent	Cumulative Percent
End Delay	2,071	40.3	40.3	40.3
Port Staging	1,428	27.8	27.8	68.1
Release from Staging	1,027	20.0	20.0	88.1
Delivery Scheduling	214	4.2	4.2	92.3
Other	88	1.7	1.7	94.0
Inclement Weather	55	1.1	1.1	95.0
Missing Documentation	52	1.0	1.0	96.0
Customs Issues	49	1.0	1.0	97.0
COVID-19	48	.9	.9	97.9
Consignee Appointment	42	.8	.8	98.8
Govt. Travel Restriction	18	.4	.4	99.1
Vessel Berthing Delay	14	.3	.3	99.4
Force Majeure	7	.1	.1	99.5
Insufficient Space for Cargo	6	.1	.1	99.6
Country Clearance Issue	4	.1	.1	99.7
Load Delay at Terminal	3	.1	.1	99.8
Holiday	3	.1	.1	99.8
Missing Health Certificates	3	.1	.1	99.9
Port Closed	3	.1	.1	99.9
Missing Cargo Details	2	.0	.0	100.0
Port Congestion	1	.0	.0	100.0
Total	5,138	100.0	100.0	

To further analyze the delay reasons, this study did a descriptive analysis of government-caused delay within Table 15. The category is sub-divided into three options: Yes, No and USC-08. The first category, (Yes), represents the shipment delays caused by the ultimate consignee with 3,305 or 64.3 percent. The second category, USC-08, are containers waiting for regularly scheduled liner services with 1,394 or 27.1 percent. This delay can happen due to the schedule that runs at regular time intervals. Hence, containers must wait for the next available schedule or liner to be released. According to sources from USTRANSCOM, the USC-08 is currently expired. However, the data records indicated that this category was relevant from 2019 to 2021. The last category (No) has 439 or 8.5 percent of delayed shipments.

Table 15. Government Caused Delay

Government Caused					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	3,305	64.3	64.3	64.3
	USC-08	1,394	27.1	27.1	91.5
	No	439	8.5	8.5	100.0
	Total	5,138	100.0	100.0	

The total number of shipments from the original data set to all MAJCOMS was 13,372. The on-time delivery shipment record shows that 6,665 or 49.80 percent of shipments arrived on time. Furthermore, Table 16 presents a statistical analysis of the reasons for the delay with 5,138 records. The total number of rows within the data set "delay reasons" was 12,947 rows utilized by containers. Additionally, the minimum range value was one, and the maximum was 30. Lastly, the mean sample obtained was 2.52, with a 4.758 standard deviation.

Table 16. Descriptive Statistics Delay Reasons All Cases

Descriptive Statistics						
	N	Min	Max	Sum	Mean	Std. Deviation
Total Rows	5,138	1	30	12,947	2.52	4.758

Lastly, Figure 10 shows a Pareto chart with the delay frequency for each reason. The alignment of the graph has longer bars on the left and shorter on the right. The length of the bars represents frequency distribution. The most significant situation was the End Delay.

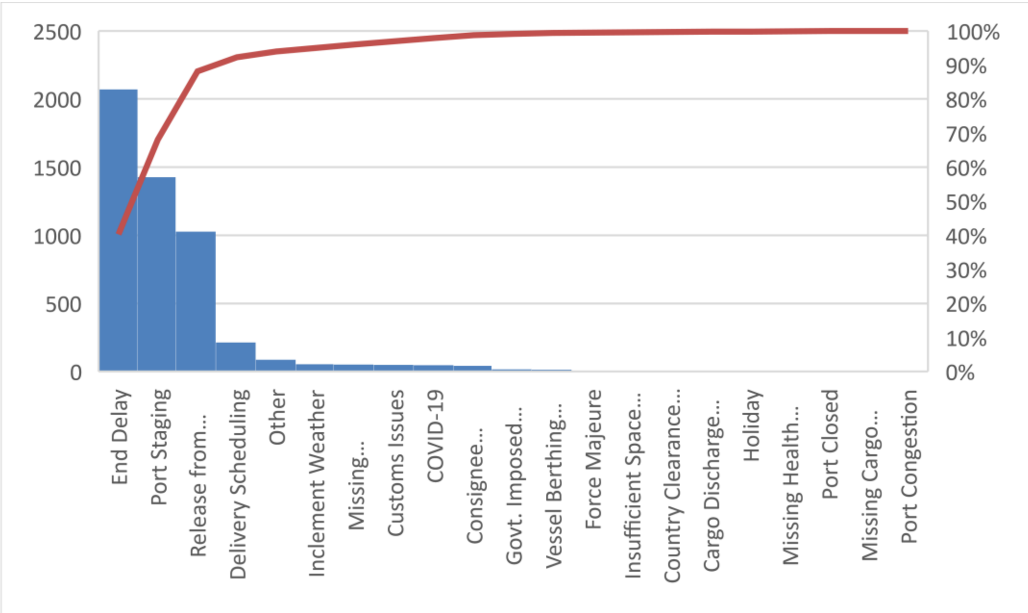

Figure 10. Delay Reason

Summary

For this study, the researcher executed a one-way ANOVA to determine whether delays greater than zero were significantly related to the destination country. The results indicated that delays were statistically significant at the required level of confidence, indicating that at least one group has a different mean from the others. The process required metrics and models for shipping to anticipate any delays. Also, the stratification and graphical methods outlined the results and purposes of using these methods.

V. Conclusion

Overview

This chapter summarizes the findings of this study. In addition, it will answer the questions presented in the objectives and provide findings, recommendations, and future directions.

Summary of findings

Since World War II, the US has enjoyed world-class mobility capacity and flexibility to execute strategic dominance. However, ever-growing adversarial forces have created a direct threat to our ability to deliver cargo. This study analyzed the main differences in shipment delays by destination and the reasons for container delays to military installations across the globe. This study provides recommendations for action to USTRANSCOM for them to achieve their strategic goals and align more commensurately with their claims to be "the DOD provider of full-spectrum global mobility solutions and enabling capabilities to our customers in peace and war" (USTRANSCOM). This study seeks to answer all research questions about the regions with the most delays, their differences, and the reasons for the delays.

Overall, 41.25 percent—over two-fifths of the shipments—were delayed for at least one day. Although delayed shipments were approved by USTRANSCOM, this finding may be significant for planning container shipments to USINDOPACOM. USTRANSCOM may examine the reasons for the delay and improve processes and take corrective measurements. USTRANSCOM must take corrective action by identifying the delay bottlenecks such as money and time constraints that can affect the process.

RQ1: What is the proportion of on-time delivery and delayed shipments?

The shipments delivered on time were 7,528 (58.75 percent). 5,283 (41.25 percent) shipments were late for at least one day, and of those shipments, 112 of those were late for 28 days or more. On-time and delayed shipments were classified into three groups by destination: South Korea (1), Japan (2), and Elsewhere (3). The results indicated the shipments delayed to South Korea had the highest delay with 6.92, followed by Elsewhere with 2.25, and, finally, Japan with 1.36. The overall shipping delay for containers arriving after the required delivery date—delay greater than zero—once again showed South Korea first with 10.31, Elsewhere in second with 7.49, and Japan is third with 5.58.

RQ2: Are there any differences in delivery time by destination? According to the results, Japan had the highest shipment frequency with 6,612 (51.6 percent). Japan was followed by South Korea, with 4,867 (38 percent). A one-way ANOVA was conducted to determine that delay was significantly related to the destination country for all cases. The results indicated that differences in delays among the three groups were statistically significant at $\alpha = 0.01$, indicating that at least one group is different from the others. In addition, Tukey's HSD report showed that the difference between South Korea (1) and Elsewhere (3) was statistically significant at $\alpha = 0.01$. Lastly, the difference between South Korea (1) and Japan (2) was statistically significant at $\alpha = 0.01$. In addition, Tukey's HSD method allowed a comparison of delays greater than zero. The results indicated that the differences between South Korea and Japan were statistically significant at $\alpha = 0.01$. The calculated mean difference was 4.727 with a 95 percent confidence interval of (3.59, 5.86). Lastly, the difference between South Korea and other countries was statistically significant at $\alpha = 0.01$. The calculations presented a mean difference of 2.821 with a 95 percent confidence interval of (0.84, 4.80).

RQ3: What is the major reason for the delay? The most frequent delay reason was End Delay with 2,071. However, the cumulative frequency of Port Staging delays amounted to 2,455 or 47 percent of delays. Significantly, 91.4 percent of delayed shipments are Government Caused, indicating that receiving installations could do a better job planning during the in-transit process and delivery. In addition, the last category (No) showed 439 or 8.5 percent of shipment delays. Lastly, a Pareto chart presented the frequency of delays for each reason.

Recommendations for action

USTRANSCOM may consider this study's data regarding reasons for delay and take corrective actions. In addition, they may incorporate the computed delay time to container shipments when planning shipments to USINDOPACOM. Accounting for these shipping delays ahead of time would help those making managerial decisions prevent mission delays, particularly in countries like South Korea.

Limitations and future directions

This study analyzed the cargo delay records and delay reasons to different destinations across USINDOPACOM. However, the shipment records and the delay reasons are saved in separate files and not connected. Because of this issue, this study is unable to analyze the shipment records by delay reasons. The reasons for the delay and the shipment delay records need to be compiled in one file for further analysis. Future studies could potentially conduct a comprehensive analysis of the container shipping processes. A comprehensive understanding of shipping delays could ensure on-time delivery and, thus, mission success.

Appendix A. Fitting Delay Data

```
> library(fitdistrplus)
Loading required package: MASS
Loading required package: survival
> library(actuar)
Attaching package: ‘actuar’
The following objects are masked from 'package:stats':
    sd, var
The following object is masked from ‘package:grDevices’:
    cm
> dat<-read.csv("delay_korea_fit.csv")
> my_data<-dat$delay
> fit_p<-fitdist(my_data, "pois")
> summary(fit_p)
Fitting of the distribution ' pois ' by maximum likelihood
Parameters :
       estimate Std. Error
lambda 6.922334 0.03771339
Loglikelihood:  -35063.22   AIC:  70128.43   BIC:  70134.92
> fit_nb<-fitdist(my_data, "nbinom")
> summary(fit_nb)
Fitting of the distribution ' nbinom ' by maximum likelihood
Parameters :
      estimate Std. Error
size 0.4960473 0.01224298
mu   6.9224071 0.14584699
Loglikelihood:  -14190.86   AIC:  28385.71   BIC:  28398.69
Correlation matrix:
              size            mu
size  1.000000e+00 -1.152062e-05
mu   -1.152062e-05  1.000000e+00
> gofstat(list(fit_p, fit_nb), fitnames=c("Poisson", "Negative
Binomial"))
Chi-squared statistic:  120173950 2862.144
Degree of freedom of the Chi-squared distribution:  16 15
Chi-squared p-value:  0 0
```

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14. ABSTRACT
USTRANSCOM (United States Transportation Command) sends containers to various overseas destinations, mainly commercial container shipping companies. Delivering the containers to the destinations on time is important to support the United States (US) Forces deployed in foreign countries. This study analyzes container shipment records for two years from 2019 to 2021 and prepares insights for USTRANSCOM. This study utilizes descriptive statistics, data visualization, and one-way analysis of variance (ANOVA). According to the records, almost half of the containers (41.25%) were delivered late for one day or longer. The container with the longest delay took 408 days. Major reasons for delays included port staging and related issues, delivery scheduling, incremental weather, missing documents, customs issues, COVID-19, and so on. One-way ANOVA results revealed that shipments to the Republic of Korea (ROK) took longer than any other country in the USINDOPACOM region, which was statistically significant. In addition, when only delayed containers to ROK were selected, the mean delay days were 6.92 days with a standard deviation of 17.078, which showed high variability. Although most delayed shipments have been approved by USTRANSCOM, it is critical for USTRANSCOM to understand delays for planning shipments to the destinations.

15. SUBJECT TERMS
Descriptive Analysis, One-way Analysis of Variance, Container transportation

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