



# **A Better Approach for Mishandled Bags Industry' Measure**

## **Embry-Riddle Aeronautical University**

**Aviation Management Program – Class of 2019**

A BETTER APPROACH FOR MISHANDLED BAGS INDUSTRY' MEASURE

by

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This Capstone Project was prepared and approved under the direction of the  
Group's Capstone Project Chair, Dr. Leila Halawi  
It was submitted to Embry-Riddle Aeronautical  
University in partial fulfillment of the requirements  
for the Aviation Management  
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We hope to repay all the trust placed in us.

## Abstract

Group: Show me the luggage  
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Since 1987, the US Department of Transportation (DOT) has ordered US airlines to report baggage handling statistics. The Code of Federal Regulations (CFR), requests each U.S. carrier to report monthly the total number of passengers enplaned, and the total number of mishandled-baggage reports (MBR), including lost, pilfered, damaged and delayed baggage.

The U.S. DOT also created a mishandled-baggage rate, which represents the total number of MBRs divided by 1,000 passengers enplaned. This KPI is monthly published at the Air Travel Consumer Report. And it is used worldwide to make comparisons between regions, airports, and airlines, characterizing efficiency and consistency in service and setting a benchmark for the industry.

The problem with this indicator created in 1987 is that it only considers passengers, not checked baggage. The customer's behavior has changed a lot after airlines started charging for the checked baggage, influencing KPI results.

Therefore, in January 2019 US DOT proposed a new mishandled bags KPI for the airline industry, instead of dividing the original KPI per 1,000 passengers, the new KPI proposes dividing the total number of mishandled baggage report per 1,000 checked baggage. This KPI considers checked bags, correcting this flaw, and creates a more accurate and reliable indicator, avoiding incorrect investment decisions and loss of money.

Desde 1987, o Departamento de Transportes dos Estados EUA (DOT) ordena que as companhias aéreas dos EUA reportem as estatísticas de manuseio de bagagem. O Código de Regulamentos Federais (CFR) solicita a cada transportadora dos EUA que reporte mensalmente o número total de passageiros embarcados e o número total de relatórios de bagagem extraviada (MBR), incluindo bagagem perdida, furtada, danificada e atrasada.

O DOT dos EUA também criou um índice de bagagem extraviadas, que representa o número total de MBRs dividido por 1.000 passageiros embarcados. Este KPI é publicado mensalmente no Air Travel Consumer Report. E é usado em todo o mundo para fazer comparações entre regiões, aeroportos e companhias aéreas, caracterizando eficiência e consistência no serviço e estabelecendo uma referência para o setor.

O problema com esse indicador criado em 1987 é que ele considera apenas passageiros, não bagagem despachada. O comportamento do cliente mudou muito depois que as companhias aéreas começaram a cobrar pela bagagem despachada, influenciando os resultados do KPI.

Portanto, este estudo propõe um novo KPI de malas mal manejadas para o setor aéreo. Esse KPI considera as malas despachadas, corrigindo essa falha e cria um indicador mais preciso e confiável, evitando decisões incorretas de investimento e perda de dinheiro.

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## **Chapter I**

### **Introduction**

The report will evaluate the problems with the traditional key performance indicator (KPI) model for mishandled bags, and embrace the use of the new indicator proposed by US DOT, taking into account the number of checked baggage instead of the number of passengers.

The study will also prove that the current KPI is distorted, making it impossible to use for cross-company comparison or guidance on investments and innovation.

### **Project Definition**

According to Peter Drucker (2009), one of the men responsible for modern business management, “if you can’t measure it, you can’t improve it.” This well-known statement sets the importance of having accurate and reliable data and models of measurements to help companies solve problems and minimize or avoid wrong decisions.

This concept also applies to the airline’s operations. The procedures performed must be measured and monitored to allow companies to improve their ability of decision making. Airports and airlines are doing their best to achieve higher levels of customer satisfaction to translate into continuously increasing demand for their services.

Both airlines and airport managers use mathematical data through metrics and indicators, same as other industries, to problem-solving and structuring business decisions before taking action. That is the main reason why ensure that the measurements are correct is so important for any company. The aviation’ industry is dynamic and passes every day for constant changes, and indicators also need to keep pace with these changes.

Linked to customer satisfaction, excellence in the baggage management process is crucial and has an important role to define overall customer experience through airlines and airports. According to ANAC Consumer Monitoring Report - 1st quarter of 2019 (ANAC,2019), the problem with baggage is the fifth in the ranking of reasons why customers are complaining, with 12.3% of the total number.

This report is to evaluate the real effectiveness of mishandled bags' indicators, the way that is measured nowadays worldwide, and how it affects positive or negative the decision making of airlines.

Our purpose is to demonstrate that airlines are losing money and wasting the opportunity to improve their procedures.

## **Project Goals and Scope**

Our main objective with this study is to create a value proposition for a new mishandled bags' KPI, which makes sense for the airline business.

The researchers strongly believe that there is a better correlation between mishandled bags and checked bags than mishandled bags and passengers. The study analyzes if, instead of using the number of carried passengers, the mishandled bags KPI was calculated with the method consisting of the number of mishandled bags and divided by 1,000 checked baggage.

In the study, the researchers will also demonstrate that company finances are directly affected if the management team makes decisions based on an incorrect KPI that is not grounded in today's industry reality. After all, the mishandled bags affect the customer experience (tracked through the Net Promoter Score, Monitoring Customer Satisfaction and others), airport

investments, and the liability and penalties outlined in contracts with third-party service providers.

### **Definitions of Terms**

Loyalty Program	Loyalty program offered by an airline
9/11	September 11,2001 terrorist attacks
A4A	Airlines for America
Y2K	Year 2000 Computer Technology Problem

### **List of Acronyms**

ABEAR	Associação Brasileira das Empresas Aéreas
ANAC	Agencia Nacional de Aviação Civil
APP	Application
ATCR	Air Travel Consumer Report
BTS	Bureau of Transportation Statistics
CASM	Cost per Available Seat-Mile
CFR	Code of Federal Regulations
DOT	U.S. Department of Transportation
FFP	Frequent Flyer Program
FSC	Traditional Full Service Carrier
GAO	Government Accountability Office
GPS	Global Passenger Survey
IATA	The International Air Transport Association

ITL	Instituto de Transporte e Logística
KPI	Key Performance Indicator
LCC	Low Cost Carrier
MBR	Mishandling Baggage Rate
NPS	Net Promoter Score
QR code	Quick Response Code
RFID	Radio Frequency Identification

## **Summary**

This study will demonstrate the importance of KPIs for all industries and how companies should treat these numbers. Also, the researches will show the airlines and airports the impacts of using an inaccurate KPI for mishandled luggage and how an incorrect indicator could cause companies to lose money.

## **Chapter II**

### **Review of the Relevant Literature**

The objective of this study is to analyze whether the current use of U.S. DOT's KPI for measuring the mishandled baggage performance meets the airline industry's needs. Also, to evaluate the new and more robust indicator that might bring financial benefits to the industry.

For this review, the study will start with a brief explanation of what KPIs are and why they are important. Then, the research dives deeper into the mishandled bags KPI. Finally, the researches list the main financial impacts if this KPI is not providing assertive information to airline managers.

#### **The definition of KPI and importance**

The economy, customers, habit and technology, have been changed faster day-by-day, and this evolution is faster in the airline industry because of the dependency of both customers and technology. To keep up to date with this rapid evolution and natural trend of the market and passengers, airlines have to adopt new measures and processes (Forbes, 2018).

A study from Deloitte Press University (2017) shows the speed of changes in various aspects of our society. The image below (Figure 2.1) shows us that technology has been changing much faster than any other factor included. This change is creating a gap of the curves and turning individuals, businesses, and public policy obsolete in a short time.

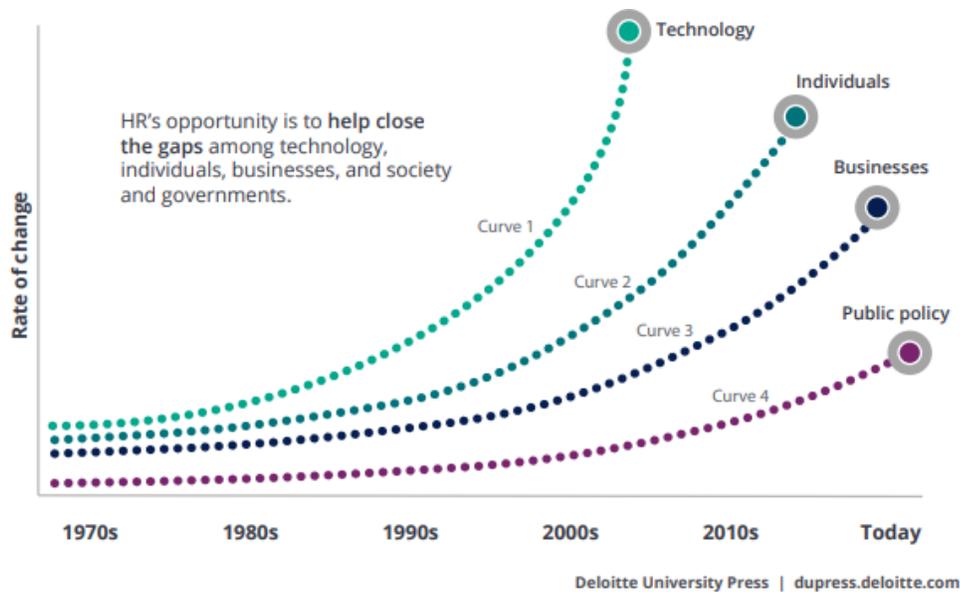


Figure 2.1 Deloitte University Press. (2017) *Rewriting the rules for the digital age*

So, it is profusely clear that technology is advancing at an unprecedented rate. The productivity of the business could not keep the same pace and might be one reason for companies are turning disrupted faster nowadays (Deloitte University Press, 2017).

According to Daniel Power (2013), managers are forced to make quick decisions in a complex, inconstant, and uncertain environment. To stay forward of this context, most managers want and need more and better analyses and decision-relevant reports to support the decision-making process.

According to Wayne (2006), “KPI is a metric to measure how well the organization or an individual performs an operational, tactical or strategic activity that is critical for the current and future success of the organization.”

The KPIs began taking place in the world, supporting the decision-making in the companies.

KPIs are relevant to business goals because they keep them steps ahead of decisions.  
(Poleski, D. 2019)

But it is very important to keep in mind the process of choosing the correct KPIs and metrics is important as well because it will reflect in better results and decisions. The best KPIs aren't ordinary metrics. One important direction expected from the KPIs is to help companies to predict future actions and understand which is the best choice for decision. When the KPIs are well developed and provide accurate and up-to-date information, it is possible to understand, for example, the entire experience of the customer, from the beginning to the end. (Barlow, 2015)

To discover new opportunities, people need to go deeper to find the metrics that represent what is going on (Barlow, 2015).

Therefore, it is necessary to keep KPIs updated and reflecting the reality of the company. One wrong decision driven by the wrong KPI can affect the company.

### **Key Performance Indicator (KPI) and the airline industry**

The Key Performance Indicator in the airline industry became more relevant after the airline deregulation act in 1978 (McDermott, 2017). The US government maintained the statistics on numerous metrics of airline service quality (Rhoades & Waguespack, 2008). However, these reports became accessible to the public with the Air Travel Consumer Report (ATCR) in 1988.

The ATCR discloses the Mishandled Baggage Rate KPI, which is used by the airline industry to analyze the performance of luggage processes (Rhoades & Waguespack, 2008).

Many companies, organizations, and researchers have adopted the use of the Air Travel Consumer Reports information as a form to categorize a service quality or create new metrics.

For example, the Airline Quality Rating (AQR), which considers 19 quality factors and includes Mishandled Baggage (Bowen, Headley, & Luedtke, 1992).

### **The history of Mishandled Baggage Rate**

The airlines' mishandled baggage reports began in October 1987, when the US Department of Transportation (DOT) has requested the U.S. carriers to report on a monthly basis the number of transported passengers system-wide and the mishandled-baggage occurrences, including lost, pilfered, damaged and delayed baggage (Gov\_info, 14 CFR 234, 2017).

The U.S. DOT also created the mishandled baggage KPI, which is the total number of MBRs divided by thousands of passengers enplaned. This number is monthly published in the Air Travel Consumer Report (ATCR).

### **Annual Surveys and Reports published with MBR to the airline industry**

Several reports disclose the MRB, and Figure 2.2 below illustrates one of them, is SITA's annual report. This image highlights that from 2007 to 2018, the number of baggage have dropped from 46.9 million to 24.8 million. From the other side, the number of passengers has increased from 2.48 billion to 4.36 billion.

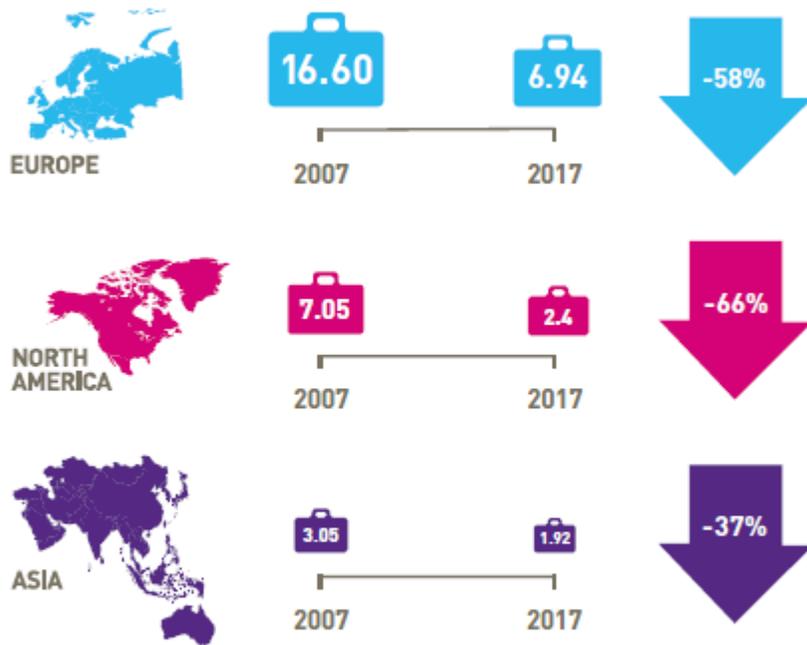


Source: SITA 2019 Baggage IT Insights

Figure 2.2 SITA baggage-it-insight,2019, long term decrease in baggage mishandling.

The next image (Figure 2.3) shows the variation in the mishandled baggage rate. Over the ten years, the KPI suffered a large reduction in different countries of the world, emphasizing that, especially in North America, there was a reduction of 66% (SITA, 2019).

## MISHANDLED BAGS PER THOUSAND PASSENGERS BY REGION



Data sources:  
Europe: 2007 - 2013 Association of European Airlines.  
2017 - 2017 SITA. North America: Airlines for America.  
Asia: Association of Asia Pacific Airlines.

Figure 2.3 SITA (2019,08), Baggage Report 2018.

Therefore, the researchers have seen in recent years a large increase in passengers and a reduction in mishandled luggage KPI. This scenario is attributed to investments in airport procedures and improved infrastructure (SITA, 2019). However, it is not until 2018 that IATA makes one official procedure guide for bag tracking (IATA, 2018).

### **Inconsistencies, Errors, or Constraints identified to MBR**

In 2001, the Bureau of Transportation Statistics (BTS) published the Mishandled Baggage Report, excluding non-revenue passenger numbers. Because of that, BTS highlighted

that the KPI did not accurately represent the carrier's capability to handle baggage, being inappropriate for cross-carriers analysis.

Stellin (2013) published an article to the Seattle Times, pointing out flaws in the report. According to her, the MBR does not include misplaced baggage during international flights or flights operated by regional carriers.

She also questioned that the reports do not express the headaches consumers face in solving their luggage problems such as late arrival, damage, or pilfered.

The 14 CFR 234 and 250 (2017) reports threshold of data for mishandled baggage is one percent of the Industry Scheduled-Service Domestic Passenger Revenues. The report is not intended to consider whether few passengers are avoiding to check baggage to avoid fees.

More recently, in 2018, Charlie Leocha(Leocha,2017), president of Travelers United, wrote that there is a distortion in Mishandled Baggage KPI. According to her, the reason is that airlines use to divide the total occurrences of baggage in numbers per 1,000 carried passengers, instead of dividing by the number of checked bags. She reports the case of two airlines that have the same baggage handling procedure, but one seems to be much better than the other because its passengers check fewer bags.

### **The influence of new commercial aviation market to the MBR**

The theme of checked baggage has become increasingly relevant due to the growing concern about flight safety. Since the unfortunate event of 9/11, political, economic, and social factors have spawned a huge crisis in the commercial aviation segment, as passenger numbers have declined sharply.

Additional security expenditures and the high fuel prices have generated the increase of the Cost per Available Seat-Mile (CASM).

The scenario of severe economic recession has forced airlines to adapt financially and economically to the low passenger demand.

Due to this complex situation, the industry began to show a high rate of baggage breakdown and loss. This situation lasted for six years until mid-2007.

All of this was only made evident in 2012 in a letter sent to the US House of Representatives by the Committee on Trade, Science and Transport of the Government Accountability Office (GAO). This letter contained an analysis of DOT information that showed a clear deterioration in Baggage Claim Rate (GAO-12-804R; P.6)

On March, 21<sup>st</sup> 2017, the US Department of Transportation put into effect a new policy([www.govinfo.gov](http://www.govinfo.gov), 14 CFR Parts 234 e 241), requiring airlines also to report the number of baggage checked on each flight. However, most of the airlines in the world, especially the Brazilian ones, continue to use the existing baggage KPI as a reference for all their internal analysis and decision making.

### **Baggage Fee and Airline Industry**

In May 2008, there was a major milestone that altered the worsening trend in the Mishandled Baggage KPI. American Airlines, the world's largest airline, has started charging \$15 for many passengers to check their first baggage in the United States (NYtimes, Maynard, 2008). After that, most airlines, including Delta and United, have followed that decision and created similar fees. Europe's Lowest Cost airline instituted baggage charges on its flights in 2006. It charges about \$32 for each bag checked at the airport.

Also, there were airlines, like Ryanair, that strongly discourage checked bags on their flights, as stated by his CEO, Michael O’Leary, to a Wall Street Journal interview (quoted in Allon, 2009). He commented that payment for checked baggage is not related to revenue. Instead, he had indicated that passengers need to change travel behavior and avoid to check baggage, helping carriers to reduce the airport handling costs.

**The passenger behaviors and preferences have changed in the aviation industry over the past years**

IATA made annual survey reports since 2012 to identify the behaviors and preferences of the passengers. Figure 2.4 shows the result of the 2018 survey with more than 10,400 respondents across 150 countries that shared their travel preferences.

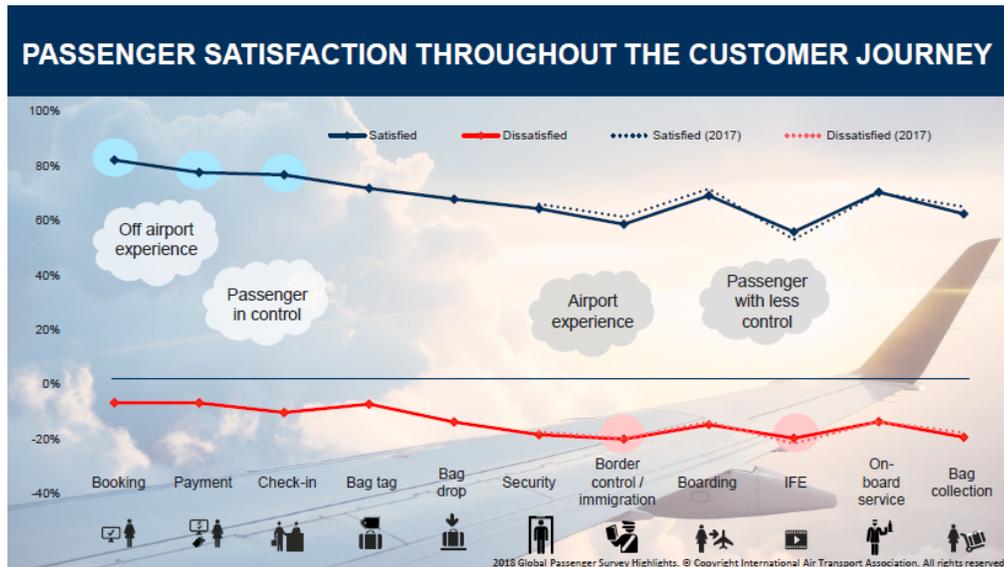


Figure 2.4 IATA 2018 Global Passenger Survey Highlights, p5.

Also, according to the SITA 2019 Baggage-IT-Insight 2019, eight out of ten passengers check-in their luggage, most traveling with one bag. In 2018 was around 4.3 billion bags carried.

Now, with IATA Resolution 753 on baggage tracking in effect, the industry is looking at RFID as a low-cost solution. Figure 2.5 shows the completion rate of airlines and airport members of IATA to be compliance with Resolution 753.

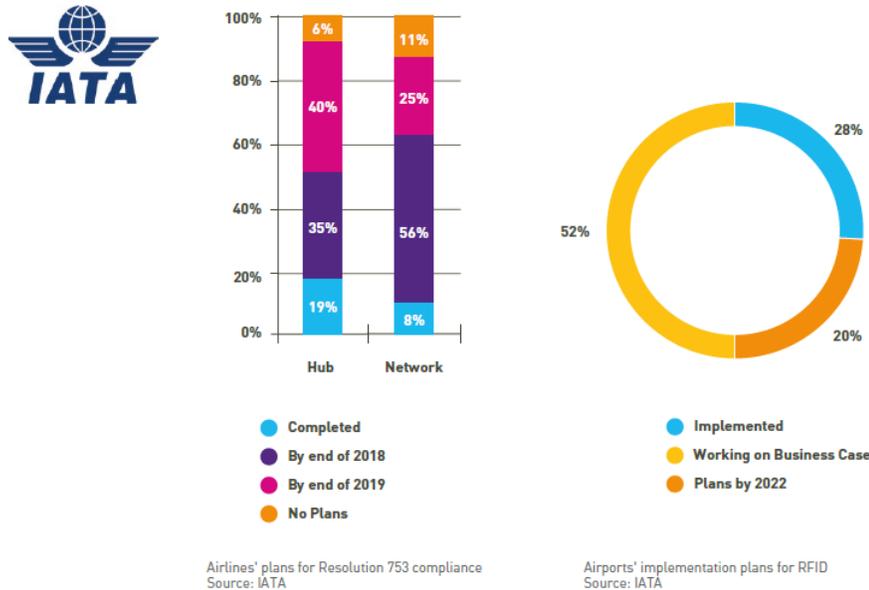


Figure 2.5 SITA baggage-it-insight,2019, IATA source,p.16

### The importance of a good KPI for the right investments

A good KPI should convert an airline's business strategy into manageable operations based on the data you monitor.

After all, the old cliché: "What gets measured gets done" (Drucker, 1954), always rings true. KPIs are used to understand and improve a company's progress. To make the right decision and drive business investments, invest in data compilation, accurate business, and leave the usual behind the old feelings and assumptions.

Airlines' main argument for implementing baggage fees would be to provide lower end-user airfares generated by lower operating costs, reduced check-in staff and baggage handlers, and lower fuel consumption. Another major consequence would be less luggage to be transferred

between flights and also increased work agility for baggage handlers. The biggest benefit of this would be for customers as flights would depart from the ground at scheduled departure times.

According to the 2019 SITA Baggage IT Insights report, the total number of handled bags fell by approximately 90% in 11 years from 2007 to 2018, even with the large growth in total transported passengers in the period.

This drop is due to factors in the behavior of passengers who have less baggage checked and also due to the high investments in technology in the sector, especially in baggage tracking. Of the total checked baggage, 0.6% is misdirected or lost each year, more than half of this baggage is lost due to problems with flight transfers. The other half of the lost baggage is due to flight delays or mishandled by the baggage operators (SITA, 2019).

Generally, these baggage operators are either independent third-party employees who provide services to various airlines or are directly hired by the airlines. As such, the quality of this service can vary dramatically.

Several corporations around the world found a strong relationship between NPS score and company growth rate (Reichheld's, 2011), compared to the score of their largest competitors in the market. Philips' annual report provided updates to the NPS reviews and announced that 60% of the company's revenue came from business in leadership or leadership positions in NPS.

In this sense, remodeling the mishandled baggage KPI, according to our proposal, would generate major financial and non-financial benefits for customers and airlines.

### **The Importance of Baggage for Passenger Experience**

According to IATA Business Care Report data, there were 22.7 million mishandled luggage in 2018, a rate of 5.57 per 1,000 passengers. Although this figure equated to a 10% decrease over the previous year, the cost to the airline industry was \$ 2.3bn.

In Brazil, if the airline does not deliver baggage, the passenger may require financial compensation for the purchase of necessities. For instance, if the baggage is not found by the carrier and not returned within seven days in case of domestic and 21 days for international flights, then the passenger is entitled to request baggage compensation.

Also, the passenger may take legal action for compensation for moral and material damages due to loss of luggage, which is very common in Brazil.

Passengers highly perceive the quality of airports and airlines through baggage handling. Passenger satisfaction and performance of baggage operations are important aspects of the success of airport operations and are closely interconnected.

Especially following resolution 753 from IATA, which encourages the carriers to reduce mishandling bags through a cross-industry tracking system, following the baggage journey (SITA, 2019). There are many efforts by airports and carriers to perform baggage tracking and improve their luggage processes.

The report IATA Business Care Report data (December 2018), says that the perception of baggage operations by end-users has been changing. When surveyed, 84% of passengers stated that they would like to have bag tracking; two-thirds expect this functionality, and the remaining believe that the additional services will be beneficial.

With the increasing use of baggage tracking data by Airlines and airports, the adoption of RFID tagging is also keeping pace with this evolution. Radio Frequency Identification (RFID)

technology captures data using a radio frequency. RFID provides more valuable information about a baggage journey and will help make the process more efficient.

Also, using artificial intelligence (AI) in baggage handling will help enhance the passenger experience, improve processes, and reduce costs.

"Few essential truths endure in time - but one of them is the notion that we should strive to turn our clients into enthusiastic advocates who comment wonderful things to our friends and colleagues." (Reichheld, 2011).

### **Use of KPI as a reference in performance contracts with third parties**

Because it is a more operational function and does not represent the core of aviation, many airlines outsource ground handling. This number is around 50% worldwide (IATA, 2018).

By providing checked baggage KPI-based solutions with innovative digital analytics applications, airlines will be able to monitor third party performance better, suggest improvements in baggage journey processes, and reduce costs with contracts that continue to charge airports and airlines for boarded passengers. As customer behavior changes to check for less baggage, third parties tend to use fewer human resources, leading to a lower cost suggestion (IATA, 2018).

### **Accurate KPI is important and contributes directly to the result**

The KPIs are important because they offer a business diagnosis to position yourself better in the market. Consistent KPIs and metrics must be connected to the business purpose to achieve the desired success. "If you don't know where you want to go, then it doesn't matter which path you take." (Carroll, 1971)

Key performance indicators are one of the important methods that companies use to measure the potential to achieve their goals (Durcevic, 2019). Also, KPIs could help airlines to obtain more effective key performance variables. Factors such as net income and EBITDA that are often the main triggers of the company's well-known recognition and profit-sharing programs, as well as revenue, operating efficiency.

There are other opportunities for airline companies with the utilization of KPI, which could impact customer satisfaction and employee work performance indirectly.

These opportunities help improve attitudes and generate quality services. Companies that use KPIs for this purpose can produce more consistent results.

In the aviation market, keeping the customer satisfied and happy based on good services and processes became the company's success and a market strategy to build customer loyalty. A satisfied and happy customer makes new purchases or services and promotes the company to family and friends. Having robust and accurate KPIs is of utmost importance to any organization that is obstinate in growing and profiting.

Being aware of your customers' level of satisfaction, constantly analyzing your market positioning, improving your production, sales, and processes are key to thriving.

Successful implementation of KPIs within a business brings time optimization and cost savings. The investments required to implement KPIs include new technologies, staff qualification, and process improvement primarily. But this cost will be rewarded with competitiveness gains.

## **Summary**

The entire aviation industry continues to use the same methodology proposed in 1987 by the U.S. Department of Transportation (DOT) to measure its mishandled baggage performance. The baggage claims occurrences divided per thousand boarded passengers generate the Mishandled Baggage KPI, which is monthly published in Air Travel Consumer Report.

Recent studies show that lost luggage statistics in the world have been falling dramatically in recent years, both in absolute numbers and per 1,000 passengers boarded.

However, since 2006 in Europe and 2008 in the US, the largest airlines in the world have started to cash in checked bags, leading to a change in passenger profile and behavior, especially concerning luggage transport.

Lost baggage causes great damage to the entire aviation industry, either through lost baggage compensation or even pain and suffering damage.

The purpose of this study is to update the Mishandled Baggage KPI.

The passenger behavior has changed greatly over the past decades. Instead of calculating the KPI as the quantity of mishandled baggage for every 1,000 passengers carried, the researches purpose to use mishandled baggage for every 1,000 checked baggage.

The number of passengers should not be considered in the actual KPI, and our results will prove that there is a much better correlation between mishandled and checked baggage.

With this KPI change, the industry will have a more robust indicator that can be used as a benchmark. Today's indicator is not reliable when comparing two airlines, or even two routes from the same company if those have different numbers of checked baggage per passenger.

Finally, this study proposes a fairer KPI, which will bring more value to the airlines and the entire industry, providing accurate and reliable information for decision making.

## **Chapter III**

### **Methodology**

This study compares the actual Mishandled Baggage KPI and the proposed one, using the checked bags. The researchers applied the method known as linear regression to compare those two indicators and define which of the two independent variables, passengers or checked bags, has the highest correlation with the dependent variable, number of mishandled bags.

The hypothesis analyzed in this study says that the form used today to calculate the Mishandled Baggage Rate does not have the appropriate criteria, distorting of results. Therefore, it is not possible to compare airlines and make the correct industry benchmark.

This distortion occurs because the indicator, proposed in 1987 by the US Department of Transportation, divides the total number of baggage occurrences per 1,000 passengers carried. However, this research aims to prove that it would be better for the industry if, instead of passengers, the indicator used the number of checked bags as the denominator.

Another analysis made it was a real case scenario, comparing data extracted from one Brazilian airline for two different routes and how the change in the denominator dividing by baggage would change the key performance results.

### **Data Source(s), Collection, and Analysis**

It is essential to obtain three airline information: (1) the number of mishandled bags, (2) the number of checked bags, and (3) the number of passengers carried.

Most airlines already report passenger numbers and the number of baggage occurrences per period. However, airlines are not required to inform the number of dispatched bags, and this was the hardest to find.

Therefore, to have access to this information and based on the primary data collection technique, the researches had to contact a Brazilian airline and ask permission for collecting those three pieces of information directly from a Brazilian airline database.

An airline agreed to share that data for the study purpose and provided two reports: (1) Number of passengers and checked bags from every flight from June 2018 to June 2019 and (2) Number of mishandled baggage reports from January 2018 to June 2019.

The present work contemplates descriptive research because it allows modeling the main characteristics of a given population or phenomenon and also the establishment of a relationship between those three quantitative and discrete studied variables.

After receiving these resources, researchers merged the data into a single database and organized the information into a week-view. This assembled information was used to graph the mishandled bags per passenger and mishandled bags per checked bags.

All database transformations, calculations, and statistical analyses were developed with the help of Excel multifunction software, a program from Microsoft Corporation. The layout of the data was also elaborated graphically to aid the interpretation of the analysis and facilitate their interrelation process.

The researchers also performed a Correlation and Simple Linear Regression analysis. This technique is used to show which of the independent variables, the number of checked bags,

or the number of passengers carried, has the highest correlation with the dependent variable, the number of mishandled bags.

### **The Simple Linear Regression Model (SLRM)**

According to Kazmier (1982, p.299), the linear regression analysis is used to forecast the value of a dependent variable, since the value of one or more an associated independent variables are known. The regression equation is the algebraic formula used to predict the value of the dependent variable.

Let Y be a random variable of interest (response variable), and let X be a random variable (regression variable). The Simple Linear Regression Model describes the variable Y as a sum of a deterministic quantity and a random quantity. The part deterministic, a line as a function of X, represents the information about Y that is already expected only with the knowledge of the variable X. The random part determined the error, represents the numerous factors that, together, can interfere in Y (Charnet, 2008).

*The Simple Linear Regression Model (MRLS) is given by:*

$$y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$$

$$\beta_0, \beta_1, x_i: \text{constants.}$$

$$Cov[\varepsilon_i; \varepsilon_j] = 0; i \neq j, i, j = 1, 2, \dots, n,$$

where  $n$  is the number of individuals,  $y_i$  is the observation of the dependent variable for the  $i$ th individual,  $x_i$  is the observation of the independent variable for the  $i$ th individual,  $\beta_0$  and  $\beta_1$  are regression coefficients (parameters) and  $\varepsilon_i$  It is a random error component. These errors are

assumed to be independent and follow a normal distribution with zero mean and unknown variance.

However, before estimating the simple linear regression model (SLRM), one must take into account other deterministic factors that will influence the model parameters. This study addresses two other important points for analysis, Pearson's Linear Correlation Coefficient and The Determination coefficient ( $R^2$ ).

### **Pearson's Linear Correlation Coefficient (P-Value)**

According to Melo (2012), Pearson's Correlation Coefficient ( $\rho(X; Y)$ ) aims to measure the degree of association between two variables; it is obtained by:

$$\rho(\hat{X}; Y) = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sqrt{\left[ \sum x^2 - \frac{(\sum x)^2}{n} \right] \left[ \sum y^2 - \frac{(\sum y)^2}{n} \right]}} = \frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}}$$

$\rho(\hat{X}; Y)$  is a dimensionless number whose value is between -1 and 1. When X and Y vary in the same direction, the correlation is positive, so  $\rho > 0$ , if  $\hat{X}$  and  $\hat{Y}$  vary; otherwise, the correlation is negative, so  $\rho < 0$ . If  $\rho = 1$ , the correlation is perfect positive, If  $\rho = -1$ , the correlation is perfect negative, If  $\rho = 0$ , the correlation is null.

Correlation Ranges are weak from 0 to |0.5|; reasonable from |0.5001| to |0,7|; and strong from |0.7001| to |1| (Melo, 2012).

### **The Determination coefficient ( $R^2$ )**

The coefficient of determination,  $R^2$ , is interpreted as the proportion of the variability Y's observed, explained by the model considered. The value of  $R^2$  belongs to the range [0; 1] and when closer to 1, the better the model fit. It is given by:

$$R^2 = \rho^2 = \frac{SQReg}{SQTotal} = 1 - \frac{SQRes}{SQTotal}$$

where SQTotal is the total square sum, which is the sum of squares of the regression (SQReg) plus the sum of squares of the residue (SQRes) (Melo, 2012).

### **Summary**

After performing all these calculations, it will be possible to determine which of the two independent variables (number of passengers or number of checked bags), has the highest correlation with the dependent variable (number of mishandled bags).

Therefore, a higher level of correlation proves that the variables can be worked together because there is an interrelationship between them. On the other hand, variables with low correlation should not be looked at together since there is no relationship between them.

## **Chapter IV**

### **Outcomes**

As stated before, this main research objective is to demonstrate that the mishandled luggage KPI has conceptual errors, which may further increase operating costs for the entire airline industry.

#### **Evaluation of analysis and results**

The researched performed the analyses described in the methodology chapter to assess the degree of correction between the variables. They also evaluated the need to replace the current KPI with a new proposal, which replaces the number of passengers carried by the number of checked baggage in a given period.

#### **The Determination coefficient ( $R^2$ ) results**

To observe the correlation of the dependent variable, mishandled bags, with the independent variables, the researches plotted the two graphs below, weekly mishandled bags per number of passengers (Figure 4.1) and weekly mishandled bags per checked bags (Figure 4.2). Also, they drew the trend line, with the linear equation, and the coefficient of determination for each of the images.

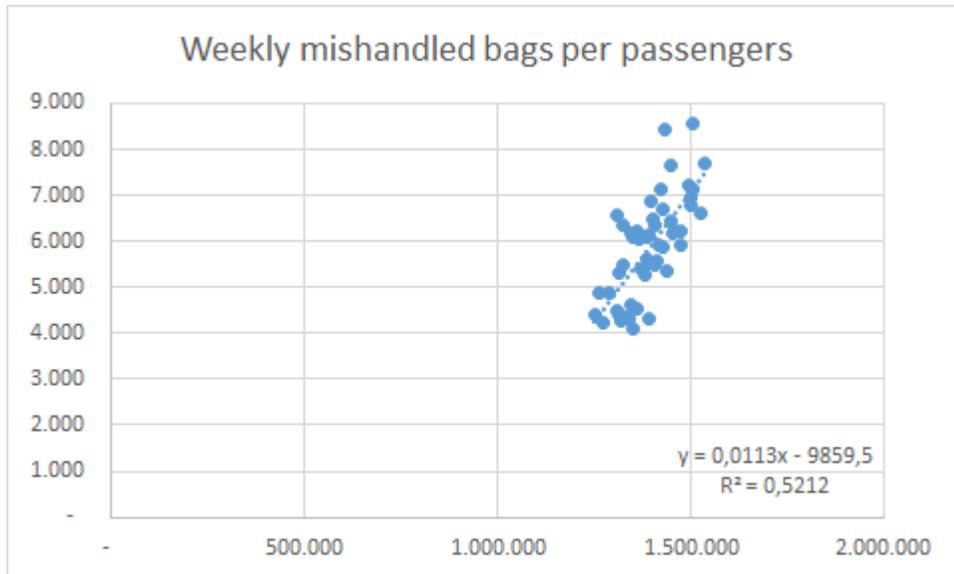


Figure 4.1 Weekly mishandled bags per number of passengers graph done in Microsoft Excel.

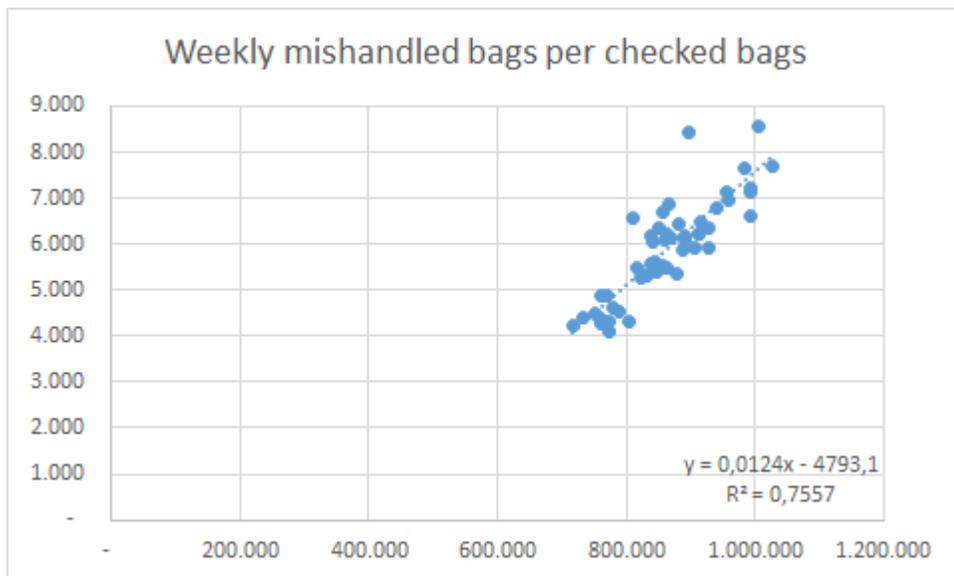


Figure 4.1 Weekly mishandled bags per checked bags graph done in Microsoft Excel.

A larger the  $R^2$  means that the model explains the better de relationship between the two variables and also that the trend line has a better fit to the numbers in the sample.

As seen in the charts, current KPI model that uses as the denominator the number of passengers has  $R^2$  of 52.12%. Therefore, in 48% of cases, the dependent variable cannot be

explained by the regressors present in the current model. However, the coefficient of determination is 75.57% in the weekly mishandled bags per checked bags' scenario, showing an increase of 23 percentage points.

This 45% increase in  $R^2$  value is indicating that the number of lost bags is much better explained by the number of checked bags, favoring the change in the way the airlines calculate the KPI today.

### **The Simple Linear Regression Model (SLRM) and The Pearson's Linear Correlation Coefficient (P-value) results**

The researchers performed the linear regression on the same data set (week performance). They used the value of Mishandled Baggage as the dependent variable and the other two variables, number of passengers and number of checked bags, as independent variables.

The result of this linear regression analysis shows that the Checked Baggage variable has a much lower Pearson's Linear Correlation Coefficient (P-value). And, as explained in the methodology chapter, a lower P-value shows a higher degree of association between two variables; the formula is as follows:

$$\rho(\hat{X}; Y) = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sqrt{\left[ \sum x^2 - \frac{(\sum x)^2}{n} \right] \left[ \sum y^2 - \frac{(\sum y)^2}{n} \right]}} = \frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}}$$

The result proves that the Checked Bags variable has a better correlation than with the Mishandled Baggage's occurrences. Table 4.1 shows the results for the Simple Linear Regression Model analysis.

Table 4.1

*Simple Linear Regression Model results for Checked Bags and Passengers as independent variables and Mishandled Baggage occurrences as the dependent variable*

<b>SLRM</b>	<b>Coefficients</b>	<b>Standard error</b>	<b>Stat t</b>	<b>P-value</b>
<b>Intersection</b>	-1154,770257	1873,157469	-0,616483278	$5,4043 \cdot 10^{-1}$
<b>Checked Bags</b>	0,01673507	0,002231895	7,498145245	$1,1266 \cdot 10^{-9}$
<b>Passengers</b>	-0,005313407	0,002452692	-2,166357501	$3,5176 \cdot 10^{-2}$

*Note: P-value wrote in scientific notation. The Regression Adjusted R Squared is 0,7679.*

After, the researchers performed two linear regressions independently, considering only one independent variable in each one. As expected, the number of P-value remains lower for the Checked Baggage variable compared to the p-Value of the Passenger Transported variable in the same period.

The tables below, Tables 4.2 and 4.3, show the result of these regressions.

Table 4.2

*Simple Linear Regression Model results for Passengers as the independent variable and Mishandled Baggage occurrences as the dependent variable*

SLRM	Coefficients	Standard error	Stat t	P-value
Intersection	-9859,55	2132,521	-4,62342	$2,69 \cdot 10^{-5}$
Passengers	0,01129	0,00153	7,377654	$1,54 \cdot 10^{-9}$

Note: Adjusted R Squared is 0,5116.

Table 4.3

*Simple Linear Regression Model results for Checked Bags as the independent variable and Mishandled Baggage occurrences as the dependent variable*

SLRM	Coefficients	Standard error	Stat t	P-value
Intersection	-4793,14	859,5704	-5,5762	$9,89 \cdot 10^{-7}$
Checked Bags	0,01237	0,000995	12,43586	$6,42 \cdot 10^{-17}$

Note: Adjusted R Squared is 0,7508.

### **Better results in the current KPI but less checked baggage per passenger**

Analyzing the historical data for Mishandled Baggage's Reports, the US airlines were able to reduce in 2016 the mishandled baggage KPI to rate of 2.70 per 1,000 passengers. The lowest annual rate since 1987, year of the US Department of Transportation (US DOT) began tracking results (Bureau of Transportation Statistics, 2017). The image below (Figure 4.3) shows the annual evolution of this indicator per passenger.

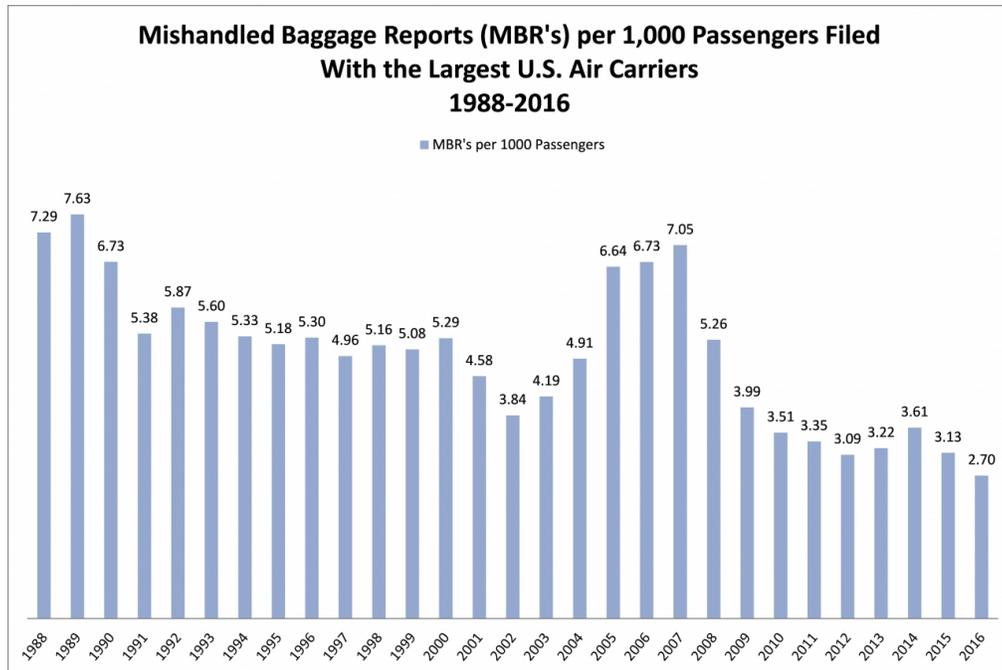


Figure 4.3 Shows the mishandled baggage reports (MBR) for the Largest U.S. Carriers from 1988 to 2016.

In October 2018, Bureau of Transportations Statistics published an addendum N° 30 Technical directive - updating the KPI to the total number of mishandled bags per the number of bags enplaned. As the addendum is only valid after January 2019, there is no historical data yet to the comparison. The table below is the result of July 2019 KPI; the new KPI has a 6.33 rate while the “passenger KPI” shows 2.4 (2017 SITA report results for North America).

AIR TRAVEL CONSUMER REPORT

MISHANDLED BAGGAGE: RANKING OF U.S. REPORTING MARKETING CARRIERS (MONTHLY)

RANK	CARRIER*	JULY 2019		
		NUMBER OF BAGS ENPLANED	NUMBER OF BAGS MISHANDLED	NUMBER OF BAGS MISHANDLED PER 1000 ENPLANED
1	ALLEGiant AIR	808,594	1,614	2.00
2	FRONTIER AIRLINES	1,167,391	4,563	3.91
3	ALASKA AIRLINES NETWORK	2,862,127	12,294	4.30
	- ALASKA AIRLINES	2,170,020	9,382	4.32
	- BRANDED CODESHARE PARTNERS	692,107	2,912	4.21
4	HAWAIIAN AIRLINES NETWORK	618,019	2,751	4.45
	- HAWAIIAN AIRLINES	601,288	2,513	4.18
	- BRANDED CODESHARE PARTNERS	16,731	238	14.23
5	SOUTHWEST AIRLINES	11,443,404	53,660	4.69
6	DELTA AIR LINES NETWORK	10,049,935	52,388	5.21
	- DELTA AIR LINES	7,728,303	41,390	5.36
	- BRANDED CODESHARE PARTNERS	2,321,632	10,998	4.74
7	SPIRIT AIRLINES	1,212,719	6,708	5.53
8	JETBLUE AIRWAYS	1,237,415	7,871	6.36
9	UNITED AIRLINES NETWORK	7,771,841	58,469	7.52
	- UNITED AIRLINES	4,823,435	35,542	7.37
	- BRANDED CODESHARE PARTNERS	2,948,406	22,927	7.78
10	AMERICAN AIRLINES NETWORK	10,789,747	103,092	9.55
	- AMERICAN AIRLINES	6,594,066	64,014	9.71
	- BRANDED CODESHARE PARTNERS	4,195,681	39,078	9.31
<b>TOTAL</b>		<b>47,961,192</b>	<b>303,410</b>	<b>6.33</b>

\* All U.S. airlines with at least 0.5 percent of total domestic scheduled-service passenger revenues.  
 (-) Data is not available for 2018. Comparison of 2020 and 2019 will appear in 2020 January-data ATCR.

Figure 4.4 Shows air travel consumer report: Mishandled baggage - Ranking of the US reporting marketing carriers (monthly)

A study made from ANAC in 2015, over a total of 1 million of domestic flights in Brazil, only 45% took off with average baggage more than 12kgs up to 23kgs (considered checked bag).

The graph (Figure 4.4) below shows this proportion:

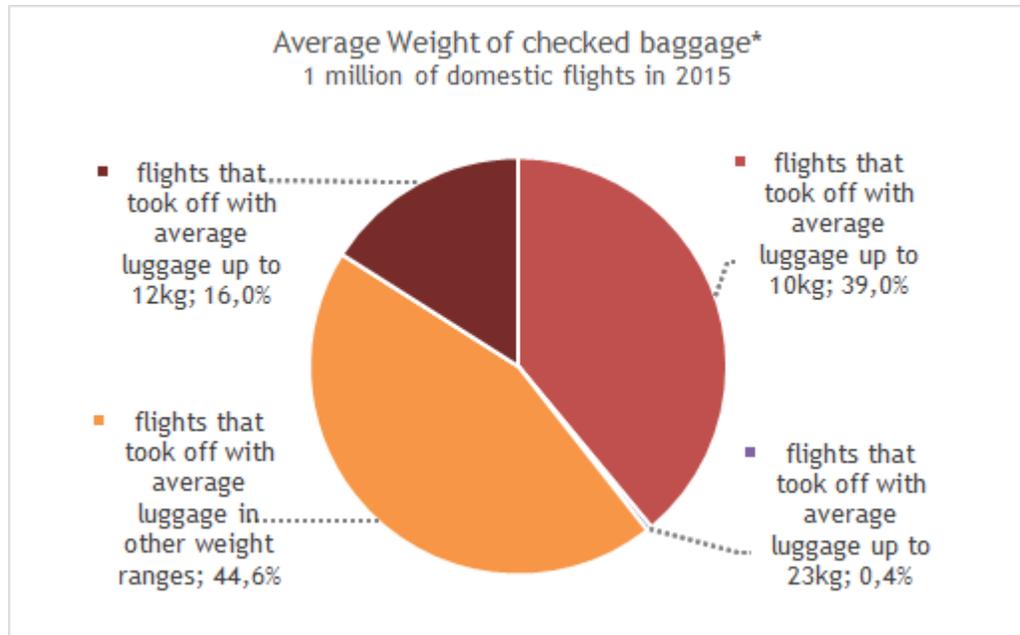


Figure 4.5 shows the average weight of checked baggage in 2015. Source: ANAC

Adding the study, also according to ANAC, in 2016, only 30.8 million passengers had checked bags of a total of 88.1 million passengers on domestic flights in Brazil.

Another relevant point of this study, the number of checked baggage had decreased in the past few years, the image below (Figure 4.5) shows this tendency.

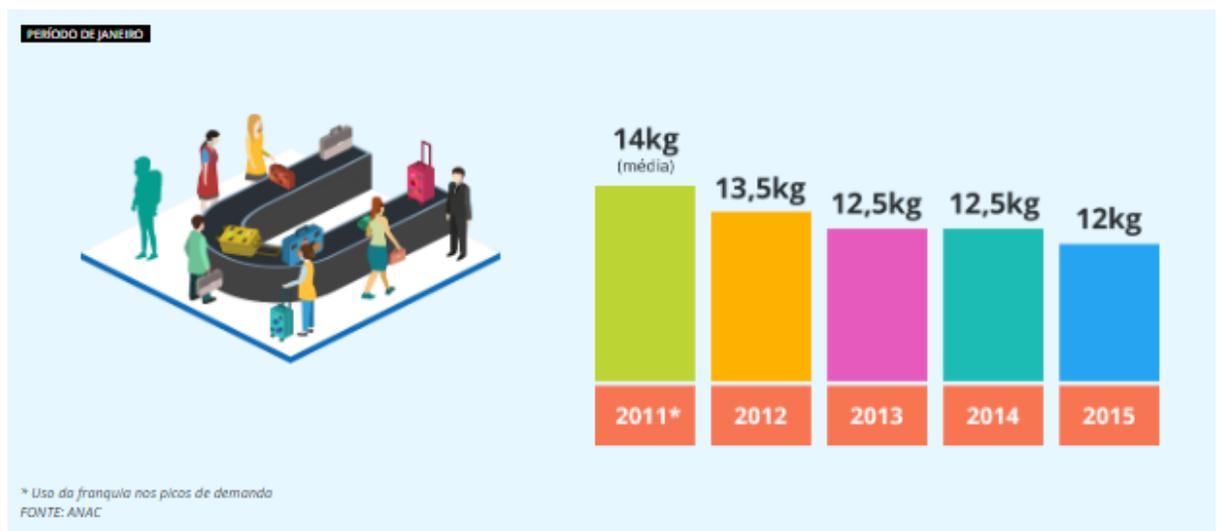
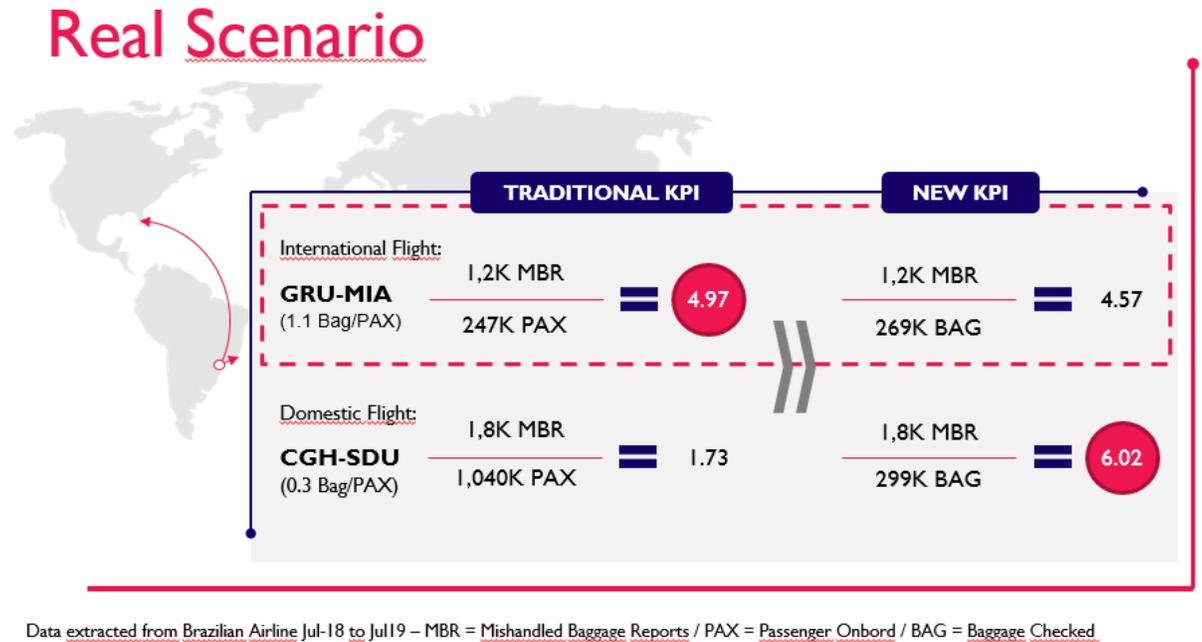


Figure 4.6 shows historical data of the average weight of baggage transported in Brazil in January of each year. Source: ANAC

As seen above in the analyses, checked bags have a higher correlation than passengers. Therefore, using passengers of part of the metric, in this case, would end up in wrong assumptions and results.

Analyzing real data extracted from a Brazilian airline for different routes, we could see above the results:



We could see that calculated by the traditional key performance indicator we had totally different results for CGH-SDU than in the new KPI, this happens mainly because it is a business route profile, which embraces our point that the customer behavior has changed and it is not possible making comparisons or track real numbers.

All these numbers reinforce our purpose of changing and updating Brazilian airlines to the new KPI, as in the U.S. for the last few months.

## **Summary**

All this happens because the KPI used today is strongly impacted by the number of checked luggage per passengers, which may vary greatly by the situation. Therefore, this makes it inappropriate to make comparisons under different conditions, such as Region and Culture and type of airline (Legacy or LCC company).

Airlines have been striving to make baggage handling safer, and consequently reduce the number of mishandled baggage. In 2018, only 5.69 lost baggage per 1,000 passengers, a decrease of 47 percent over 2007. It should also be considered that this reduction impacted the US \$ 2.4 billion for the aviation industry in 2018 with the handling of baggage (Mazareanu, 2019). This means that there is a clear signal of reduction curve, mainly from the implementation of the new Resolution 753 of the International Air Transport Association (IATA).

There is no doubt that airlines will need to adapt to new baggage scanning and scanning technologies and thereby be able to raise the level of baggage handling efficiency.

## **Chapter V**

### **Conclusions and Recommendations**

This project motivation was based upon updating the KPI of mishandled baggage used worldwide. The current KPI is measure on passengers as a variable instead of checked bags, which is most correlated with the real root problem.

The most important deliverable of change the KPI is to increase customer experience and minimize the risk of losing revenue.

#### **Conclusions**

As discussed in our recent analysis and studies, the advantages of upgrading the KPI measurement of mishandled baggage from boarded passengers to checked baggage significantly outweigh the disadvantages. In addition to presenting a higher correlation in the performance of the simple linear regression analysis model, the new KPI will allow for improvements in baggage handling processes and will reduce costs with outsourced or own airline labor. Also, the rapid growth in the use of baggage tracking data technology through the adoption of RFID tagging, and the changing customer behavior that check less baggage, further supports our thesis to update the mishandled KPI.

The researchers know that baggage handling is a sensitive item for customers, and directly influences customer loyalty and experience, as well as impacting a brand's outcome and recommendations.

The effects of changing the KPI would be even more beneficial in a high-risk industry such as aviation. In Brazil, the companies face some particularities such as exchange rate

volatility and excess regulatory standards that make the environment even more challenging for our companies.

## **Recommendations**

Based on our studies as well as analyzing the big picture of world aviation, especially the Brazilian industry, our recommendation to airlines, airports and industry partners is to make the gradual transition from the current KPI model of mishandled baggage. Despite the dramatic drop in mishandling rates in recent times, each mishandled bag is an additional cost for airports and airlines. There is still a lot of opportunities for more efficient ground operations, and faster walking. Airlines must work directly with industry regulators, transportation departments, representative associations, and technology experts to put this issue on the agenda of industry discussions.

According to our analysis and conclusions, the updating of this KPI would positively affect the results of the organizations.

Two immediately benefits of this change are: adjustments of third party contracts, making them more coherent regarding the fair amount of checked bags; and improving the comparability of airlines and ground handlers' operations.

Another important advantage in the remodeling of this KPI is, higher accurate and reality-related indicators, better will be the strategy to improve the service. So, consumers are likely to be the main beneficiaries and can expect better service at a sensitive key point of the journey experience.

In the final consequence, higher proportions of happiest customer's end in increase revenue for the industry and to the companies.

Further researches should focus on the gradual increase in technology application in airport baggage handling operations. In addition to the industry-leading RFID technology, the trend in baggage handling is the gradual replacement for an automation-driven model.

So the researches bet on better KPIs that translate into a long list of benefits, including reduced labor costs, increased accuracy, and increased customer service levels.

### **Key Lesson Learned**

One of the greatest lessons learned is the continuing challenge of reconciling the speed of technological innovation, with operational efficiency in reducing the number of lost baggage and consumer satisfaction. This involves, in addition to the financial issue for airlines and service providers, the real needs of customers and how much value the airline can add.

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