Revenue management of air cargo service in theory and practice

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Abstract. This study examines the air cargo service by comparing existing theories from previous research with the conditions on the ground. The object of the study is focused on the freight forwarder and the airport management. This study reviews the models and results of previous research that will be summarized and used to identify any issues related to the characteristics of air cargo operational services, as well as observing and monitoring literature with airlines, shipping companies, and airport management to explore and see the gap between prior research and implementation of its process in the air cargo service. The first phase in this study is to provide an overview of the air cargo industry. The second phase analyzes the characteristic differences between air cargo services and air passenger operating services. And the third phase is a literary bibliography study of air cargo operations, where the focus is on the studies using quantitative models from the perspective of the object of the study, which is the optimization of revenue management on air cargo services. From the results of the study, which is based on the gap between theory and practice, new research opportunities which are related to management of air cargo service revenue in the form of model development are found by adding booking timelines aspects of cargo that can affect the revenue of cargo airline companies and airports.

1. Introduction

The development of air transport activities around the world has increased the demand for airport services and the needs for a more efficient process of aircraft, passenger, and cargo services. During this decade, the demand for air cargo transportation has grown rapidly. This is reflected in the increase of air cargo fleets, the addition of cargo terminals, and the number of new cargo routes.

All airlines seek to expand their operations efficiently at airports to reduce costs and improve the customer service quality [1][2][3] explained that when carrying out their activities, airports aim to maximize aircraft mobility to improve the efficiency of operations in the competitive environment where they operate in. IATA revealed their forecast at the end of 2016 in preparation for the increasing demand in 2017, as depicted in the market distribution table below.

This could be proven through the monthly data provided by the IATA Air Cargo Market Analysis. In October 2017, the growth of Global Freight Tonne Kilometres (FTK) was at 5.9%, as shown in the graph below:
The graph above shows the high growth of the cargo market in 3 years. Hence the cargo carriers must be able to keep the dynamic and keep up with the trend to face such a market pattern. This situation is consistent with research conducted [1] which reveals, with the graph below, the basis of air cargo research:

This research [1] not only shows that the gross income from Asia's air cargo is the largest, but also the flow of Asia's air cargo is the largest within the Asian continent as well.
Boeing also conducted a forecasting analysis in the World Air Cargo Development 2016-2017. Boeing stated that between 2005-2015, air cargo growth reached 2%, while the estimated air cargo development from 2015 to 2035 concluded 4.2%. Besides that, the research also explained that although the Chinese market growth rate has decreased from 7.6% to 6.2% in a future forecast, the Chinese market still holds the highest air cargo growth in the world.

In response to that condition, this study aims to determine the challenges faced by the air cargo transportation industry by looking thoroughly over papers on aspects of air cargo operations. The complexity of increasing revenue problems faced in carrying out the operation of air cargo encouraged a large number of research regarding air cargo. The research done by [4][5][6][7] explained the uniqueness and complexity of operating the air cargo business in comparison to passenger transportation. [7][8] explained the capacity of cargo in terms of the issue of overbooking. [9] did a research regarding air cargo revenue management based on weight and air cargo volume. [10] in their research considered the increased rate to maximize income. [11][12] explained the function of booking demands with cargo capacity, and [30] elaborated on the optimization of air cargo volume based on the container to be transported.

However, with the complexity of the issues that occur, most issues in this field remain unsolved in the end, especially on the optimization of income, or more commonly known as the Management Revenue. This is a culture that must be done constantly over time to increase revenue through the optimization and understanding of needs and demands of the market. The success of increased revenue on cargo shipping services for both the airline and the airport air cargo management (forwarder) cannot be separated from the operating system, as the demand factor with few optimizations in the quality, cost, and delivery must be taken into account. Additional cost(s) that arise in the income management can be converted into components of production costs that could be charged to the consumer in the form of the product selling price. The role of the cost is attached to the internal carrier itself so it depends on the airline how to handle its cargo. If managed well, the production cost will be lower, if not, the production cost and the selling price will be high with low competitive ability. Being successful in the revenue management for the airlines and airport cargo managers mean a larger size and a larger number of goods can be transported and distributed, hence more income for both. On the other hand, this also shows the success of positive contribution on general distribution activities, transportation, and development.

Therefore, the focus of this research is to develop a model of revenue optimization on air cargo operations by looking at the variables which affect it in overall air cargo operations so that it can be used in decision making, then conduct a comparison from previous theoretical research with practical experience in real life.
2. The decision problem and research questions
The common problems related to revenue management is about how the company manager makes decisions with the complexity of the air cargo problems with the uncertainty factors of arrival, quantity, and volume of goods ordered in the limited time, weight, and volume of goods to be transported on a plane. The decision whether the order of goods received can be accepted or rejected determines the level of income. Meanwhile, the research question here is: How does the problem of air cargo Management Revenue Optimization based on the coherent of existing theory and actual market activities.

3. Research method, process and procedures air cargo

3.1 Research Method
Steps to accomplish this research are: The first section of this study gives an insight on the air cargo industry, both its current condition and the problems faced. Then the second part will explain the concepts and methods of research, and explain the process and identification of air cargo operations. Section three focuses on reviewing previous research and performing air cargo literature tabulations which consists of theories and models to review the compatibility with current theories. Section four presents issues that occur in the actual practice of air cargo operations and compares it with theory to see the gap between theoretical researches and facts in the field, so that in the end we will provide new research opportunities. Finally, section 5 presents the summary.

The literature review method used in this research is to first by separate the study group based on the implementation of the concept of revenue management and the process of revenue management. The second phase of the literature review focuses on the process of revenue management that classifies the literature categories based on three main components. The next stage is to classify the existing literature based on the component group, and the following are the components and literature groups:

Preliminary studies on revenue management on air cargo based on research conducted by [14][17] [20]. In the three main components literature the revenue management process are as follows :

- Forecasting Components. This process estimates demand, available capacity, demand, and rate of price increase. [2][3][13][14]
- Spatial Capacity Component. In this process, how much space should be sold under long-term contracts and ensure which requests should be received by the airlines.[8][9][13]and [16]
- Overbooking component. In this process, accepting orders more than the available physical capacity to avoid losses due to order cancellation. Refers to research conducted by [11][12][18] and [19]

By grouping and categorizing the existing literature articles selection, it will provide a comprehensive literature description in the field of revenue management.

3.2 Process of air cargo handling

1. First, reserve to the registration operator with the shipping instruction documents as proof that the agent/shipper has made a booking and confirm the type and quantity of goods in detail to the Airlines.
2. Then, the goods are stored in the warehouse. After it is received, there will be inspection of the goods’ packaging to categorize where the products would be separated, whether into the group of Special Cargo/General Cargo.
3. After that, the labeling process would label the goods with the name, the exact address of the shipper, and the consignee. Label/cargo stickers are used to mark the packaging. All fees are charged on the freight forwarding services and must be paid directly by the sender using cash upon receipt of the cargo.
4. Last, the examination of required documents, such as the Airway Bill & Shipper Document (for Dangerous Goods), then followed by Build Up process by setting up a ULD (Unit Load Device) which will be put into the trunk of the plane. If the goods are categorized as Special
Cargo, then the sender would need to prepare a document NOTOC (Notification to Captain). The goods are then ready to be sent.

Figure 5. Process of air cargo handling

3.2 Procedure of cargo departure

Several research studies related to air cargo operations as undertaken by [4][5][6] [7] described the uniqueness and complexity of air cargo operations in comparison with passenger transport. Some of the things studied involve aspects of Uncertainty, Complexity, and Flexibility.

a. Uncertainty
Air transport is a combination of cargo and passenger, in which the passenger is more prioritized compared to the cargo. Thus, the level of uncertainty on air cargo is higher due to the availability of capacity that is influenced by the number and size of the airline’s passengers [15], disclosed that the shipper must ensure the use of cargo capacity long before the flight. The number of goods
to be shipped is actual and not order, and this shows the high fluctuation rate in capacity management on air cargo.

Figure 7. Uncertainty of plane capacity

b. Complexity
Determining cargo capacity through forecasting methods is significantly more complicated than estimating the capacity of a passenger aircraft. This is because before we identify the cargo capacity, which depends on the cargo space and the remaining size of the total weight of the aircraft, we must first know the number of passengers on the plane. Meanwhile, calculating the capacity through passenger aircraft can be determined from the number of seats in use, the cargo capacity depending on the type of container used, which are called unit load devices (ULDs), and which are further defined by several dimensions, such as weight, volume, type, and center of gravity[2][21].

c. Flexibility
The delivery schedule from the origin to destination in air cargo is more flexible than passenger transport. Basically, the delivery can be done by using any kind of aircraft without having to consider the number of transit stops, as long as it arrives in the specified time; on the other hand, having several transit stops to reach a destination would be very risky for a human passenger [15]. In optimizing the use of network capacity, the airline could make a delivery plan by simply determining the origin airport, the transit airport(s), and the destination airport to the forwarder.

4. Research on air cargo
Several researches on air cargo have been done with different focuses, such as the air cargo system, its operation process, and the development of the air cargo industry. The growth of the air cargo market is pushing the current research further into optimizing revenue by optimizing available capacity in the form
of a quantitative decision method with a mathematical model for air cargo operations. There are several articles related to air cargo that would be discussed in the following literature.

4.1 Concept of management revenue

Revenue management is defined as the integrated management of prices and inventory to maximize profitability. According to [22] in his article, "Revenue Management Hard-Core Tactics for Market Domination," Revenue Management is the application of various tactical disciplines to maximize revenue growth. While [23] qualify Revenue Management into two categories, quantity-based and quality-based. Capacity control is to allocate capacity optimally to different classes of demand, while overbooking is when a company accepts reservations more than the available physical size in order to avoid losses due to order cancellations. The study of cargo space control was first done by [9]. In his research, he used a mathematical model with a heuristic method, HD Method, separating the two-dimensional problem of cargo into one separate dimension and later combining them together. The discussion of revenue management is always associated with passenger and freight transport. [14] stated that the revenue management is the management of passenger and seats’ fare along with the levels of cargo and cargo space. In the same study, [14] described the process for air cargo revenue management into the following three steps, which are: (1) forecasting capacity available for sale, (2) ordering more forecasting capacity to compensate ordering behavior regarding cancellation and absence, and (3) allocating extra capacity to different products or markets that can maximize total revenue or profitability. This is called space allocation or capacity allocation.

### Table 1. Air Cargo Revenue Management Publication.

| Reference          | Model                           | Focus             | Method                              | Variable                                |
|--------------------|---------------------------------|-------------------|-------------------------------------|-----------------------------------------|
| Kasilingam (1996)[14] | Stochastic programming          | Overbooking       | Discrete or continuous probability distribution | Capacity, spoilage cost                |
| Kasilingam (1997)[39] | Stochastic programming          | Overbooking       | Discrete or continuous probability distribution | Capacity, spoilage cost                |
| Popescu et al. (2006)[8] | Nonparametric distribution estimation and forecasting | Overbooking        | Discrete distribution               | rate (weight or volume)                |
| Popescu (2006)[27]    | Proabilistic nonlinear dynamic programming | Accept or reject policy | Rates as a function of weight and cargo level | Capacity (weight and volume); classes  |
| Amaruchkul et al.(2007)[9] | Stochastic dynamic programming | Accept or reject policy | Joint distribution of volume and weight | Capacity shipment type; terminal value  |
| Gupta (2008)[25]      | Stackelberg game                | Capacity contract | Deterministic demand                | Forwarder’s effort level; freight rate  |
| Wang and Kao (2008)[7] | Fuzzy reasoning                 | Overbooking       | Fuzziness method                    | Capacity spoilage cost, over-sale cost, show uprate |
| Han et al. (2010)[37] | Stochastic dynamic programming | Accept-or reject Policy | Joint distribution of volume and weight | Capacity (weight and volume); profit rate; |
| Huang and Chang (2010)[10] | Stochastic dynamic programming | Accept-or reject Policy | Joint distribution of volume and weight | Capacity, profit rate; shipment type; |
| Amaruchkul and Lorchirachoonkul (2011)[15] | Stochastic dynamic programming | Accept-or reject Policy | Joint distribution of volume and weight | Capacity (space) |
| Amaruchkul et al.(2007)[9] | Random demand                   | Capacity contract | Principle-agent game                | lump-sum payment and refund rate        |
| Qin et al. (2012)[26] | Dynamic programming – Game      | Overbooking       | Continuous distribution             | capacity                                |
| Hellermann et         |                                 | Capacity          | Demand is a function of             | Booking level, reservation             |
[24] observed the development of Revenue Management from the 1960s until 1990s. The earliest usage of Revenue Management was by the American Airlines company, when they developed an online reservation system called Saber (Semi-Automated Business Research Environment) in the 1960s. In another study on American Airlines, a typical revenue management system is expected to generate an additional income of 3-5% [11]. Excess requests create substantial revenue and income management profits.

![Figure 8. Management revenue](image)

### 4.2 Previous studies of air cargo

The study of air cargo services from several researches, is as follows: [25] explained that the current problem with cargo capacity is that the air cargo supply chain consists of the shipper, freight forwarder, and airline. The shipper sends the order to the sending aircraft and is responsible for contacting the carrier and obtaining space to transport the cargo as the sender requires. This process often takes a long time because of the lack of coordination between the aircraft sender and carrier. This could be easily solved if an integrator or a transport plane has their own fleet.

[28] proposed the management of results with the number of passengers as an indicator of air cargo performance. An example of the case is American Airlines, which could gain $ 1.4 billion profits in three years and earn an expected profit of $ 500 million per year.

[14] correlated the level of cargo capacity with forecasting results. In his research, the capacity forecast affects the amount of capacity an airline could provide, and the demand forecast affects the number of decomposers and the quantity of freight cancellation.

[17] The cargo transport capacity is sold based on two models: (1) Contracts of assured capacity: consumer approval involving guaranteed capacity (defined in expenses and volume) on specific flights/working days. (2) Free sales: no capacity warranty, it is usually based on a specific order. The airline may receive a booking request or space booking for more profit in the future.
in his doctoral dissertation, stated that cargo costs and capacity could affect the level of cargo services. The booking fee occurs if the airline has not set up space for cargo transport. A pending fee happens if the carrier can no longer haul the cargo due to limited capacity. Both costs could result in the reputation of air cargo services being questioned.

Stated that air cargo capacity assessments may occur due to expiration costs and the cost of cargo carrying capacity cancellation. Expiration costs occur if the cargo cannot be delivered on time, so it will decay or expire on the road. The price of freight cancellation is charged if the cargo is already in place, yet cannot be transported to the plane. Both costs are different, although they can sometimes happen during the same time. If this happens, the airline (shipping service company) would get into trouble because consumers would feel that they are being disadvantaged, which will ultimately affect the company's reputation.

Also stated that the market cannot be separated from scheduling. Scheduling is required for the airline's target market to be met. These two supports are the scheduling of vehicles and the amount of cargo. The number of vehicles/aircrafts is vital because without knowing the exact number of aircrafts in operation, the airline may not be able to arrange the scheduling properly. The amount of cargo should also be categorized by priority setting and mapping. Some loads that must be sent immediately must be transported first by the aircraft that can pass the route at the earliest. Other loads can be adjusted according to the allocation of aircraft and directions taken.

Fixed bookings or free sales may affect overall air cargo capacity performance, where network optimization is a leading indicator of air cargo performance [13].

5. Real condition revenue management in air cargo
5.1 The Operational of Air Cargo
In this research, the study is conducted in Husein Sastranegara Bandung Airport, Indonesia, and involved several airlines; Implementation of Air Traffic Management Revenue at Husein Sastranegara airport has its own uniqueness related to its actual condition and is as follows:

1. Air cargo demand in Husein S. reached an average of 25 tonnes/day while the ability to deliver is at 20 tonnes/day (source: Husein's Cargo Warehouse). The current situation shows imbalance between supply and demand; although the numbers are very profitable, but in reality, the amount of sent goods are not well distributed to all available flights, only to one or two destinations because of the limited loads.

2. The types of goods that can be sent from the Husein S. airport are all goods types for General Cargo and Special Cargo (source: Husein Cargo Sheds). This condition will provide a large room for revenue increase attempt but will probably be constrained by the cargo space arrangements and packaging problem.

| Airline | General Cargo | Special Cargo |
|---------|---------------|---------------|
|         |               |               |
| G.A     | Yes           | Yes           |
|         | Yes           | Yes           |
| L.A     | Yes           | Yes           |
|         | Yes           | Yes           |
| A.A     | Yes           | Yes           |
|         | Yes           | Yes           |
| CL.A    | Yes           | No            |
|         | Yes           | Yes           |
| N.A     | Garment       | No            |
|         | Yes           | No            |
| E.A     | Yes           | Yes           |
|         | Yes           | Yes           |
|         | Yes           | Yes           |
|         | Yes           | Yes           |
|         | Yes           | Yes           |

Table 2. Type Of Cargo
3. The aircraft used for cargo is a passenger aircraft type: Air Bus A320, Boeing 737 - 700 and - 800 and ATR (source: AP II Husein S.). The limited size of the aircraft and the runway reflects on the limited loading of freighter cargoes.

Table 3. The Cargo Load Limit

| No | Airline | Type | Max Weight |
|----|---------|------|------------|
| 1  | G.A     | B737 | 4 Tonnes   |
| 2  | L.A     | B738 | 2 Tonnes   |
| 3  | A.A     | A320 | 2 Tonnes   |
| 4  | C.L.A   | A320 | 4 Tonnes   |
| 5  | N.A     | B737 | 600 Kg     |
| 6  | E.A     | B737 | 2 Tonnes   |

4. The cargo storage system in the aircraft is by bulk storage (not using a Container or Pallet) (source: Husein Cargo Warehouse). This condition resulted in ineffective utilization of cargo space.

5. The absence of airlines that operate a special cargo aircraft.

6. The aircraft used is a combination transporting plane for passengers and cargo.

7. The limited size and number of the transport aircraft.

Based on the conditions stated above, it can be seen that the potential benefits are large, but it will be difficult to optimize in accordance with the theory of revenue management. In fact, the cargo business at Husein Sastranegara airport is still considered an optional business after passenger service. The problem in using a passenger and cargo combined transporting plane with an aircraft of limited size and the optional condition of having cargo as payload, is that the number of the goods loaded will be very dependent on the number of passengers and baggage loads carried by the passenger. This means that the optimization that could be done is by calculating the remaining capacity of the cargo space and the weight of goods to be loaded and by applying an overbooking strategy in an effort to anticipate losses due to the occurrence of spoilage (if the cargo goods already on the booking did not arrive, then it will cause losses due to unused space) and oversale (a condition which happens before the departure of the aircraft, as the weight and volume of cargo exceeds the capacity of the plane, then some cargo loads must be unloaded, reducing the revenue of the airline). Other facts at Husein S Airport are large market potentials not being utilized by applying pricing strategies to optimize revenue. The application of the price made static is not distinguished by the time of booking and urgency. This causes and is reflected by a not optimal income.

6. New research opportunities

After comparing the theory and practice, there are a few interesting points to be researched to obtain optimal results, such as: the various types of cargo shipments with different weight and volume in its activities, following the distribution with random variables. Aircrafts have limitations on weight capacity and volume capacity. Airline pursue a policy towards different booking and loading timeframe. Each booking request arrival is independent of the booking horizon of each carrier. Upon receiving the booking request, the airline must pay attention to the maximum load of the aircraft by looking at the number of passengers to be transported, so in this case the airline must decide whether to accept or reject the incoming booking request.

There is a condition that: (1) When a booking request is received, the airline does not know exactly the type, weight, and volume of the cargo before the departure of the plane. (2) Each received booking request could be cancelled anytime or does not arrive when the plane is departing.

This situation, of course, will cause losses for the airline if the existing capacity is not utilized correctly. Implementation of overbooking is one way to overcome this. However, excessive overbooking
will cause an oversale penalty that will create more significant losses than the shortage. To overcome this problem, we need to find the optimal cargo overbooking limits obtained.[12]

Further works to do in relation to research opportunities are:

1. By observing the amount of capacity wasted associated with weight loss and transported passengers’ baggage, it would provide opportunities to optimize the load capacity by allocating the remaining capacity for cargo loads.
2. Search for the optimal amount of time towards the cargo booking deadline (booking time close), considering the possibility of wasted load capacity by the total load of passenger and baggage. It is expected that further research will be able to answer these problems to enhance the airline overbooking policy over the years.

Knowing the optimal time limit of the cargo booking time would impact on: (1) Increasing revenue for airlines and airport managers. (2) Reducing queue time and the duration of airport parking lot usage. (3) Reducing the occurrence of delayed flights. (4) Improving service efficiency for airlines and airport managers. (4) Having goods flowing faster to reduce the number of loads dwelling in the cargo warehouse. (5) Increasing the capacity of cargo warehouses and airports as a whole.

7. Summary
In this paper, we reviewed literature on revenue optimization through capacity utilization in air cargo operations and compared recent theories with the practical practice.

The first thing we did was to map the air cargo industry, and then we analyzed the characteristics of air cargo and compared it with air passenger operations. Later, we conducted a literary bibliography survey on the optimization of air cargo operations capacity, where we focus on studies that used quantitative models from the perspective of airlines, freight forwarders, and air cargo. Furthermore, we identified the main decision issues in air cargo operations and discussed the gap between previous research and practical practice based on literature review and in-depth interviews with airlines and forwarders. The literature has investigated some real-world problems in the air cargo industry.

This review identified several significant differences between theory and practice in relation to capacity optimization in air cargo operations. The theories examined in this paper still provide room for them to be more refined, given the studies conducted under different situation, conditions, and characteristics. Models often differ from operational reality.

Two major points to conclude this study. First, the overbooking policy to increase airline revenue could be achieved by expanding the utilization of aircraft capacity. Second, the overbooking policy would be more optimal if we calculate the optimum booking time limit. The broader the booking time horizon, the higher the revenue opportunity would be.

Research opportunities that could be done are: developing the model of revenue optimization by considering the booking time limit on the air cargo service and the utilization of the wasted load capacity due to the remaining load of passengers and baggage transported in the aircraft (the number of passengers and baggage loads are smaller than the available size).

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