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Operating costs and capacity in the airline industry

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Abstract

This study illustrates how to calculate accurate costs, including the operating costs for individual airplanes and flights, as well as the costs per available seat kilometers, and per available ton kilometers using activity based costing. It also identifies the main activity items and drivers of each airplane and flight. Additionally, it uses a case study to illustrate the calculation of production variance, marketing variance and expected idle passenger capacity in the airline industry. This is useful information when the purchase or lease an airplane under the conditions of idle capacity.

Keywords: Activity-based costing (ABC); Operating costs; Idle passenger capacity; Airline industry

1. Introduction

The major terrorist attack on the US on September 11, 2001 had major adverse impacts on the airline and tourism industries and has caused airlines to incur millions of dollars in increased security costs. Cost control is important in this situation. Airlines are aware that poor costing can distort pricing leading to a loss of business. Problems in particular can arise when using traditional cost accounting methods (Cooper, 1989).

The airline industry has reported accumulated losses of $30 billion since the events of September 11, the war in Iraq accounting for about $10 billion of this. Three US airlines have sought Chapter 11 bankruptcy protection. The outbreak of Severe Acute Respiratory Syndrome (SARS) created additional fear for travelers, especially in Asia. The combination of September 11, the Iraq war and SARS has reduced airline passenger demand leading to cuts in flight schedules. Industry experts forecast that the airline industry might not be profitable until at least 2005.

This study has two objectives. It explores operating costs in the airline industry using activity-based costing (ABC). Second, it uses a case study to demonstrate how to calculate production variance, marketing variance and expected idle passenger carrying capacity in the airline industry.

2. Concepts of ABC

Traditional cost accounting (TCA), which mainly uses direct labor to allocate overhead costs, can systematically distort product costs in advanced manufacturing environments when overhead costs are a significant portion of overall costs. ABC techniques, developed by Cooper and Kaplan (1992) are seen as accurately assigning overhead costs to products.

Fig. 1 shows the detailed cost assignment view of ABC. It assumes that cost objects (products, product lines, processes, customers, channels, markets, and so on) create the need for activities, and activities create the need for resources. Accordingly, the technique uses a two-stage procedure to assign resource costs to cost objects.

In the first stage, resource costs are assigned to various activities using resource drivers. Resource drivers are the factors selected to approximate resources consumed by various activities. Each type of resource traced to an activity becomes a cost element of an activity cost pool. An activity cost pool is thus the total cost associated with an activity. An activity center...
comprises related activities, usually clustered by function or process.

In the second stage, each activity cost pool is distributed to cost objects using an adequate activity driver that measures activity consumption by cost objects (Turney, 1991). The various kinds of activity costs are traced to cost objects by using the different kinds of activity drivers. For example, machine hours is used as the activity driver for the activity machining; setup hours or the number of setup for machine set-up; and the number of drawings for product design (Tsai, 1996a, b). If cost objects are products, then the total cost of a specific product can be calculated by adding the costs of the various activities assigned to that product. The product unit cost is achieved by dividing the total cost by the product quantity.

Since 1988, ABC has evolved from the concept stage and has been widely used. Applications extend from manufacturing industries (Dhavale, 1993; Zhuang and Burns, 1992) to service industries (Carlson and Young, 1993; Chan, 1993), non-profit organizations (Antos, 1992), and government bodies (Harr, 1990). The information achieved through ABC cost assignment can be used for decisions concerning pricing, quoting, product mix (Tsai, 1994), quality improvement (Tsai, 1998), make versus buy, sourcing, product design, profitability analysis, and so on (Turney, 1991). ABC frequently is applied together with other manufacturing management techniques, such as just-in-time and total quality management (Carlson and Young, 1993).

3. Comparison of ABC and TCA

TCA involves collecting indirect costs from departments and then allocates them to products or services. In contrast, ABC collects indirect costs of activities and assigns activity costs to cost objects (Table 1). This produces some differences. ABC assumes an activity to be an activity cost pool with an activity driver, while TCA usually considers a department to be a cost pool with an allocation base. Additionally, the activity drivers of the ABC emphasize causality between activities and activity drivers, while the allocation bases of the TCA do not emphasize cost causality.

| Table 1 | The comparison of ABC and traditional cost accounting (TCA) in indirect cost allocation |
|---------|-------------------------------------------------------------------------------------|
| Cost system | Allocation stage | First stage | Second stage |
| Traditional cost accounting (TCA) | Indirect costs → Departments → Products |
| ABC | Indirect costs → Activities → Cost objects |

4. Cost assignment for an airline under the ABC concept

Reliability of cost information for decision-making has been a critical issue in cost accounting. Johnson and Kaplan (1987) argue that traditional cost accounting systems frequently fail to provide information useful for decision-making. Currently, most airlines do not use the ABC method for cost calculations.

One approach to applying ABC to the airline sector is seen in the flow chart depicted as Fig. 2.

Operating costs for individual airplanes and flights are divided into direct costs and overheads (indirect costs), while direct costs are divided into direct variable costs and direct fixed costs. The direct variable costs are those that can be directly traced to cost objects—airplanes or flights—and that change according to the
Fig. 2. The new flow chart of cost assignment for an airline under ABC. Note: 1. M&R represents the abbreviation of maintenance and repair; P&M represents the abbreviation of planning and managing. 2. This cost will be incurred if passengers are carried.
degree of utilization of the cost objects. Direct fixed costs can be directly traced to cost objects, but do not change according to the degree of utilization of these objects.

Table 2 uses three conditions (a, b, c) to illustrate the attribution of direct costs of individual airplanes or flights. Salaries of direct maintenance employees, part and component costs, outsourcing maintenance costs, and airplane insurance, leasing, and depreciation costs are initially traced to individual airplanes and then allocated to individual flights based on the ratio of flight length to total kilometers for all flights. Fuel costs, pilot salaries, and direct costs associated with using airports (such as landing fees) are directly attached to flights, not aircraft, because they are incurred as a result of the flights themselves. Additionally, salaries of cabin crew, and direct costs of passenger service—e.g., in-flight catering—are directly traced to flight costs (Table 2). It is usually easy for airlines to gather and calculate the related direct costs for each airplane and flight. ABC and TCA require the same direct costs information.

ABC and TCA differ in the assignment of overhead costs. Thus there is a focus here on examining the allocation of overhead costs to cost objects for an airline using the ABC method. Overhead costs are divided into four main activities: pool-maintenance and repair, flight planning and management, marketing, and service activities. The main costs in the maintenance and repair activity pool are salaries of indirect maintenance employees, machine equipment costs, quality-checking costs, and hangar costs. The flight planning and management activity pool includes costs of flight dispatching, monitoring and coordination, and the costs of rental, office equipment and other supplies related to flight activity planning and management. The main components of the marketing activity pool are promotion costs, salaries of financial planning and cabin allocation employees, and the costs of rental, office equipment, and other marketing related supplies. Service activity pool components include the salaries of ground staff, and the costs of rental, office equipment and other supplies associated with related service activity (Table 3).

Airlines can obtain most of the cost information of individual airplanes by adding the direct variable costs (including the salaries of direct maintenance employees, part costs and outsourcing maintenance costs), direct fixed costs (including insurances, leasing costs and depreciation) and various maintenance and repair activity costs (including the salaries of indirect maintenance employees, machine equipment costs, quality checking costs and hangar costs) associated with that airplane. The costs for each airplane are allocated to individual flights based on the percentage of the kilometers of individual flights to total kilometers for the fleet. Besides the assigned costs for each airplane, flight related costs include fuel costs, pilot salaries, direct costs associated with using airports, flight dispatching, monitoring and coordinating costs, promotion costs, salaries of financial planning and cabin allocation employees, salaries of ground staff and the costs of rental, office equipment and supplies. The salaries of cabin crew and direct costs of passenger service, for example, in-flight catering, are incurred because these costs belong to one of flight costs for airliners but not freighters.

If an airplane only carries passengers, then the cost per available seat kilometers is found by dividing the total costs of each flight by the number of seats available for passengers. For airplanes that only carry cargo, the

| Direct costs               | Cost contents                       | a    | b    | c    |
|----------------------------|-------------------------------------|------|------|------|
| Direct variable costs      | Salaries of direct M&R employees    | Yes  | No   | No   |
|                            | Part and component costs            | Yes  | No   | No   |
|                            | Outsourcing maintenance costs       | Yes  | No   | No   |
|                            | Fuel costs                          | No   | Yes  | No   |
|                            | Pilot salaries                      | No   | Yes  | No   |
|                            | Direct costs using airports         | No   | Yes  | No   |
|                            | Cabin crew salaries                 | No   | Yes  | Yes  |
|                            | Direct costs for passenger service   | No   | Yes  | Yes  |
| Direct fixed costs         | Insurance of airplanes              | Yes  | No   | No   |
|                            | Leasing costs of airplanes          | Yes  | No   | No   |
|                            | Depreciation of airplanes           | Yes  | No   | No   |

Note: a: These costs are traced to individual airplanes, and then they are assigned to individual flights by percentage of individual flight kilometers to total flight kilometers; b: these costs are directly traced to individual flights; c: these costs will be additionally incurred if passengers are carried. M&R represents the abbreviation of maintenance and repair.
cost per available ton kilometers is acquired by dividing the total costs of each flight by the quantity of tons available for freighters. If an airplane carries passengers and cargo, then costs are first divided into passenger or cargo costs based on causality of cost occurrence. If costs are incurred for passengers, then these costs are attributed to passenger costs. If costs are incurred for cargo, then these costs are attributed to cargo costs. As for common costs in flight costs, these costs are allocated as passenger or cargo costs based on the percentage of carrying space occupied by each. After distinguishing passenger costs from cargo costs, the costs per available seat or ton kilometers are obtained (Fig. 2 and Table 4).

5. Classification of capacity

There are a number of ways capacity may be defined: theoretical capacity, practical capacity, normal capacity, master-budget capacity and actual capacity (DeBruine and Sopariwala, 1994; McNair, 1994).

- Theoretical capacity is the denominator-level concept based on producing at full efficiency all the time.
- Practical capacity is the denominator-level concept that reduces theoretical capacity by unavoidable operating interruptions such as scheduled maintenance time, shutdowns for holidays, and so on.
- Normal capacity is the denominator-level concept based on the level of capacity utilization that satisfies average customer demand over a time period (2–3 years) that includes seasonal, cyclical, and trend factors.
- Master-budget capacity is the denominator-level concept based on the expected level of capacity utilization for the next budget period (typically one year).
- Actual capacity is actual usage of current production capacity.

Furthermore, many researchers emphasize using practical capacity to calculate fixed manufacturing
overhead rates, because theoretical capacity is not real and the other methods hide waste and inefficiency (Cooper and Kaplan, 1992).

### 6. Production variance, marketing variance and expected idle passenger capacity in the airline industry

To define production variance, marketing variance and expected idle passenger capacity in the airline industry, the following notation is used: $Z_i$ is the total seats of aircrafts $i$ ($i = 1, 2, \ldots, n$); $P_{ij}$ is the actual passenger load factor of aircrafts $i$ for week $j$ ($j = 1, 2, \ldots, 52$); $P'_{ij}$ is the expected passenger load factor of aircrafts $i$ for week $j$; $X_{ij}'$ is capacity flight kilometers of aircrafts $i$ for week $j$; $X_{ij}''$ actual flight kilometers of aircrafts $i$ for week $j$; $X_{ij}'''$ is expected flight kilometers of aircrafts $i$ for week $j$; ASK is available seat kilometers (i.e. actual supply passenger capacity); RPK is revenue passenger kilometers (i.e. actual sale passenger capacity); SKEPC is seat kilometers of expected sale passenger capacity; SKPC is seat kilometers of practical passenger capacity; PVPC is production variance of passenger capacity; MVPC is marketing variance of passenger capacity; EIPC is expected idle of passenger capacity. The notation allows us to make use of the following relationships:

\[
\text{EIPC} = \text{SKPC} - \text{SKEPC} = \sum_{i=1}^{n} \sum_{j=1}^{52} X_{ij}' Z_{ij} - \sum_{i=1}^{n} \sum_{j=1}^{52} X_{ij}'' Z_{ij} P'_{ij},
\]

\[
\text{MVPC} = \text{RPK} - \text{SKEPC} = \sum_{i=1}^{n} \sum_{j=1}^{52} X_{ij}' Z_{ij} P_{ij} - \sum_{i=1}^{n} \sum_{j=1}^{52} X_{ij}'' Z_{ij} P'_{ij},
\]

\[
\text{PVPC} = \text{ASK} - \text{RPK} = \sum_{i=1}^{n} \sum_{j=1}^{52} X_{ij}' Z_{ij} - \sum_{i=1}^{n} \sum_{j=1}^{52} X_{ij}' Z_{ij} P_{ij}.
\]

Take an example of ‘C Airlines’ (which for confidentiality reasons is not identified). This was founded in 1959 and its fleet had grown to include 40 Boeing and 16 Airbus aircrafts by 2002—42 passenger planes and 14 freighters. The average age of the fleet is 5.7 years. In 2002, the management of C Airlines decided to purchase new aircrafts over a 2–3 year period, including 13 747-400, two 737-800, two A340-300 and six A330. After implementing this fleet renewal and simplification plan, C Airlines will be one of the youngest fleets in this industry, rivaling those of the major international airlines. Additionally, it is expanding its routes to 50 cities in 25 countries. In 2002, total operating revenue reached NT$73,117 million, an increase of 4.6% over 2001, while total operating costs rose by 1.9% to reach NT$67,841 million.

Passenger flight capacity data of C Airlines for 2002 is taken to represent its practical capacity (Table 5). This practical passenger flight capacity includes unavoidable operating interruptions such as scheduled maintenance time. Boeing 747-400 aircrafts provided more flight hours and seat kilometers than any other type of aircraft in the fleet.

### Table 5

| Aircraft purpose | Type       | Quantity | Flight time (h) | Flight distance (km) | Seats | Seat kilometers (Thousand) |
|------------------|------------|----------|-----------------|----------------------|-------|---------------------------|
| Passenger        | Boeing 747-400 | 13       | 65,598          | 51,488,632            | 411   | 21,161,827                |
|                  | Boeing 737-800 | 13       | 42,501          | 27,393,912            | 158   | 4,328,238                 |
|                  | A300-600R     | 11       | 34,606          | 21,549,112            | 265   | 5,710,515                 |
|                  | A340-300      | 5        | 35,611          | 26,529,048            | 258   | 6,844,494                 |
| Total            |             | 42       | 178,316         | 126,960,704           | 38,045,074 |

Fig. 3. The analysis of passenger flight capacity for C Airlines in 2002. Note: ASK is available seat kilometers, RPK is revenue passenger kilometers, SKEPC is seat kilometers of expected sale passenger capacity, SKPC is seat kilometers of practical passenger capacity, PVPC is production variance of passenger capacity, MVPC is marketing variance of passenger capacity, EIPC is expected idle of passenger capacity, (+) represents ‘favorable’ and (−) represents “unfavorable”. All figures mentioned above should be multiplied by 1000 and their unit is seat kilometer.
Fig. 3 looks at the production variance, marketing variance and expected idle passenger capacity are relevant for fleet renewal and composition decisions in 2002. First, a positive production variance indicates that actual supply exceeds actual sales of flight capacity. In 2002, the actual supply and sales of passenger capacity of C Airlines was 35,671,875 and 26,806,371 seat kilometers, respectively, yielding 8,865,504 seat kilometers of idle potential passenger load, or 24.85%.

Second, a positive marketing variance indicates actual sales exceed expected sales of flight capacity. In 2002, actual and expected sales of passenger capacity of C Airlines were 26,806,371 and 26,602,179 seat kilometers, 204,192 seat kilometers meaning that marketing ability exceeded management expectations by 0.77%.

Third, negative expected idle capacity implies that expected sales are below practical capacity. The 2002 data show expected sales of 26,602,179 with a practical of 38,045,074 seat kilometers. The expected idle passenger load factor of C Airlines in 2002 was thus 30.08%.

Based on these facts it seems inappropriate for C Airlines to purchase 23 new aircrafts over the next 2–3 years.

7. Conclusions

Accurate airline costing is important in competitive markets, and the recent imposition of security measures with the concomitant additional costs, has posed additional needs for good cost accountancy practices. The paper has looked at the merits of applying ABC methods to the airline industry and, through the practical application to a carrier, shown how it may be applied.

References

Antos, J., 1992. Activity-based management for service, not-for-profit, and governmental organizations. Journal of Cost Management 6, 13–23.
Carlson, D.A., Young, S.M., 1993. Activity-based total quality management at American express. Journal of Cost Management 7, 48–58.
Chan, Y.-C., 1993. Improving hospital cost accounting with activity-based costing. Health Care Management Review 18, 71–77.
Cooper, R., 1989. You need a new cost system when…. Harvard Business Review 67, 77–82.
Cooper, R., Kaplan, R.S., 1992. Activity-based systems: measuring the costs of resource usage. Accounting Horizons 6, 1–13.
DeBruine, M., Sopariwala, P.R., 1994. The use of practical capacity for better management decision. Journal of Cost Management 8, 25–31.
Dhavale, D.G., 1993. Activity-based costing in cellular manufacturing systems. Journal of Cost Management 7, 48–58.
Harr, D.J., 1990. How activity accounting works in government. Management Accounting 72 (3), 36–40.
Johnson, H.T., Kaplan, R.S., 1987. Relevance Lost: The rise and fall of Management Accounting. Harvard Business School Press, Cambridge, MA.
McNair, C.J., 1994. The hidden costs of capacity. Journal of Cost Management 8, 12–24.
Tsai, W.-H., 1994. Product-mix decision model under activity-based costing. Proceeding of 1994 Japan–USA. Symposium on Flexible Automation, Vol. I, Institute of System, Control and Information Engineers, Kobe.
Tsai, W.-H., 1996a. A technical note on using work sampling to estimate the effort on activities under activity-based costing. Computers and Industrial Engineering 31, 725–729.
Tsai, W.-H., 1998. Quality cost measurement under activity-based costing. International Journal of Quality and Reliability Management 15, 719–752.
Turney, P.B.B., 1991. Common cents: the ABC Performance Breakthrough—How to Succeed with Activity-based Costing. Cost Technology, Hillsboro.
Zhuang, L., Burns, G., 1992. Activity-based costing in non-standard route manufacturing. International Journal of Operations and Production Management 12, 38–60.