Fleet modelling in strategic multi-criteria decision-making of approved training organization from capacity building and resource dependency theory perspective: risk taxonomy methodology

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Abstract

Purpose – In this study, research problem has been designed as a fleet-based optimization problem. This paper aims to present fleet modelling with risk taxonomy. Fleet modelling has been assumed as strategic multi-criteria decision-making problem to capacity building. Capacity building risk management is an essential element within the scope of its strategy to ensure sustainable corporate performance. Optimization is a fundamental target in aviation business' strategy and management since the manager make decisions in their multi-interrelated criteria environment. Also, aviation is a highly regulated sector, and its operational and business procedures have certain limits by both national and international authorities. For this reason, companies implement risk management for strategic optimization while performing operations in compliance with the legislation. Risk management with capacity building and resource dependency perspective applied for strategic optimization aims to capture opportunities and result in threats with minimum accidents and incidents.

Design/methodology/approach – The taxonomy and analytical hierarchy process (AHP) have been identified as methodologies in this research. The type of training in the high organizational performance of an approved training organization, strategy, resources and allocations with the corporate objectives, the amount and qualifications of the flight crew, their professionalism, maintenance team and licenses, hangar conditions and capacity, authority requirements and limits, region conditions, altitude and meteorology, student profile, together with a multi-criteria decision are to be considered. For each criterion, there are resources and thus resource dependence. In this study, the analytical network process method was used. In the construction of new taxonomy, specific criteria have been considered, and the analysis has been accomplished as multi-criteria decision-making problem because of the relationship and interaction between them. A number of professionals with high knowledge of the pilots and manager from Air Traffic Organization participated in the study.

Findings – The fleet modelling is both strategic and operational decision issue for training organizations. In this issue, there is a vital problem as which aircrafts should include fleet? Main criteria and sub-criteria are analyzed by AHP method supported by structured interview and sorted according to their priorities and the fleet qualifications consisting of the most suitable aircraft/aircraft are presented. The finding and suggestions will contribute to establish sustainable organization in based on capacity building and resource dependency for managers. While analyzing main criteria, the important criteria which were found were strategic and then operational. After ordering main criteria, sub-criteria were analyzed and were multiplicated with their items. According to study findings, aircraft suitability for training model is the most important item. It follows respectively aircraft maintenance sustainability, cost of aircraft supply and faculty budget adequacy. However, operation characteristics of the square that is less important item was found. It was seen that the strategies used to manage dependencies used the bridge strategy. The results we obtained with the interviews with pilot managers are very significant in terms of resource dependence on the subject of fleet optimization. While first criterion is operational, it continues with strategic and financial criteria. After interviews with pilot managers, it was figured out that maintenance is also very important criteria. For managing this dependency, university has acquisitions, which is one of the strategy

The current issue and full text archive of this journal is available on Emerald Insight at: **https://www.emerald.com/insight/1748-8842.htm**



Aircraft Engineering and Aerospace Technology
© Emerald Publishing Limited [ISSN 1748-8842]
[DOI 10.1108/AEAT-03-2020-0051]

Received 16 March 2020
Revised 20 April 2020
Accepted 20 April 2020

to manage dependency, rather than outsourcing. For this reason, maintenance criterion has lower importance than others. When thinking of other criteria, strategic and financial criteria have played an important role. University has tried to decrease dependency and increase sustainability.

Research limitations/implications – Aircraft selection is a strategic decision of fleet modelling in both aviation business and also training organizations via influencing their corporate performance, operational performance, capacity building and their sustainability. There are some factors that limit the criteria, as research problem has been developed for approved training organizations not airlines. For this reason, our research is limited with fleet of training organizations. Our findings and suggestions may be useful for flight schools to managing their resource dependency and also to their capacity building. In this research, new taxonomy has been developed depending on training organizations' qualifications. Airlines may improve this taxonomy to use in their decision-making process.

Practical implications – The fleets, which were established considering the taxonomy in this study, will be able to manage the risk of resource dependency more successfully. Pilot candidates will be able to provide a more ergonomic and higher quality education. This research and its findings will contribute to the development of organizations' accurate and timely decision-making skills. Resource dependency may threat organizational sustainability in our research, New taxonomy and our holistic approach will support organizational efforts to achieve sustainable strategies.

Social implications – New taxonomy to modelling fleet that has been developed in this research may provide contribution to approved training organizations for both managing resource dependency-based risks and to capacity building-related decision-making process. This research may serve organizations as strategic decision-making tool. And also this kind of study may contribute to improve sustainability of organizations and serve more good fleet for their pilot candidates. For these reasons, this research may create social implications, as both resource using and capacity building will make contribution for society and add value.

Originality/value – This research presents new risk taxonomy and criteria. Also new taxonomy and its criteria are analysed with AHP. It is thought that this research shows risk management-based approach for fleet modelling creates benefits for approved training organizations to using their limited sources effectively and efficiently. The article includes risk management and capacity building-related approach to decision-making. also, this research presents modeling which will contribute to the management field besides literature. In developing taxonomy process, the analysis has been conducted, based on expert opinions and referred to for these pairwise comparisons. Airlines managers and risk managers may examine their fleet modelling according to our taxonomy which is based on risk management.

Keywords Analytic hierarchy process, Approved training organization, Capacity building, Fleet modelling, Optimization, Management and strategy, Multi-criteria problem-solving, Resource dependency theory

Paper type Research paper

Introduction

Capacity building and resource dependency in view of decision-making is an agenda in corporate risk management and also business management. Managers make decision in daily routine. Decision-making is a routine but also a vital part of managers' responsibilities. Especially in aviation, the decision may create considerable results owing to industry-related qualifications with high operational costs. Decisions pertaining to risk management should be made both carefully and thoughtfully. To manage risk holistically and to support sustainability, managers in aviation must optimize situational awareness in their decision-making process (Yilmaz and Flouris, 2019). Airports, airlines, air navigation service providers and regulators should pursue all possible technical innovations to improve utilisation of available capacity in view of economics based approach. Collaborative decision-making is critical to this (Egeland and Smale, 2017). As stated in their book, Kucuk Yilmaz and Flouris (2019) expressed that decision making is tailored by dynamic and continually changing conditions. Changing conditions have impact on risk of organization's goals. To get optimization, decision-making should be consider with risk analysis, which is one of the fundamental part of enterprise risk management process (Yilmaz and Flouris, 2019).

Since the publication of Pfeffer and Salancik's (1978) The External Control of Organizations: A Resource Dependence Theory, RDT has become one of the most influential theories in organizational theory and strategic management. RDT characterizes the corporation as an open system, dependent on contingencies in the external environment (Pfeffer amd Salancik, 2003). RDT recognizes the influence of external factors on organizational behavior and, although constrained by their context, managers can act to reduce environmental uncertainty and dependence. Central to these actions is the concept of power, which is the control over vital resources (Üsdiken, 2007). Clearly, this review supports Pfeffer and Salancik's (1978) original assertion that firms that depend on the environment can and do enact multiple strategies to combat these contingencies. Mergers, Acquisitions and Joint Ventures (M&As)/other interorganizational relationships, boards of directors, corporate political action and executive succession are used to manage these dependencies. Empirical evidence across each of these areas validates the reciprocal effect of uncertainty and interdependence on firm action. In surveying extant research, RDT appears to be well established in terms of the general relationships between firms, their environments and the actions firms take to reduce these dependencies. Although the areas of political action and executive succession are less frequently explored, on balance we can say that RDT's underlying model is an accurate portrayal of M&As, interorganizational relationships and boards of directors. However, we share concern over relative lack of recent theoretical interest in RDT as a foundational theory because of the opportunity for further development, refinement and application. We now turn our attention to our thoughts regarding an initial future research agenda that would help move RDT forward (Hillman *et al.*, 2009, p. 1406).

The qualifications required by an aeronautical authority in European Aviation Safety Agency and Directorate General of Civil Aviation (Turkey) directives and regulations are defined

as minimum requirements for Air Traffic Organization (ATO) to continue its activities. It must meet and maintain these essential requirements. Any qualification on these limits will be a preferential decision. Because the most critical elements of its resources are its own ownership. Aircraft fleet, pilots, maintenance unit and personnel, airport and operational base sources are not subject to external dependency and even third parties are sold to these sources. Therefore, resource has a unique characteristic of producing its own resources in terms of dependency such as spare parts, component repair and fuel. This creates a serious advantage over other ATOs. Owning its own fleet, owning its own airport and owning air traffic control tower communication, navigation, surveillance/air traffic management navigation service, having its own maintenance unit, hangar and staff of type training technicians to care for all aircraft of the fleet are the sources of superiority and provide advantages in terms of resource dependency. In this determination, risk portfolio has been formed by taking into consideration the source-based risks. The sustainability of the resource's supply/supply feature was also taken into account. For example, the fact that the aircraft manufacturer only provides service in the foreign country exposes customs, quota and ambargo risks. Therefore, there is a strategic multi-criteria decision-making problem. Sensitivity analysis was also performed. It will contribute to managers as a guide in making decisions. Aviation management and optimization will contribute to the field. Future work can be done on the organization facility optimization of organizational structure. Besides the issues such as airport selection, the transaction cost and the new theoretical theory can be analyzed with the same resource dependency theory.

The fleet modelling with risk taxonomy

Pilot needs are provided by the flight schools, which are formed by the airline companies within their own structure, from private or state flight schools. Below is some information about Turkey authorized approved training organization providing education with its own aircraft and fleet structures of these organizations (Table 1).

Faculty of Aeronautical and Astronomics' ATO is one of the leader institutes in Turkey and around the globe thanks to its international airport, ATPL (A) licensing permit, sector experienced flight trainers and many more unique qualities.

Table 1 Approved training organizations in Turkey

Approved Training Organizations	No. of aircraft
Vizyon Aviation	5
Davut Flight Academy	5
Atlantic Flight Academy	20
Topair Flight Academy	8
GDH Flight Academy	8
Gaziantep University	3
Erah Academy	20
Istanbul Aviation Club	8
THK Flight Academy	26
THY Flight Academy	27
UZAYTEM	8
Eskisehir Technical University	15

With the permission to air transportation and airport management rights given to private sector provided by the Turkish Civil Aviation Law No. 2920 in 1983, significant growth has started in Turkish Civil Aviation and need of qualified operational staff has risen. Anadolu University soon took the first step towards meeting the needs and with the resources provided by Turkish Government and ICAO, Civil Aviation Vocational School was founded. In 1992, the school started four-year programs leading to B.Sc. and B.A degrees and changed its name to "Civil Aviation School". Finally, in 2012, the school was restructured as Faculty of Aeronautics and Astronautics to provide more qualified academic training meeting with international higher education standards and global aviation industry requirements. In addition, in accordance with the demands of Turkish National Police (EGM), helicopter pilots and technicians were trained between 1993 and 2005.

When we look at Faculty of Aeronautical and Astronomics' ATO Fleet Structure and Aircraft Technic Features, there are Cessna/Reims-Cessna 172/F172 Series, Beech 90 Series and Socata TB Series aircraft types in current fleet. Technical characteristics of the Cessna/Reims-Cessna 172/F172 Series Cessna 172 Skyhawk is a four-seater, single-engine, high-wing and fixed-wing aircraft made by Cessna Aircraft Company. Produced in 1955 for the first time, the most reliable aircraft in the segment of the General Aviation aircraft is accepted (THK Flight Academy, 2018). Socata TB 20 Trinidad, located in the Approved Training Organization (ATO) fleet, is a metal semi-monocoque, single-piston motor with a fixed-speed propeller and retractable landing gear designed by Daher-Socata in the late 1970s. The Beechcraft King Air family is part of a line of twin-turboprop aircraft produced by Beechcraft. The King Air line comprises a number of models that have been divided into two families; the Model 90 and 100 series are known as King Airs, while the Model 200 and 300 series were originally marketed as Super King Airs, with "Super" being dropped by Beechcraft in 1996 (Küçük Yılmaz, 2018).

Risk analysis for fleet modelling with new criteria taxonomy model

Kucuk Yılmaz (2014) studied the management strategies for resource dependency risk in aviation business. Doğan (2018) studied factors affecting airline's ground handling outsourcing decisions and the ways they manage dependency relations throughout outsourcing process, is investigated based on resource dependence and transaction cost theories through a qualitative research. However, ATO operation and sustainability is a special area that requires very costly and qualified resource use. Some of the resources are outsourcing, some of which are not-outsourcing, and the continuity of supply and performance is a matter of special concern. This issue has not been investigated previously in relation to resource dependence. However, resource dependence is the most important risk for current sustainability. In this context, it is aimed that the article contributes to this gap in the literature. In the literature, resource dependence has been associated with many management issues, but no comprehensive studies in approved training organizations have been found.

We have developed new taxonomy to evaluate aircrafts according to analytical network process benefit opportunity

cost risk mentality-based approach. There are four groups that we consider in terms of management and strategy. Therefore, it was taken into account all the related variables with system approach. System approach was effective because Estu, which is approved training organization, has maintenance unit. It is important that the fleet is suitable both for corporate sustainability and operational performance, as well as for its costs and availability. ATO could make decision about strategic, operational, maintenance and financial. Taxonomy has been designed to address all these factors.

Presented new taxonomy entitled as strategic and managerial main criteria; financial Main criteria; operational and performance criteria; and maintenance and repair criteria (SFOM). These four categories represent sustainability and resource dependency from a risk management perspective. Our developed taxonomy has four main field as following (Figure 1):

1 strategic and managerial main criteria;
2 financial criteria;
3 operational and performance criteria; and
4 maintenance and repair criteria.

Delphi may be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem (Linstone and Turoff, 2002, p. 3). All in criteria has sub-criteria. In the beginning in this research, we have researched both literature and completed interview of experienced pilot managers. In first, we have identified 109 criteria. After application of Delphi method, final criteria list is given following:

New Taxonomy for Fleet Risk criteria and sub-criteria:

1 Strategic and managerial main criteria:
   - aircraft suitability for training model (modular, integrated);
   - aircraft maintenance and operation sustainability;
   - school budget adequacy;
   - number of students to be educated;
   - similarity to existing aircraft (in terms of training and technical team licenses and authorizations); and
   - status of schools in country (important for resource sharing) but not critical.

2 Operational and performance main criteria:
   - aircraft suitability of the physical characteristics and meteorological conditions of the region;
   - stability of aircraft and endurance;
   - climbing ability and maximum height that can climb (service ceiling);
   - stall speed;
   - minimum take-off distance;
   - cockpit ergonomics;
   - aircraft strength at the time of accident;
   - license and qualification of teacher pilots; and
   - operation characteristics of the square.

3 Financial main criteria:
   - cost of aircraft supply (cost, time and financial costs);
   - spare parts supply time, location and ease (in-country and out-of-country);
   - operating and insurance costs; and
   - oil-fuel expenses.

4 Maintenance and repair main criteria:
   - compliance of flight personnel and related equipment;
   - provision of technical support;
   - maintenance and repair expenses;
   - maintenance repair facilities (hangar, workshops);
   - the degree of convenience of maintenance and repair activities; and
   - technical and service life of the aircraft.

Figure 1 New taxonomy of fleet optimization



Research methodology

In this research methodology is identified as the analytic hierarchy process (AHP). And AHP analysis has been developed as its algorithm and after its results with comments of finding. The AHP (Saaty, 1980), developed by Thomas L. Saaty in the 1970s, is one of the multi-criteria decision-making methods based on the paired comparison of criteria and alternatives in complex decision-making problems and thus frequently used in obtaining the best solution (Önder and Önder, 2015, p. 21). The main purpose of the AHS method is to contribute to the solution by considering the criteria, sub-criteria and alternatives in existing decision-making problems together (Ishizaka and Nemery, 2013, p. 13; Ömürbek and Şimşek, 2014, p. 308). The key features of the EHS method are that the decision maker can make objective or subjective evaluations and that the problem of decision-making through hierarchical structure can be dealt with in detail (Harker and Vargas, 1987, p. 1383). Although a hierarchical structure is established in the method, the elements at the same level are assumed to be independent from each other (Özdağoğlu, 2011, p. 13). AHS also offers a comprehensive framework to incorporate rational, irrational preferences and intuitions into the decision-making process (Arıkan Kargı, 2015, p. 39). The AHS method allows the use of qualitative and

quantitative factors, including one or more decision makers, allowing individual and group decisions to be made in environments of uncertainty and uncertainty. The power of the method lies in its ability to address elements that cannot be dealt with in different approaches or which are quite difficult but affect decisions (Harker and Vargas, 1987, p. 1383). The steps to be taken in the solution of decision making by AHS method can be listed as follows (Arıkan Kargı, 2015, p. 43; Özdağoğlu, 2011, pp. 15–20; Saaty, 1990):

- Establishment and formulation of hierarchical structure.
- Forming a pairwise comparison matrix and determining weights.
- Determination of relative weights of criteria and calculation of consistency ratio.

Intensity of importance is given in the Table 2.

It has been ordered with analytical network process according to importance levels of main criteria of SFOM taxonomy after sending to experts the final lists (Table 3). It is calculated with the followings formulae to pairwise comparison of main criteria (Table 4).

$CI = (\lambda \max - n)/(n - 1)$

For $\lambda \max = 4.0058$ and n=4;

$CI = (4.0058 - 4)/(4 - 1)$

$CI = 0.0019$.

Consistency ratio's formulae are given, For $n = 4$, RI= 0.9. Thus;

CR= CI/RI

CR=0.0019/0.9

CR=0.0021.

For results of analysis, because of CR $<$ 1, is consistency. As shown in Table 3, that has the most importance among taxonomy is strategic criteria. After that ordering main criteria, sub-criteria's importance level are ordered (Table 5).

For $\lambda \max = 6.0278$ and $n = 6$ $CI = (6.0278 - 6)/(6 - 1)$

$CI = 0.0055$.

Consistency ratio's formulae are given, For $n = 6$, RI = 1.25. Thus;

CR = CI/RI

CR = 0.0055/1.25

CR = 0.0044.

With analysis sub-criteria, aircraft suitability for training model is the most important criteria for choosing aircraft. Then it follows aircraft maintenance sustainability (Table 6).

For $\lambda \max = 15.6492$ and $n = 9$ $CI = (15.6492 - 9)/(9 - 1)$

$CI = 0.8311$.

Consistency ratio's formulae are given, For $n = 9$, RI = 1.45.

Thus;

CR = CI/RI

CR = 0.8311/1.45

CR = 0.5732.

For operational criteria, there is the most important criteria is aircraft suitability of the physical characteristics. Then it follows stability of aircraft and endurance and climbing ability and maximum height. Financial criteria list is given in Table 7.

Table 2 Importance scale

Intensity of importance	Definition
1	Equally important
3	Moderate importance
5	Strong importance
7	Very strong or demonstrated importance
9	Extreme importance
2,4,6,8	Intermediate values

Source: Önder and Önder (2015, p. 23)

Table 3 Results sf SFOM taxonomy

SFOM taxonomy	Level
Strategic	0.3857
Operational	0.2771
Financial	0.1961
Maintenance	0.1410

Table 4 Rassal index

Dimension (*N*)	1	2	3	4	5	6	7	8	9
Rassal index	0	0	0.58	0.90	1.12	1.25	1.32	1.41	1.45

Table 5 Sub-criteria for strategic criteria

Aircraft suitability for training model	0.305185412
Aircraft maintenance sustainability	0.23088137
School budget adequacy	0.171609941
Number of students to be educated	0.12671819
Similarity to existing aircraft	0.094075703
Status of schools in country	0.071529384

Table 6 Sub-criteria for operational criteria

Aircraft suitability of the physical characteristics	0.243661
Stability of aircraft and endurance	0.193391
Climbing ability and maximum height	0.151511
Stall speed	0.117812
Minimum take-off distance	0.091195
Cockpit ergonomics	0.070485
Aircraft strength at the time of accident	0.054654
License and qualification of teacher pilots	0.04286
Operation characteristics of the square	0.03443

Table 7 Sub-criteria for financial criteria

Cost of aircraft supply	0.385735233
Spare parts supply time, location	0.2771261
Operating and insurance costs	0.19611437
Oil-Fuel expenses	0.141024298

For λ max= 4.0058 and n = 4 CI = (4.0058 – 4)/(4 – 1)

CI = 0.0019.

Consistency ratio's formulae are given, For n = 4, RI = 0.9. Thus;

CR= CI/RI

CR = 0.0019/0.9

CR = 0.0021.

The most important financial criteria are cost of aircraft supply. Then it follows spare parts supply time and location. Maintenance criteria are given in Table 8.

For λ max = 6.0278 and n = 6 CI = (6.0278 – 6)/(6 – 1)

CI = 0.0055.

Consistency ratio's formulae are given, For n = 4, RI = 0.9. Thus;

CR = CI/RI

CR = 0.0055/1.25

CR = 0.0044.

For all results of analysis, because of CR < 1, is consistency. With all analysis, there are formed ordered all sub criteria according to their importance level in Table 9.

With analyzing main criteria, the important criteria were found strategic and then operational. After ordering main criteria, sub criteria were analyzed and were multiplicated with their items. According to study findings, aircraft suitability for training model is the most important item. It follows respectively aircraft maintenance sustainability, cost of aircraft supply, and faculty budget adequacy. However, operation characteristics of the square that is less important item was found. It was seen that the strategies were used to manage dependencies using the bridge strategy. University within its own maintenance unit that is most importance factor reduces its dependence.

Findings, conclusion and discussion

The study's results and findings present that the decision-making on fleet modelling has a vital part for ATO for both effective using of resources and also corporate sustainability for growth. Also, the quality of flight training is directly related with the fleet of the organizations. Therefore, approved training organizations and airlines should invest for both the fleet planning, risk analysis, modelling and capacity building issues.

Table 8 Sub-criteria for maintenance criteria

Compliance of flight personnel and related equipment	0.305185412
Provision of technical support	0.23088137
Maintenance and repair expenses	0.171609941
Maintenance repair facilities	0.12671819
The degree of convenience of maintenance and repair activities	0.094075703
Technical and service life of the aircraft	0.071529384

Table 9 Order of all sub-criteria according to their importance level

1	Total
0.11772	Aircraft suitability for training model
0.08906	Aircraft maintenance sustainability
0.07565	Cost of aircraft supply
0.06620	School budget adequacy
0.05435	Spare parts supply time, location
0.04888	Number of students to be educated
0.04779	Aircraft suitability of the physical characteristics
0.04304	Compliance of flight personnel and related equipment
0.03846	Operating and insurance costs
0.03793	Stability of aircraft and endurance
0.03629	Similarity to existing aircraft
0.03256	Provision of technical support
0.02971	Climbing ability and maximum height
0.02766	Oil-fuel expenses
0.02759	Status of schools in country
0.02420	Maintenance and repair expenses
0.02310	Stall speed
0.01788	Minimum take-off distance
0.01787	Maintenance repair facilities
0.01382	Cockpit ergonomics
0.01327	The degree of convenience of maintenance and repair activities
0.01072	Aircraft strength at the time of accident
0.01009	Technical and service life of the aircraft
0.00841	License and qualification of teacher pilots
0.00675	Operation characteristics of the square

The results we obtained with the interviews with pilot managers are very significant in terms of resource dependence on the subject of fleet optimization. While first criteria is operational, it continues with strategic and financial criteria. After interviews with pilot managers, it figured out that maintenance is also very important criteria. For managing this dependency, university has acquisitions, which is one of the strategy to manage dependency, rather than outsourcing. For this reason, maintenance criteria is lower importance than others. When thinking of other criteria, strategic and financial criteria have played important role. University has tried to decrease dependency and increase sustainability. This study may contribute in both social implications and economic implications beside practical implications for manager. Resource management is very costly and critic in aviation. Resource dependency risk is high in aviation. So, fleet modelling will support decision-making process in approved training organizations. The capacity building and resource dependency-based perspective, the option of renting instead of buying aircraft was also considered as a strategic option. It has been concluded that the cost of renting a new airplane and the cost of renting a new airplane and the cost of renting two aircraft for a period of 12 months are approximately the same. The production of the Tb 20 aircraft in the fleet has stopped.

For Tb20 airplanes has problem to service-based issues. There is no regular flow of sub parts. Tb20 aircrafts have higher the age of the aircraft beside the lower the service life. The most essential requirement of a sustainable flight school is the good fleet structure. This study will provide significant contribution to optimization.

Future works

Future works may be extend of this research via including other parameters of ATO such as airport and airline facilities, role of aircraft maintenance organization (AMO)-based modelling to optimization resources of AMO. Also, our presented taxonomy may easily be tailored to airlines. And airline managers may develop their taxonomy then they may get advantages in their decision-making process.

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