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A digital transformation maturity model for the airline industry with a self-assessment tool

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ABSTRACT

The technological habitat in which successful firms may flourish is in rapid change. With digital transformation (DT), everything is connected and interdependent. Manual processes are now automated for most businesses. As a result, habits, and needs are changing, which, in turn, affects the conventional way firms offer their goods and services. Airlines are eager to participate in the trend as well. Those who adapt quickly to this new world will gain a greater share of the pie. However, most airlines have bulky and rigid systems designed based on the industry's strict rules and regulations. Thus, the transformation process required to adapt to the new era of digitalization is not a simple task. Several interrelated factors, such as strategy, organization, customer, technology, operations, ecosystem, and innovation, have to be redefined to conceptualize a valid and functioning business framework. On the other hand, connectivity and accessibility are the game's name from the passengers' perspective. Acknowledging the necessities of the new era, the aim of this study is two-fold: (i) to highlight the essence of DT by examining the role of DT's sub-dimensions in the civil airline industry, (ii) and propose a Digital Transformation Maturity (DTM) self-assessment tool for determining the DT maturity level of airline firms. The former is assessed by the judgments of aviation experts using Interval Type-2 Fuzzy AHP (IT2F-AHP), while the second stage was done with a survey in an airline company. According to the results, the digital strategy and the technology are highlighted as the most prominent dimensions of the proposed DTM tool. DTM evaluation of the selected airline reveals that the company is on the right path, with an overall score of 62 in its DT journey. However, some clear improvement opportunities are visible.

Contents

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1. Introduction

The pandemic has had an enormous impact on the airline industry, affecting air passengers and cargo. We all observed that the aviation sector has almost operationally stopped during these times. Many companies work remotely with technology infrastructure, and it is seen that office work can be done without significant loss of efficiency. In the aviation sector, contactless technologies during the check-in process and AI applications were some of the immediate responses that emerged in the sector. However, it is doubtless that many reflections of the pandemic on the aviation industry are still unknown and will be observed in the long term. Hence, company executives monitoring the DTM level will make the situation visible and make it easier to manage the transformation.

In the airline industry, DT can be defined as a process that refers to all efforts aiming to change the flow of operations and decision-making mechanisms, especially those directly linked with airline passenger experience, using digital technologies and accordingly harmonizing internal processes. The process of digital transformation in the airline industry is unprecedented. As a result, airline companies are being forced to innovate new offerings for their customers to stay in business. In the airline industry, digital transformation programs could generate an additional $5-$10 per passenger annually [1]. Considering data-intensive services offered by the aviation industry, DT provides the following values added for an airline company:

- Airlines can easily access personal customer data and offer tailor-made products to the customer.
- Airline executives can understand how they should communicate with the customer by examining the data and extending the customer's lifetime value with the airline.
- By keeping customer support one-to-one, airlines can stay in touch with the customer during and after the trip.
- Crisis management can be done more easily thanks to increased communication between organizational units.
- With insightful business analytics, trends can be forecasted, the crisis can be prevented, and new channels can be opened.

We recognize that different industries encounter different challenges while adopting their conventional business processes, strategies, and models to the digital era. This is something that the airline industry is not immune to. In this research, we examine the effect of the wave of digital transformation in the airline industry by aiming to answer two different but related questions: first, what are the dimensions of DT within the airline industry, and second, how can the level of DTM of an airline and its compliance with these dimensions be measured.

With the motivation stated above, this paper proposes a three-stage methodology that also proves the study's merit. First, research is initiated based on nine hypothetical dimensions to measure the maturity of Digital Transformation (DT), which are selected based on a literature review. Secondly, due to the subjective nature of the criteria selection process, we asked experts both in DT and airline sectors about the relative importance of dimensions concerning DTM. We employed the Interval Type-2 Fuzzy Analytical Hierarchy (IT2F-AHP). Lastly, In the light of the results, the DTM Self-Assessment Tool consisting of questions from each of the nine dimensions is developed and proposed as a tool to measure the DT maturity of an airline company. We obtain a DTM tool for practitioners and managers by reducing dimensions with factor analysis. The proposed tool is then applied to an airline company to measure the DTM of the company. From this point of view, the proposed model can be used by airlines as a self-assessment tool. Thus, it can be determined by the company which DT dimensions should be focused on and which should be improved.

The rest of this work is arranged as follows: Section 2 provides the literature review and methodology, where the methodological details of the study are elaborated. Then, in Section 3, the data and the research findings are presented, while Section 4 gives insights into the case study on evaluating the DTM of the airline company along with its managerial implications. Lastly, Section 5 concludes the research.

2. Literature review and methodology

2.1. Related studies on DT in aviation

There is a lot of confusion on the definition of DT. In recognition of this deficiency in the literature, Gong and Ribiere [2] rigorously reviewed 134 published definitions of DT. Their paper defined DT as "A fundamental change process, enabled by the innovative use of digital technologies accompanied by the strategic leverage of key resources and capabilities, aiming to radically improve an entity and redefine its value proposition for its stakeholders." In earlier works, Verdino [3] argued that "DT closes the gap between what digital customers already expect and what analog businesses actually deliver". According to Saldanha [4], real DT can be defined as considering the needs of the people, operations, and systems to be the winner of the next "Industrial Revolution". Another attempt to define DT focuses on synchronizing technology, business models, and processes to create new value for customers and employees in a constantly changing digital economy [5]. In a nutshell, DT has fundamentally changed the expectations and behaviors of consumers and led to a lot of pressure on traditional firms and many disruptions in numerous markets [6]

A relatively small body of literature looks at the trend in digital transformation in the airline industry. This industry is nevertheless among those with the greatest need for a shift in how business is carried out. Low-profit margins and high costs (fuel and personnel) are some of the biggest challenges that call for a swift adoption of digital tools to improve efficiency for better margins. Competitive pressure, improvement in technological competencies, and e-business know-how have pushed the industry towards more digital transformation [7]. Recently, the outbreak of the Covid-19 has further proven the need for organizations to transform digitally. Kronblad and Envall Pregmark [8] argued that the pandemic has enduring effects on business models, and organizations' transformations will remain for the future. According to Silling [9], the adoption of digital solutions has the power to resolve previously unresolved problems. This is argued to be a channel to create new revenue streams and cost-cutting techniques through better customer and staff experience. Such initiatives, he pointed out, have been seen in the form of innovation labs of major airlines such as EasyJet, Ryanair, Lufthansa, etc. Evidence of the need for digitalization in the airline industry was provided by Nurhadi et al. [10] in their study of the Indonesian aviation industry. Their research showed a general dissatisfaction of travelers with the wi-fi facilities in Indonesian airports irrespective of the frequency of travel. Furthermore, they concluded that digitalized facilities generally positively impact the customer's experience.

DT in the aviation industry accompanies the generation of bulky data. As a result, big data and machine learning are making this industry's waves. To this end, Gui et al. [11] studied the use of big data and machine learning to predict flight delays. Similar to this study was done by Lampathaki' et al. [12], who conclude that the design and implementation of the ICARUS data platform in Europe will enable data sharing in a fair manner in an end-to-end secured way. In Jordan, Abu-Dalbouh [13] outlined the importance of innovative management tools and strategies in making Jordan a regional center for aviation and aviation education.

Aviation in this digital era, commonly known as aviation 4.0, is expected to be a safer world where data and technology provide solutions to human fear. Arnaldo et al. [14] argued that cyber–physical systems can be used as vital tools in assisting humans in decision-making and dangerous situations that may arise. In their paper, automation was proposed as a tool for safety purposes in the aviation industry. Moreover, the Covid-19 pandemic has ignited our awareness of the need for a world where the human touch is minimal. When effectively integrated into the aviation industry, current technologies can provide solutions such as self-check in service, e-bag for baggage handling, biometric auto-check in immigration and facial recognitions, self-gate check for electronic tickets, etc. [15]. In both of their studies, Büyüközkan et al. [16,17] found variables related to digital technologies to be ranked among the highest criteria for success in aviation 4.0.

As mentioned in the above studies, the waves of DT have pushed the aviation industry to a new normality. Similar to industry 4.0, aviation 4.0 will be dominated by airlines and airports that are up-to-speed with DT projects that had, are, and will happen within the aviation industry. In light of these studies, Lobschat et al. [18] called for organizations to inculcate corporate digital responsibilities (CDR) in their broader organizational culture for actionable guidelines to address ethical concerns that are increasingly arising from digital technologies that come with DT. Management commitment must also be present for a successful DT [19]. However, it is essential to note that reskilling is a major hindrance for many organizations. The existing gap between the available skills and the required skills needs to be closed even though it has been proven to be a challenge [20]

2.2. Methodology

Our adopted methodology followed a three-stage approach; the first is the determination of nine dimensions to measure digital transformation maturity (DTM). These dimensions are obtained from an extensive search of the literature on DT. Secondly, we used IT2F-AHP method to determine the significance of the given dimensions. This step in our research involved the opinion of experts in both DT and the airlines for their perceived importance of the determined dimensions. At this step, IT2F sets are utilized to evaluate the subjective judgments of the experts on the relative importance of the dimensions obtained with a literature review. In the third and final stage, we use factor analysis to reduce our dimensions and thus obtain a DTM tool for practitioners and managers. This proposed tool is then applied to an airline company to measure its DTM. In operationalizing these dimensions, we adopt the DTM Self-Assessment Tool developed by Rogers [21]. Fig. 1 is a step-by-step depiction of our proposed methodology.

2.3. Dimensions of DT

DT involves a bunch of interrelated concepts of disruptive technologies that fundamentally affect organizational behavior. There is no former shopping behavior, and competition has changed a lot. The value that is offered to the customer has changed. In this study, we inspire mainly from two resources which are the most relevant studies for DT. According to Rogers [21], there are five domains in DT; customer, competition, data, innovation, and value. According to Valdez-de Leon [22], however, there are seven dimensions defining DT; strategy, organization, customer, technology, operation, ecosystem, and innovation as seen in Table 1. Comparing these two approaches, it is seen that they overlap in certain dimensions, customer and innovation, whereas they disagree on the majority of dimensions. Our study combines both approaches and assumes that both models are valid and represent different angles of reality while elaborating DT. Hence, the relevant dimensions used in our work are customer, competition, data, innovation, value, organization, digital ecosystem, technology, and strategy. A deep dive examination of these nine dimensions will be held in the following sections.

2.4. Interval type-2 Fuzzy sets

IT2F sets are a derivative of type-1 fuzzy sets. They are proposed to accommodate the high level of uncertainty linked with ambiguous verbal expressions of individual judgments [23]. We present some fundamental definitions of IT2F sets in this section based on the work by Chen and Lee [24]:

Table 1
Dimensions of DT.

Dimensions	References	
Customer	Rogers [21]	Valdez-de Leon [22]
Competition	Rogers [21]	
Data	Rogers [21]	
Innovation	Rogers [21]	Valdez-de Leon [22]
Value	Rogers [21]	
Organization		Valdez-de Leon [22]
Digital Ecosystem		Valdez-de Leon [22]
Technology		Valdez-de Leon [22]
Strategy		Valdez-de Leon [22]

Definition 1. A type 2 fuzzy set, $\tilde{\tilde{A}}$, is given by a type-2 membership function, $\mu_{\tilde{\tilde{A}}}$, and defined in the universe of discourse X as:

$$\tilde{\tilde{A}} = \left\{ \left((x,u), \mu_{\tilde{\tilde{A}}}(x,u) \right) | \forall x \in X, \forall u \in J_x \subseteq [0,1], 0 \leq \mu_{\tilde{\tilde{A}}}(x,u) \leq 1 \right\}$$

Alternatively, $\tilde{\tilde{A}}$ can be denoted as:

$$\tilde{\tilde{A}} = \iint_{x \in X, u \in J_x} \mu_{\tilde{\tilde{A}}}(x,u)/(x,u)$$

$J_x \subseteq [0,1]$ and $\iint$ is union over all admissible x and u.

Definition 2. For any $\tilde{\tilde{A}}$, if all $\mu_{\tilde{\tilde{A}}}(x,u) = 1$, then $\tilde{\tilde{A}}$ is called an IT2F set where

$$\tilde{\tilde{A}} = \iint_{x \in X, u \in J_x}^{1} /(x,u), \ J_x \subseteq [0,1].$$

Definition 3. An IT2F consists of two membership functions, the upper and the lower, which are type-1 membership functions (see Fig. 2). Accordingly, trapezoidal IT2F set, $\tilde{\tilde{A}}_i$, is denoted as;

$$\tilde{\tilde{A}}_i = \left(\tilde{A}_i^U, \tilde{A}_i^L\right) = \left(a_{i1}^U, a_{i2}^U, a_{i3}^U, a_{i4}^U; H_1\left(\tilde{A}_i^U\right), H_2\left(\tilde{A}_i^U\right)\right), \left(a_{i1}^L, a_{i2}^L, a_{i3}^L, a_{i4}^L; H_1\left(\tilde{A}_i^L\right), H_2\left(\tilde{A}_i^L\right)\right)$$

where $H_j\left(\tilde{A}_i^U\right)$ denotes the membership value of the element $a_{i(j+1)}^U$ in the upper trapezoidal membership function, $\tilde{A}_i^U, 1 \leq j \leq 2$, whereas $H_j\left(\tilde{A}_i^L\right)$ denotes the membership value of the element $a_{i(j+1)}^L$ in the lower trapezoidal membership function $\tilde{A}_i^L, 1 \leq j \leq 2, H_1\left(\tilde{A}_i^U\right) \in [0,1], H_2\left(\tilde{A}_i^U\right) \in [0,1], H_1\left(\tilde{A}_i^L\right) \in [0,1], H_2\left(\tilde{A}_i^L\right) \in [0,1]$ and $1 \leq i \leq n$.

Definition 4. Given $\tilde{\tilde{A}}_1$ and $\tilde{\tilde{A}}_2$ as

$$\tilde{\tilde{A}}_1 = \left(\tilde{A}_1^U, \tilde{A}_1^L\right) = \left(a_{11}^U, a_{12}^U, a_{13}^U, a_{14}^U; H_1\left(\tilde{A}_1^U\right), H_2\left(\tilde{A}_1^U\right)\right), \left(a_{11}^L, a_{12}^L, a_{13}^L, a_{14}^L; H_1\left(\tilde{A}_1^L\right), H_2\left(\tilde{A}_1^L\right)\right)$$

$$\tilde{\tilde{A}}_2 = \left(\tilde{A}_2^U, \tilde{A}_2^L\right) = \left(a_{21}^U, a_{22}^U, a_{23}^U, a_{24}^U; H_1\left(\tilde{A}_2^U\right), H_2\left(\tilde{A}_2^U\right)\right), \left(a_{21}^L, a_{22}^L, a_{23}^L, a_{24}^L; H_1\left(\tilde{A}_2^L\right), H_2\left(\tilde{A}_2^L\right)\right)$$

The basic four arithmetic operations, addition, subtraction, multiplication, and division, between two IT2F sets are defined as follows:

$$\begin{aligned}
&\tilde{\tilde{A}}_1 \bigoplus \tilde{\tilde{A}}_2 = \left(\tilde{A}_1^U, \tilde{A}_1^L\right) \bigoplus \left(\tilde{A}_2^U, \tilde{A}_2^L\right) \\
&= [a_{11}^U + a_{21}^U, a_{12}^U + a_{22}^U, a_{13}^U + a_{23}^U, a_{14}^U + a_{24}^U; \\
&\min\left(H_1\left(\tilde{A}_1^U\right), H_1\left(\tilde{A}_2^U\right)\right), \min\left(H_2\left(\tilde{A}_1^U\right), H_2\left(\tilde{A}_2^U\right)\right)], \\
&[a_{11}^L + a_{21}^L, a_{12}^L + a_{22}^L, a_{13}^L + a_{23}^L, a_{14}^L + a_{24}^L; \\
&\min\left(H_1\left(\tilde{A}_1^L\right), H_1\left(\tilde{A}_2^L\right)\right), \min\left(H_2\left(\tilde{A}_1^L\right), H_2\left(\tilde{A}_2^L\right)\right)]
\end{aligned} \quad (1)$$

$$\begin{aligned}
&\tilde{\tilde{A}}_1 \ominus \tilde{\tilde{A}}_2 = \left(\tilde{A}_1^U, \tilde{A}_1^L\right) \ominus \left(\tilde{A}_2^U, \tilde{A}_2^L\right) \\
&= [a_{11}^U - a_{21}^U, a_{12}^U - a_{22}^U, a_{13}^U - a_{23}^U, a_{14}^U - a_{24}^U; \\
&\min\left(H_1\left(\tilde{A}_1^U\right), H_1\left(\tilde{A}_2^U\right)\right), \min\left(H_2\left(\tilde{A}_1^U\right), H_2\left(\tilde{A}_2^U\right)\right)], \\
&[a_{11}^L - a_{21}^L, a_{12}^L - a_{22}^L, a_{13}^L - a_{23}^L, a_{14}^L - a_{24}^L; \\
&\min\left(H_1\left(\tilde{A}_1^L\right), H_1\left(\tilde{A}_2^L\right)\right), \min\left(H_2\left(\tilde{A}_1^L\right), H_2\left(\tilde{A}_2^L\right)\right)]
\end{aligned} \quad (2)$$

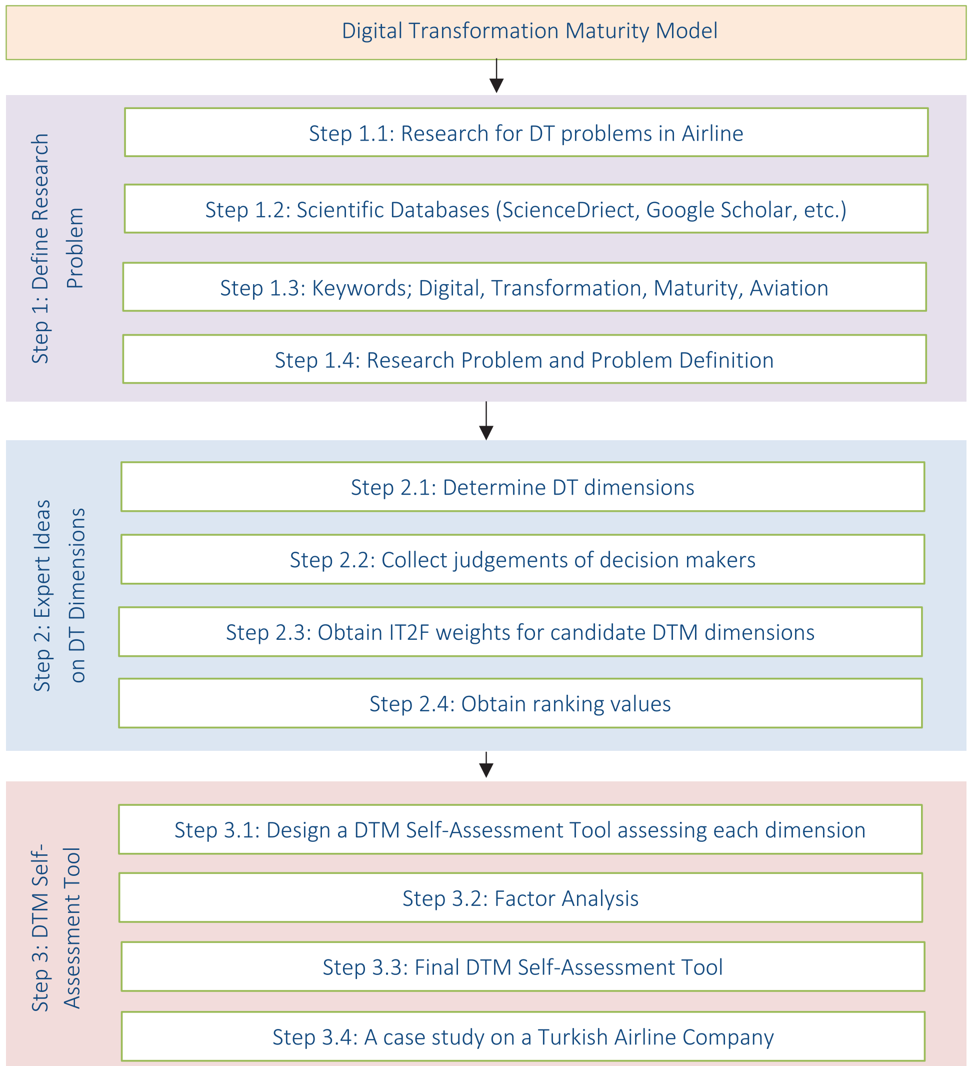


Fig. 1. Main steps of the proposed methodology.

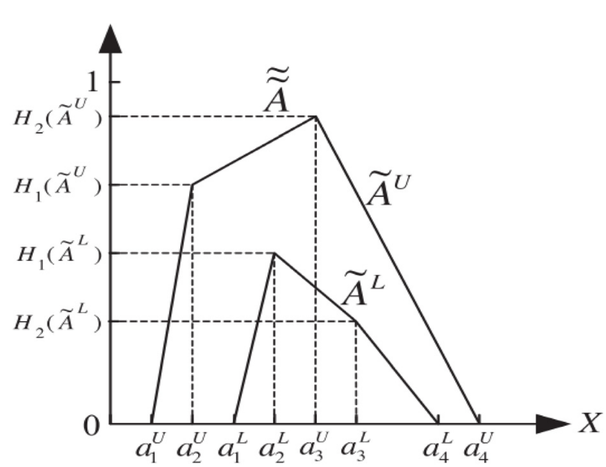


Fig. 2. Trapezoidal membership functions, $\tilde{A}_i^U$(upper) and $\tilde{A}_i^L$(lower), of a IT2F set, $\tilde{\tilde{A}}_i$.

$$\tilde{\tilde{A}}_1 \bigotimes \tilde{\tilde{A}}_2 = (\tilde{A}_1^U, \tilde{A}_1^L) \bigotimes (\tilde{A}_2^U, \tilde{A}_2^L) = [a_{11}^U \times a_{21}^U, a_{12}^U \times a_{22}^U, a_{13}^U \times a_{23}^U, a_{14}^U \times a_{24}^U; \min\left(H_1\left(\tilde{A}_1^U\right), H_1\left(\tilde{A}_2^U\right)\right), \min\left(H_2\left(\tilde{A}_1^U\right), H_2\left(\tilde{A}_2^U\right)\right)], [a_{11}^L \times a_{21}^L, a_{12}^L \times a_{22}^L, a_{13}^L \times a_{23}^L, a_{14}^L \times a_{24}^L; \min\left(H_1\left(\tilde{A}_1^L\right), H_1\left(\tilde{A}_2^L\right)\right), \min\left(H_2\left(\tilde{A}_1^L\right), H_2\left(\tilde{A}_2^L\right)\right)] \tag{3}$$

$$\frac{\tilde{\tilde{A}}_1}{\tilde{\tilde{A}}_2} = [\frac{a_{11}^U}{a_{24}^U}, \frac{a_{12}^U}{a_{23}^U}, \frac{a_{13}^U}{a_{22}^U}, \frac{a_{14}^U}{a_{21}^U}; \min\left(H_1\left(\tilde{A}_1^U\right), H_1\left(\tilde{A}_2^U\right)\right), \min\left(H_2\left(\tilde{A}_1^U\right), H_2\left(\tilde{A}_2^U\right)\right)], [\frac{a_{11}^L}{a_{24}^L}, \frac{a_{12}^L}{a_{23}^L}, \frac{a_{13}^L}{a_{22}^L}, \frac{a_{14}^L}{a_{21}^L}; \min\left(H_1\left(\tilde{A}_1^L\right), H_1\left(\tilde{A}_2^L\right)\right), \min\left(H_2\left(\tilde{A}_1^L\right), H_2\left(\tilde{A}_2^L\right)\right)] \tag{4}$$

Definition 5. The arithmetic operations between a scalar, k, and a trapezoidal IT2F set, $\tilde{\tilde{A}}_1$, are as follows:

$$k\tilde{\tilde{A}}_1 = \left(k \times a_{11}^U, k \times a_{12}^U, k \times a_{13}^U, k \times a_{14}^U; H_1\left(\tilde{A}_1^U\right), H_2\left(\tilde{A}_1^U\right)\right), [k \times a_{11}^L, k \times a_{12}^L, k \times a_{13}^L, k \times a_{14}^L; H_1\left(\tilde{A}_1^L\right), H_2\left(\tilde{A}_1^L\right)]$$
$$\frac{\tilde{\tilde{A}}_1}{k} = \left(a_{11}^U/k, a_{12}^U/k, a_{13}^U/k, a_{14}^U/k; H_1\left(\tilde{A}_1^U\right), H_2\left(\tilde{A}_1^U\right)\right), \left(a_{11}^L/k, a_{12}^L/k, a_{13}^L/k, a_{14}^L/k; H_1\left(\tilde{A}_1^L\right), H_2\left(\tilde{A}_1^L\right)\right) \tag{5}$$

Definition 6. The ranking value, Rank $\left(\tilde{\tilde{A}}_i\right)$, of $\tilde{\tilde{A}}_i$ is given as follows [25]:

$$Rank\left(\tilde{\tilde{A}}_i\right) = M_1\left(\tilde{A}_i^U\right) + M_1\left(\tilde{A}_i^L\right) + M_2\left(\tilde{A}_i^U\right) + M_2\left(\tilde{A}_i^L\right) + M_3\left(\tilde{A}_i^U\right) + M_3\left(\tilde{A}_i^L\right) - \frac{1}{4}\left(S_1\left(\tilde{A}_i^U\right) + S_1\left(\tilde{A}_i^L\right) + S_2\left(\tilde{A}_i^U\right) + S_2\left(\tilde{A}_i^L\right) + S_3\left(\tilde{A}_i^U\right) + S_3\left(\tilde{A}_i^L\right) + S_4\left(\tilde{A}_i^U\right) + S_4\left(\tilde{A}_i^L\right)\right) + H_1\left(\tilde{A}_i^U\right) + H_1\left(\tilde{A}_i^L\right) + H_2\left(\tilde{A}_i^U\right) + H_2\left(\tilde{A}_i^L\right) \tag{6}$$

where $M_p\left(\tilde{A}_i^j\right)$ is the average and defined as $M_p\left(\tilde{A}_i^j\right) = \frac{\left(a_{ip}^j + a_{i(p+1)}^j\right)}{2}$, $1 \le p \le 3$, whereas the standard deviation of the elements a_{ip}^j and $a_{i(p+1)}^j$, $S_p\left(\tilde{A}_i^j\right) = \sqrt{\frac{1}{2}\sum_{k=q}^{q+1}\left(a_{ik}^j - \frac{1}{2}\sum_{k=q}^{q+1} a_{ik}^j\right)^2}$, $1 \le q \le 3$, denotes the standard deviations of $a_{i1}^j, a_{i2}^j, a_{i3}^j, a_{i4}^j$, $S_4\left(\tilde{A}_i^j\right) = \sqrt{\frac{1}{4}\sum_{k=1}^{4}\left(a_{ik}^j - \frac{1}{4}\sum_{k=1}^{4} a_{ik}^j\right)^2}$ $H_p\left(\tilde{A}_i^j\right)$, which signifies the membership value of the element $a_{i(p+1)}^j$ in the trapezoidal membership function $\tilde{A}_i^j$, $1 \le p \le 3$, $j \in \{U, L\}$, and $1 \le i \le n$.

Definition 7. The reciprocal of $\tilde{\tilde{A}}$ is calculated as:

$$1/\tilde{\tilde{A}} = \begin{bmatrix} \left(\frac{1}{a_4^U}, \frac{1}{a_3^U}, \frac{1}{a_2^U}, \frac{1}{a_1^U}; \quad H_1^U(\text{A}), H_2^U(\text{A})\right) \\ \left(\frac{1}{a_4^L}, \frac{1}{a_3^L}, \frac{1}{a_2^L}, \frac{1}{a_1^L}; \quad H_1^L(\text{A}), H_2^L(\text{A})\right) \end{bmatrix} \tag{7}$$

Definition 8. For any $\tilde{\tilde{A}}$, $\sqrt[m]{\tilde{\tilde{A}}}$ is defined as:

$$\sqrt[m]{\tilde{\tilde{A}}} = \begin{pmatrix} \left(\sqrt[m]{a_1^U}, \sqrt[m]{a_2^U}, \sqrt[m]{a_3^U}, \sqrt[m]{a_4^U}; H_1^U(\text{A}), H_2^U(\text{A})\right), \\ \left(\sqrt[m]{a_1^L}, \sqrt[m]{a_2^L}, \sqrt[m]{a_3^L}, \sqrt[m]{a_4^L}; H_1^L(\text{A}), H_2^L(\text{A})\right) \end{pmatrix}. \tag{8}$$

2.5. Interval type-2 Fuzzy AHP

AHP is a frequently used multi-criteria decision-making method (MCMD) [26]. The method is based on the idea that the experts determine the criteria weights and the scores of the alternatives by paired comparisons. However, since MCMD problems have subjectivity in their nature, it is difficult for deterministic forms of AHP to deal with such decision-making problems [27,28]. IT2F-AHP is a new systematical MCDM method used for different decision-making situations which require concentrated personal judgments under fuzziness. A recent IT2F-AHP model by Kahraman et al. [29,30] is the bedrock of our study. In this study, IT2F-AHP is utilized to make an order of a set of dimensions used for measuring the relative importance of different dimensions concerning DT. More precisely, the main focus is determining the importance of n possible criteria evaluated subjectively by m decision-makers.

The major steps of IT2F-AHP are as follows:

Step 1. Identify the problem and form a hierarchy of the problem.

Step 2. Construct m fuzzy pairwise comparison matrices, $\tilde{\tilde{\boldsymbol{A}}}^{\boldsymbol{k}}$, where $k = 1, \dots, m$. $\tilde{\tilde{\boldsymbol{A}}}^{\boldsymbol{k}}$ is a nxn matrix of trapezoidal IT2F sets.

$$\tilde{\tilde{\boldsymbol{A}}}^{\boldsymbol{k}} = \begin{bmatrix} 1 & \tilde{\tilde{a}}_{12}^k & \dots & \tilde{\tilde{a}}_{1n}^k \\ \tilde{\tilde{a}}_{21}^k & 1 & \dots & \tilde{\tilde{a}}_{2n}^k \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{\tilde{a}}_{n1}^k & \tilde{\tilde{a}}_{n2}^k & \dots & 1 \end{bmatrix} \tag{9}$$

where $\tilde{\tilde{a}}_{ji}$ is reciprocal of $\tilde{\tilde{a}}_{ij}$, which is calculated with Eq. (7). Here, $\tilde{\tilde{a}}_{ij}^k$ represents the IT2F pairwise comparison between criteria i and j made by kth decision-maker.

Step 3. Evaluate the fuzzy pairwise comparison matrices' consistency. To be able to do this, the fuzzy reciprocal matrices are defuzzified. After that, consistency is examined.

Step 4. Geometric mean is calculated to aggregate the comparisons of m decision-makers, $\tilde{\tilde{\boldsymbol{r}}}_{\boldsymbol{ij}}$, with Eqs. (3) and (8).

$$\tilde{\tilde{\boldsymbol{r}}}_{\boldsymbol{ij}} = \left[\tilde{\tilde{a}}_{ij}^1 \dots \bigotimes \tilde{\tilde{a}}_{ij}^k \bigotimes \dots \bigotimes \tilde{\tilde{a}}_{ij}^m\right]^{1/m} \tag{10}$$

Step 5. To estimate the fuzzy weights of each criterion, the geometric mean of each row, $\tilde{\tilde{r}}_i$, is calculated using Eq. (11). Likewise, the fuzzy priorities are computed by the normalization of each row. Accordingly, $\tilde{\tilde{w}}_i$, the fuzzy weight of the ith criterion, is calculated with Eq. (11):

$$\tilde{\tilde{w}}_i = \tilde{\tilde{r}}_i \bigotimes \left[\tilde{\tilde{r}}_1 \bigoplus \dots \bigoplus \tilde{\tilde{r}}_i \bigoplus \dots \bigoplus \tilde{\tilde{r}}_n\right]^{-1} \tag{11}$$

Step 6. Calculate the ranking value, $Rank(\tilde{\tilde{w}}_i)$, of the T2F weights using Eq. (6). The ranking scores, R_i, of the alternatives are:

$$R_i = \text{Rank}(\tilde{\tilde{w}}_i) \tag{12}$$

3. Data and findings

3.1. Results of IT2F AHP

To evaluate the DTM of an airline company, firstly, the comprised dimensions must be determined. These dimensions were obtained based on the literature review. The nine candidate dimensions of the DT are outlined in Fig. 3.

To create the IT2F comparison matrices, the opinion of six experts who are actively involved in DT projects in aviation was collected through an interview. Table 2 provides the linguistic terms and their corresponding trapezoidal IT2F sets (reciprocal values are calculated with Eq. (7)).

Next, we aimed to remove inconsistencies by using a check-and-revise approach. Subsequent to the procedure described in Section 2.5, the final consistency check reveals that the experts are consistent during the pairwise comparison process.

Eq. (11) is then used to build aggregated comparison matrices. Consequently, the aggregated fuzzy matrices are normalized via Equation (12). Final T2F weights are given in Table 3 below.

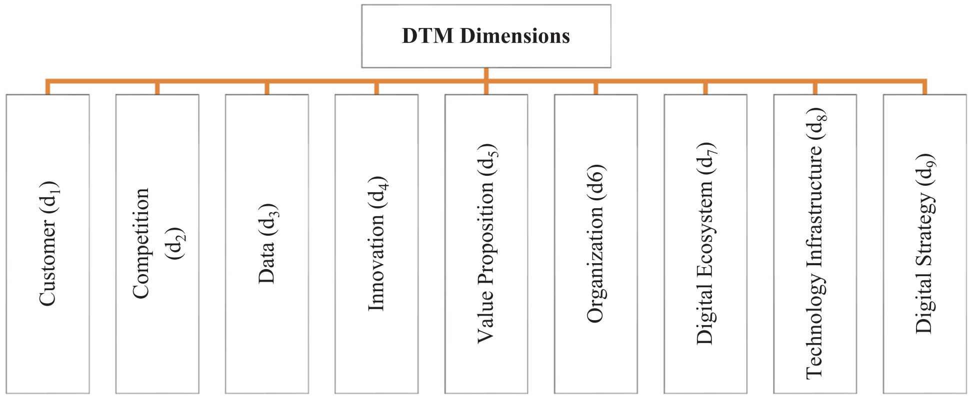


Fig. 3. Proposed DTM dimensions used for IT2F-AHP.

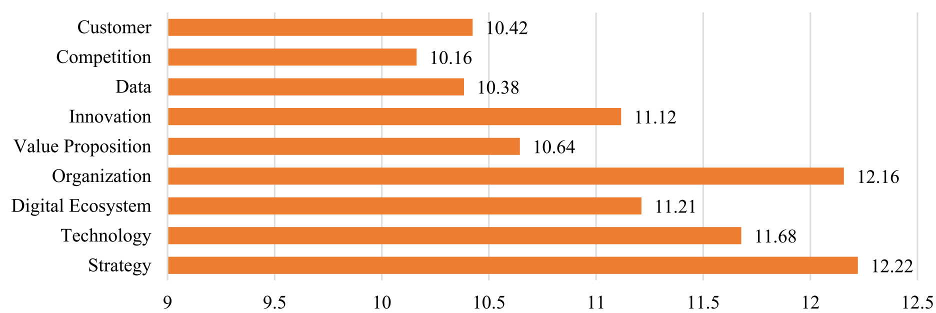


Fig. 4. Normalized ranking scores of nine candidate dimensions.

Table 2
Linguistic expressions and their IT2F sets.

Linguistic term	Trapezoidal interval type-2 fuzzy sets
AS:Absolutely strong	$\tilde{\tilde{AS}}$ = ((7, 8, 9, 9; 1, 1), (7.2, 8.2, 8.8, 9; 0.8, 0.8))
VS:Very strong	$\tilde{\tilde{VS}}$ = ((5, 6, 8, 9; 1, 1), (5.2, 6.2, 7.8, 8.8; 0.8, 0.8))
FS:Fairly strong	$\tilde{\tilde{FS}}$ = ((3, 4, 6, 7; 1, 1), (3.2, 4.2, 5.8, 6.8; 0.8, 0.8))
SS:Slightly strong	$\tilde{\tilde{SS}}$ = ((1, 2, 4, 5; 1, 1), (1.2, 2.2, 3.8, 4.8; 0.8, 0.8))
E:Exactly equal	$\tilde{E}$ = ((1, 1, 1, 1; 1, 1), (1, 1, 1, 1; 1, 1))
1/SS:Slightly weak	$1/\tilde{\tilde{SS}}$ = ((0.200, 0.250, 0.500, 1; 1, 1), (0.208, 0.263, 0.454, 0.833; 0.8, 0.8))
1/FS:Fairly weak	$1/\tilde{\tilde{FS}}$ = ((0.143, 0.167, 0.250, 0.333; 1, 1), (0.147, 0.172, 0.238, 0.312; 0.8, 0.8))
1/VS:Very weak	$1/\tilde{\tilde{VS}}$ = ((0.111, 0.125, 0.167, 0.200; 1, 1), (0.114, 0.128, 0.161, 0.192; 0.8, 0.8))
1/AS:Absolutely weak	$1/\tilde{\tilde{AS}}$ = ((0.111, 0.111, 0.125, 0.143; 1, 1), (0.111, 0.114, 0.122, 0.139; 0.8, 0.8))

Table 3
Averaged IT2F weights of dimensions.

Dimensions	IT2F Weights											
Customer	(0.033,	0.048,	0,091,	0.139,	1,	1)	(0.036,	0.051,	0.085,	0.126,	0.8,	0.8)
Competition	(0.023,	0.033,	0.069,	0.113,	1,	1)	(0.025,	0.036,	0.063,	0.100,	0.8,	0.8)
Data	(0.028,	0.042,	0.090,	0.155,	1,	1)	(0.031,	0.045,	0.083,	0.136,	0.8,	0.8)
Innovation	(0.045,	0.073,	0.164,	0.273,	1,	1)	(0.050,	0.079,	0.150,	0.242,	0.8,	0.8)
Value Proposition	(0.035,	0.054,	0.116,	0.189,	1,	1)	(0.039,	0.059,	0.107,	0.169,	0.8,	0.8)
Organization	(0.080,	0.127,	0.261,	0.390,	1,	1)	(0.089,	0.138,	0.243,	0.356,	0.8,	0.8)
Digital Ecosystem	(0.051,	0.081,	0.171,	0.268,	1,	1)	(0.057,	0.088,	0.158,	0.242,	0.8,	0.8)
Technology	(0.064,	0.103,	0.216,	0.335,	1,	1)	(0.071,	0.111,	0.200,	0.303,	0.8,	0.8)
Strategy	(0.085,	0.132,	0.265,	0.391,	1,	1)	(0.094,	0.142,	0.247,	0.359,	1,	1)

Finally, IT2F weights found in Table 3 are used for each dimension to get a crisp ranking score R_i. Fig. 4 shows the obtained ranking scores of dimensions.

The normalized preference scores of the dimensions suggest that the scores are very close to each other. For example, strategy, organization, and technology dimensions are the most important ones for the evaluation of DTM. This is not surprising because they are three dimensions extensively discussed in various papers [22,31,32] as the core dimensions of DTM. On the other hand, competition, data, and customer are the least important ones. However, none of the dimensions are distinguishably most or least vital as they all have a preference score close to each other. So, all of the nine dimensions are kept for further evaluation while designing DTM Self-Assessment Tool.

To evaluate the sensitivity of the rankings on the selected method, we employed Intuitionistic Fuzzy AHP (IF-AHP) [33,34], as an alternative ranking method. IF-AHP stresses the values in both extremes; the small values became slightly smaller while the largest ones became slightly more significant on the scale. However, the new ranking scores

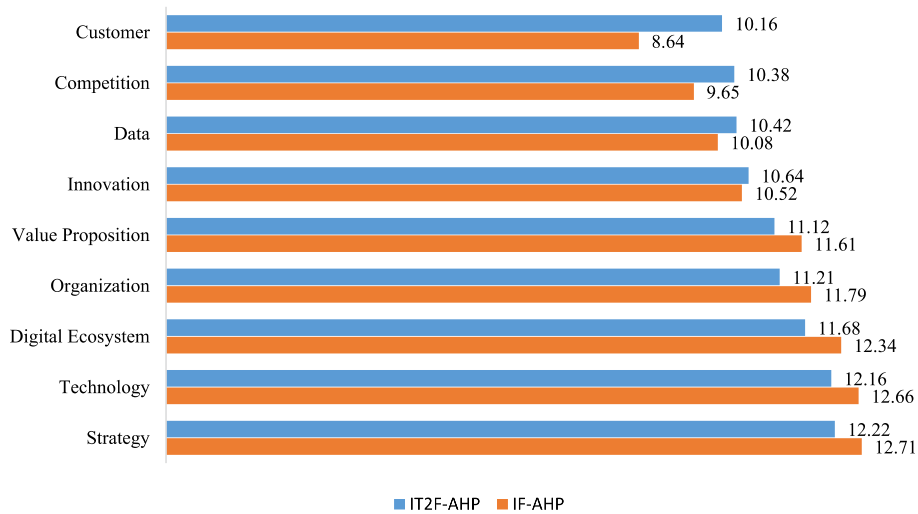


Fig. 5. Comparisons of normalized ranking scores with IT2F-AHP and IF-AHP.

Table 4
KMO and Bartlett's Test.

KMO Measure of Sampling Adequacy		0,818
Bartlett's Test of Sphericity	Approx. Chi-Square	709,485
	Df	171
	Sig.	0.000

confirm the initial scores obtained with IT2F-AHP (See Fig. 5). Accordingly, we can conclude that the results are not sensitive to the method used.

3.2. DTM self-assessment survey data

The survey comprised of three questions for each dimension and 27 in total which are shown in Table A.1. The Likert scale of 1–5 is used, where one represents the least important and five is the most important. Our sample comprised 62 respondents from a Turkish aviation firm, actively involved in DT-related operations. Subsequently, exploratory factor analysis was used to reduce the variables by grouping them under factors.

Both our KMO and Bartlett's test of sphericity showed satisfactory results, with KMO being greater than 0.8 (0.818) and Bartlett's test of sphericity being statistically significant (0.000). These findings are shown in Table 4.

Furthermore, the pattern matrix from the factor analysis produced four factors consisting of 19 variables (questions) after the deletion of eight variables with very low loadings (< 0,4). The output of the factor analysis is represented in Table 5.

Table 5
Pattern matrix of DTM self-assessment tool and obtained factors.

	Component			
	1	2	3	4
Innovation Q10	.762			
Value Proposition Q14	.683			
Organization Q16	.930			
Organization Q17	.834			
Organization Q18	.735			
Technology Infrastructure Q22	.573			
Technology Infrastructure Q23	.589			
Technology Infrastructure Q24	.627			
Digital Strategy Q25	.737			
Digital Ecosystem Q19		.785		
Digital Ecosystem Q20		.812		
Digital Ecosystem Q21		.620		
Data Q7			.852	
Data Q8			.560	
Data Q9			.760	
Digital Strategy Q27			.479	
Customer Q2				.846
Competition Q4				.724
Competition Q5				.601

Based on the content (what they represent) of the variables under each factor, factors 1, 2, 3, and 4 were labeled as "Organization and Technology", "Digital Ecosystem", "Data and Metrics", and "Competition and Marketing" respectively.

4. A model for evaluating the DTM of an airline company

This section suggests a model to measure the DTM level of airline firms designed based on four dimensions obtained in the previous section. This research used a similar classification approach that Odio [35] suggested for software delivery evolution. The study proposed a five-stage evaluation model ranging from "snail", the slowest software delivery, to "rocket", the fastest software delivery evolution. Similarly, our model evaluates the DTM based on the four dimensions with 19 questions where a five-point scale is used to assess the reached maturity of the firm at each item. After the evaluation, the firm's position on a five-phase maturity evolution scale will be determined, where the "Snail"-phase ($DTM_{score} \leq 19$) represents a case that the firm operates in a legacy perspective, does not have any intention to go digital while "Rocket"-phase indicates a high level of DTM on which a new business ecosystem is established. The proposed DTM-phases and their indications are listed in Fig. 6.

5. A case study on an airline company

The proposed DTM Self-Assessment Tool is applied on a Turkish airline firm which is evaluated by the DT experts of the firm. Fig. 7 depicts the average scores on four dimensions.

The figure shows that the company received nearly the same score in each of the four dimensions with slight differences. More precisely, the respondents evaluated the company's DTM in the "Data and Metrics" dimension as slightly higher when compared to other dimensions, whereas the "Organization and Technology Investments" dimension seemed to be assessed as the weakest one. In the following subsections, each dimension is analyzed.

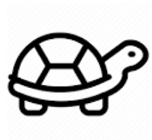
Phase 1	**Phase 2**	**Phase 3**	**Phase 4**	**Phase 5**
Score <= 19	Score <=38	Score <=57	Score <=76	Score <=95
 Snail	Turtle 	Rabbit 	Car 	Rocket 
The organization operates from a legacy perspective and does not intend to go digital. The firm does not see DT as a necessity.	Digital is a blurred area. They make some plans for going digital. However, none of them have gone to live.	The organization is conducting intentional experiments on going digital. Results are at a promising and capable level. Agents of change search for the support of managers for new technologies and resources.	A dedicated DT team is formed. The new team infrastructure takes shape as roles, models, and processes to support the DT, which is solidified.	Digital is the new way of doing business. A new ecosystem is established. Digital is in every aspect of the business.

Fig. 6. The proposed DTM-phases and their indications.

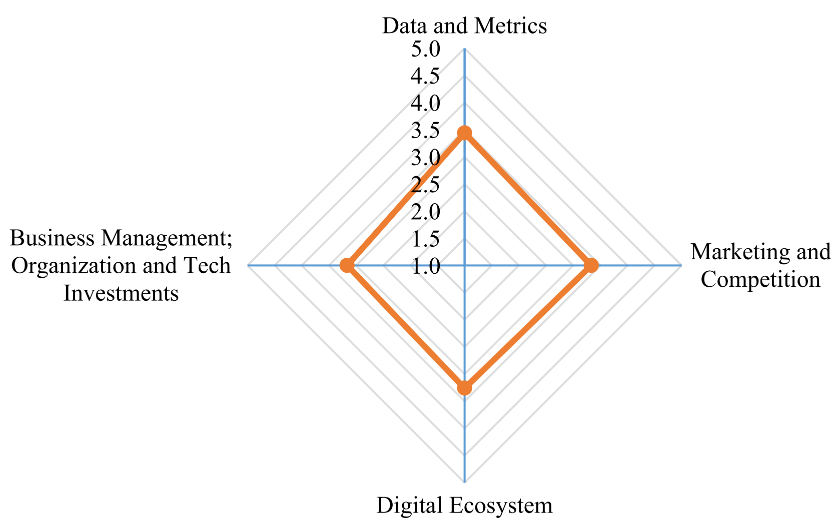


Fig. 7. Overall scores obtained by the firm on four dimensions.

Organization and Technology The average score of each sub-item under "Organization and Technology" is given in Fig. 8. The highest score is allocated to the statement "We evaluate new technologies based on the additional value we can create for our customers" (3.56), and the lowest is given to "We make our decisions with extensive participation and by conducting experiments and testing" (2.81). These two scores indicate that the organization is customer-centric and the decisions are shaped around the customer desires and are hierarchical in nature; most probably, the decisions are made according to the senior managers' insights and experience, respectively.

Digital Ecosystem: The highest score in this factor is attributed to the statement, "We have a large number of digital solution partners who support us in developing our services". (3.53) (see Fig. 9). On the other hand, the lowest score (3.03) is given to the statement, "We are working on product development with partners from at least three different industries". Considering the given scores, we observe that the company has operationalized an adequate vertical network of digital partners with similar activity fields. However, on the other hand, the firm needs to establish a sufficiently wide network of partners in the horizontal plane.

Data and Metrics: Three out of the four items under this factor are data-related. Respondents attached the highest average score within this dimension (3.64) to the statement, "Our data strategy is focused on how to turn data into more value for our customers"., as depicted in

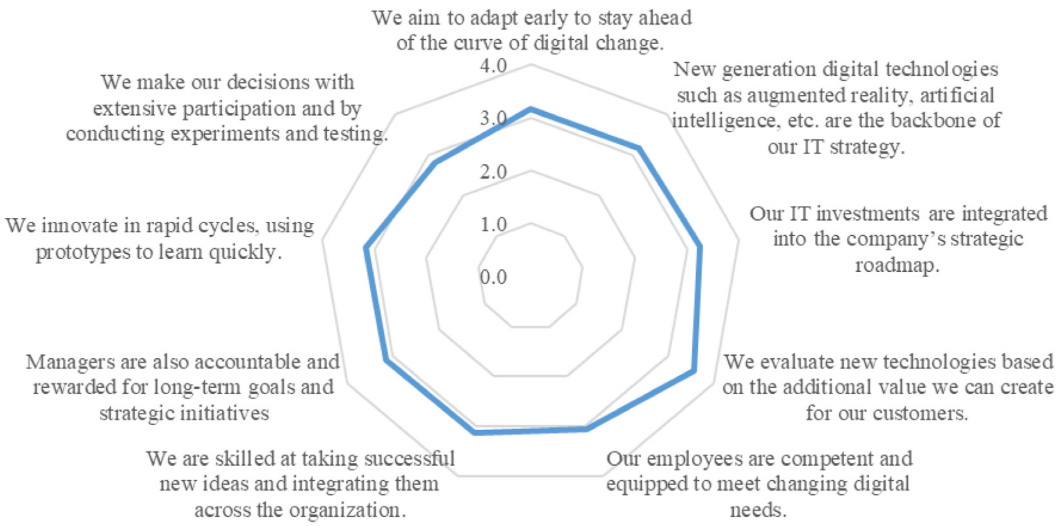


Fig. 8. Average scores obtained by the firm on the "Organization and Technology" dimension.

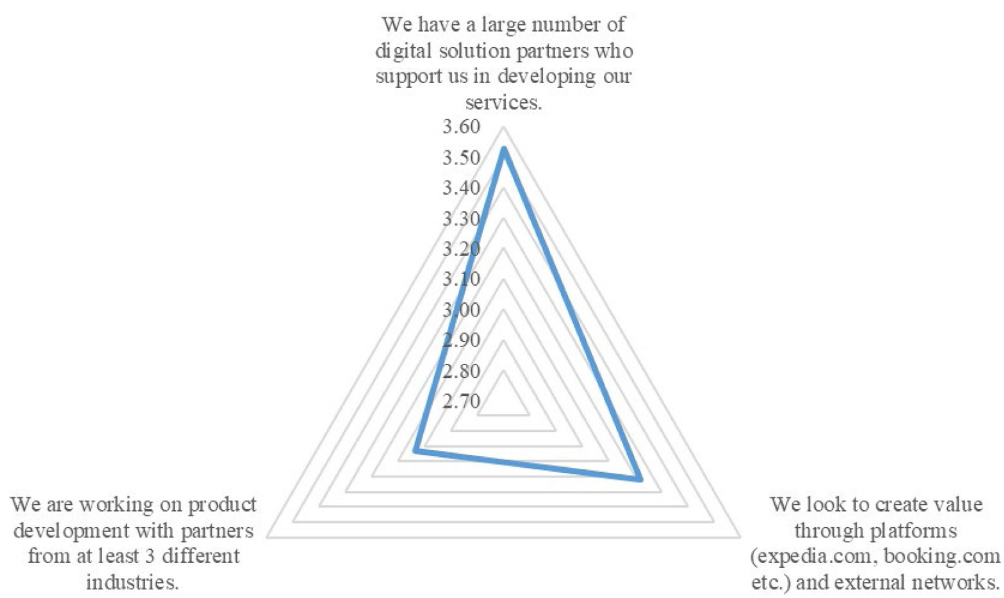


Fig. 9. Average scores obtained by the firm on "Digital Ecosystem" dimension.

Fig. 10. On the other hand, the lowest score of this dimension (3.19) is given to the DTM item, "Our business metrics are in line with strategic objectives, adaptable, and reflects the maturity of a business line". Accordingly, the firm needs to establish a system of business metrics that support the firm's strategic objectives.

Competition and Marketing: Under this dimension, the respondents assigned the highest score (3.61) to the statement "We use marketing to attract, engage, inspire, and collaborate with customers". Whereas the lowest score of this dimension (3.05) was allocated to the statement "We view our competition as broader than our current industry" (see Fig. 11).

5.1. Managerial insights

This section aims to provide some clues to the managers based on the study's findings. The proposed DTM Self-Assessment Tool offers IT managers an expeditious tool to evaluate the DTM of airline firms. The proposed model evaluates maturity level in DT based on four dimensions.

The average score allocated by 59 respondents to the considered airline firm is 62 out of 95. According to the model proposed in Fig. 6, the company is in the fourth phase, called "Car". According to the description, "A dedicated DT team is formed. The new team infrastructure takes shape as roles, models, and processes to support the DT, which is solidified". For a fast track of DT, the company should establish a dedicated team for DT and roles should be shared accordingly. Upper management starting from the CEO level should adequately support the DT strategy. Newly hired employees should be selected required skills for DT, and training should support current employees to increase the DT capacity of the firm.

A closer look at the case study results reveals additional insights into the company's maturity level. Highly appreciated items of the DTM tool by the managers shows that;

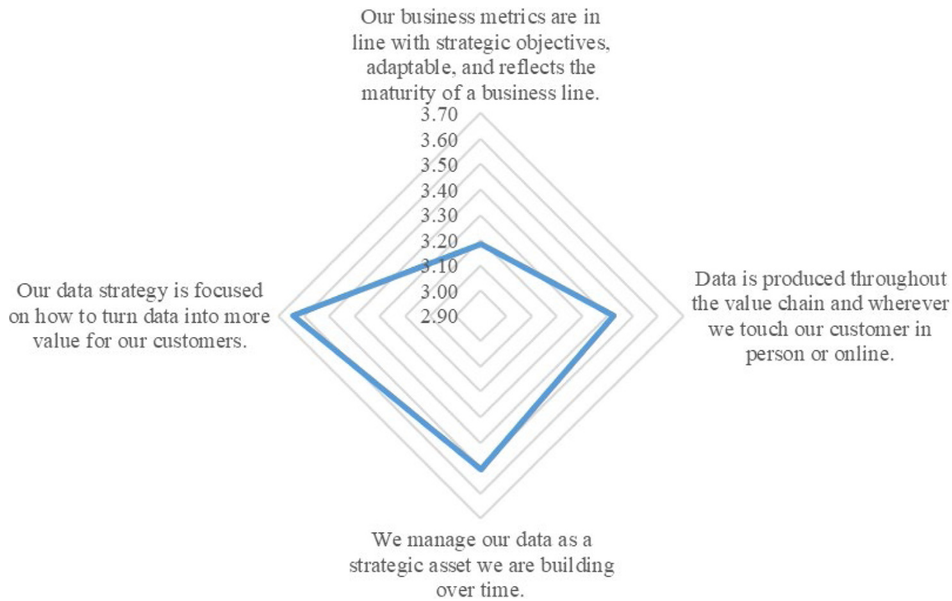


Fig. 10. Average scores obtained by the firm on the "Data and Metrics" dimension.

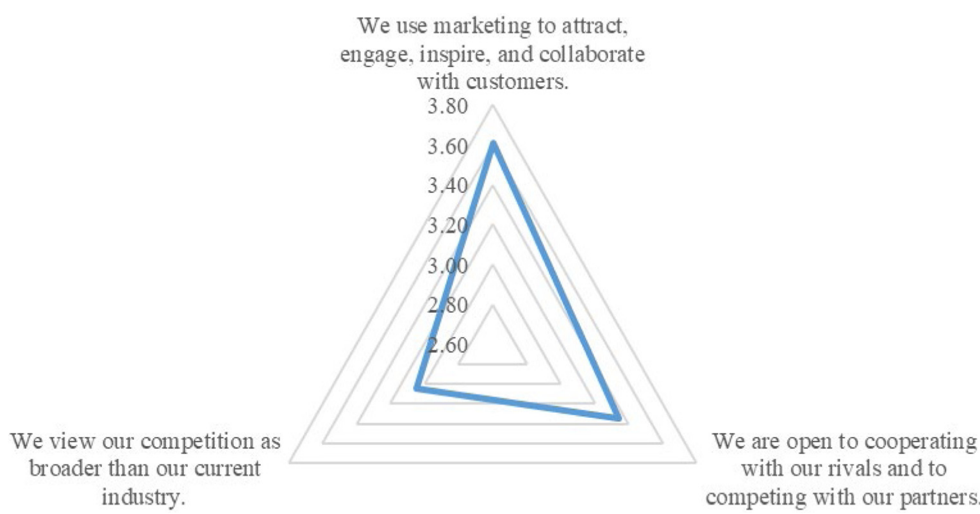


Fig. 11. Average scores obtained by the firm on the "Competition and Marketing" dimension.

- The company's strategy is mainly concentrated on turning data into more value for the clients.
- New technologies are evaluated based on the additional value that company can create for customers.
- Marketing is used to attract new customers and engage and collaborate with them while causing inspiration.
- Lastly, the company has a large number of digital solution partners that support developing the services.

The DTM tool applied to the company also indicates some weaknesses concerning the digital practices that the company employs. These can be listed as;

- The company is primarily focused on its own industry and direct competitors. However, DT requires a broader strategic perspective.
- The decisions are made at the top and cascaded to others as instructions which may reduce the effectiveness of the proposed DT projects.
- The key performance metrics relate only to sustaining the existing businesses. However, digital technologies are naturally interrelated with innovations and new business ideas.

These results show us that the DTM of the company is strong on the customer side, and the firm works hard to answer customers' digital-oriented demands. However, it should also focus on outside of the industry because the threat can be from outside the industry. Furthermore, the company should see the issue of competition from a broader perspective than the industry infers. Lastly, decisions related to DT should be made with extensive participation as DT projects require strong diffusion rates in the entire hierarchical levels of the company so that they will be successfully implemented.

Focusing on innovation can be the answer to the weak sides. Obviously, companies should focus on innovations to compete with their competitors in a digital world [36]. Innovations can also be the answer to the threats coming from outside of the industry. To boost innovation, "Design Thinking" is a very handy method that was also recently adopted by the company. The company's top management expects to observe the mid- and long-term effects of the newly initialized DT projects.

6. Conclusion

DT has recently become a major milestone of an inevitable shift in many sectors. While some industries adapt quickly to this, some have slower progress. Especially with the Covid-19 Pandemic period, we observed that the growth of DT is a mandatory process pulling companies in even involuntarily. Obviously, it is not an easy task to realize DT so that it will boost the business and increase the experience of customers. To make a success story from DT experience, there are many factors such as the technology infrastructure investments, senior management support, skilled/trained employees, readiness of the sector, and many others. Companies that are able to catch up with these factors are leaders in their industries, while those that fall short are destined to lose their past glories.

Accordingly, this work aimed to elaborate on the dimensions of DTM of airline firms. Based on the literature review, nine candidate dimensions were determined. By collecting subjective judgments of the DT practitioners and experts, the relevance of the candidate dimensions is evaluated while assessing the DTM of firms in the airline sector. This stage also provides the weights of the nine dimensions. The conducted explanatory factor analysis resulted in four significant dimensions, which provided us a basis to develop a DTM tool for the evaluation of maturity levels of airline firms. The four dimensions we extracted are Organization and Technology, Digital Ecosystem, Data and Metrics, and Competition and Marketing.

The DTM Self-Assessment Tool is an expeditious survey for airline companies to be able to examine the DT roadmap based on the dimensions mentioned above. Furthermore, it offers an evaluation model which consists of five stages from Snail to Rocket, so that companies can determine their position in the DT journey. Finally, the proposed tool was applied to a Turkish airline firm by collecting responses from the company's middle- and high-level managers. The results show that the company is on the correct path to becoming a mature applier of digital technologies to transform its existing operations and can be labeled as "Car" in the snail to rocket scale with a score of 62.

DT will shape the future for sure. When starting this study COVID-19 pandemic was not in the picture. However, everyone appreciates the critical role digital technologies play in this process while we conclude the study. Airlines are bound with DT much more tightly during the course of the pandemic. AI-enabled bots and fever detection technologies will be used widely in aviation. In future work, we may focus on how the pandemic will shape the appetite of airline firms for implementing DT.

In this research, we provide an insider perspective on the DTM of the chosen airline company. The people on active duties in digital processes within the company were intentionally selected as the field requires unique expertise. Namely, the respondents were expected to be well-aware of the company's digital transformation journey. Alternatively, the DTM tool could also be evaluated by external respondents. However, this could only measure their personal perceptions and be far from the company's internal reality. Nevertheless, measuring the DTM perception of external parties may be a promising future research direction that may reveal valuable findings on the DTM of a company.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

See Fig. A.1 and Table A.1.

Table A.1
DTM Self-Assessment Tool Questions.

Dimension	#	DEF1						DEF2
Customer	1	We are focused on selling to and interacting with customers through the usual channels.	1	2	3	4	5	We are focused on our customers' changing digital habits and path to purchase.
Customer	2	We use marketing to target, reach, and persuade customers.	1	2	3	4	5	We use marketing to attract, engage, inspire, and collaborate with customers.
Customer	3	Our brand and reputation are what we communicate to our customers.	1	2	3	4	5	Our customers' advocacy is the biggest influence on our brand and reputation.
Competition	4	Our sole competitive focus is beating our rivals.	1	2	3	4	5	We are open to cooperating with our rivals and to competing with our partners.
Competition	5	We are focused primarily on our own industry and on direct competitors.	1	2	3	4	5	We view our competition as broader than our current industry.
Competition	6	As soon as we offer the lowest ticket price, we can be the leader.	1	2	3	4	5	Our leadership in the airline industry determines how much we differentiate our business from our competitors and the value we generate for our passengers.
Data	7	Our data strategy is focused on how to create, store, and manage our data.	1	2	3	4	5	Our data strategy is focused on how to turn data into more value for our customers.
Data	8	We use our data to manage day-to-day operations.	1	2	3	4	5	We manage our data as a strategic asset we are building over time.
Data	9	Our data is generated during our day-to-day operations.	1	2	3	4	5	Data is produced throughout the value chain and wherever we touch our customer in person or online.
Innovation	10	Our innovation projects always go over time or over budget.	1	2	3	4	5	We innovate in rapid cycles, using prototypes to learn quickly.

(*continued on next page*)

Table A.1 (*continued*).

Dimension	#	DEF1						DEF2
Innovation	11	We try to avoid failure in new ventures at all costs.	1	2	3	4	5	We accept failure in new ventures but look to reduce cost and increase learning.
Innovation	12	Our major initiatives are mostly aimed at operational needs.	1	2	3	4	5	In addition to the operational projects, we also produce R&D projects.
Value Proposition	13	The most important value we offer to our passengers are our flight safety, cabin services and service quality in all classes of flight experience.	1	2	3	4	5	Additionally, we are pioneers in providing new experiences to our passengers using technologies like augmented reality and artificial intelligence, and expanding our service areas
Value Proposition	14	We are focused on executing and optimizing our current business model.	1	2	3	4	5	We aim to adapt early to stay ahead of the curve of digital change.
Value Proposition	15	Our first priority is maximizing shareholder return.	1	2	3	4	5	Our first priority is creating value for customers.
Organization	16	Managers are accountable and rewarded for immediate results on short-term objectives.	1	2	3	4	5	Managers are also accountable and rewarded for long-term goals and strategic initiatives
Organization	17	The sharing of best practices across our organization is slow and inconsistent.	1	2	3	4	5	We are skilled at taking successful new ideas and integrating them across the organization.
Organization	18	We are not fast to recruit employees who can meet the needs of the digital age.	1	2	3	4	5	Our employees are competent and equipped to meet changing digital needs.
Digital Ecosystem	19	Our value proposition is defined by our products and our industry.	1	2	3	4	5	We look to create value through platforms (expedia.com, booking.com etc.) and external networks.
Digital Ecosystem	20	We develop services we offer to our passengers in-house.	1	2	3	4	5	We have a large number of digital solution partners who support us in developing our services.
Digital Ecosystem	21	We are solely focused on our own industry.	1	2	3	4	5	We are working on product development with partners from at least 3 different industries.
Technology Infrastructure	22	We evaluate new technologies on how they affect our business.	1	2	3	4	5	We evaluate new technologies based on the additional value we can create for our customers.
Technology Infrastructure	23	Our IT investments are seen as operational.	1	2	3	4	5	Our IT investments are integrated into the company's strategic roadmap.
Technology Infrastructure	24	The technologies we use are considered old in the industry.	1	2	3	4	5	New generation digital technologies such as augmented reality, artificial intelligence, etc. are the backbone of our IT strategy.
Digital Strategy	25	The decisions are made at the top and cascaded to us as instructions.	1	2	3	4	5	We make our decisions with extensive participation and by conducting experiments and testing.
Digital Strategy	26	It is hard to allocate resources away from existing lines of business.	1	2	3	4	5	We are able to invest in new ventures even if they compete with our current business.
Digital Strategy	27	Our key performance metrics relate only to sustaining our existing businesses.	1	2	3	4	5	Our business metrics are in line with strategic objectives, adaptable, and reflects the maturity of a business line.

How to enter data?

This study aims to evaluate the relevance of various factors on Digital Transformation Maturity (DTM) in civil aviation sector. To this end, we use a multicriteria decision making method, Interval Type-2 Fuzzy AHP. Please rate the relative importance of different attributes with respect to Digital Transformation Maturity based on your subjective judgement using the scale below.

For Example: Assume you evaluate the relative importance of "Customer" in comparison to "Competition". If your subjective judgment goes as "Customer" is "fairly important" in comparison to "Competition" while assessing the Digital Transformation Maturity of an aviation firm, then you need to input the key "FS (fairly strong importance)" in cell "C5".

Please only fill the "light blue" colored region in the matrix.

We extend our gratitude for your kind support to this study.

	1	2	3	4	5	6	7	8	9
Pairwise Comparison matrix	Customer	Competition	Data	Innovation	Value Proposition	Organization	Digital Ecosystem	Technology	Strategy
Customer	E	E	E	E	E	E	E	E	E
Competition		E	1/SS	1/SS	1/SS	FS	FS	FS	FS
Data			E	1/SS	SS	FS	FS	FS	FS
Innovation				E	SS	FS	FS	E	FS
Value Proposition					E	FS	FS	E	FS
Organization						E	E	E	FS
Digital Ecosystem							E	E	FS
Technology								E	FS
Strategy									E

Scale To be Used	
Absolutely Strong	AS
Very Strong	VS
Fairly Strong	FS
Slightly Strong	SS
Exactly Equal	E
Slightly Weak	SW
Fairly Weak	FW
Very Weak	VW
Absolutely Weak	AW

Fig. A.1. A sample data collected for pairwise comparisons of DTM dimensions for IT2F-AHP.

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