

Sustainable Development and Its Impact on the Competitive Advantage of Sana'a Flight Information Region

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ABSTRACT

With the growth in air traffic and the accompanying increase in fuel consumption and carbon emissions, international demands are increasing on the civil aviation sector to comply with sustainable development (SD) requirements. Accordingly, the purpose of this study was to explore whether meeting these requirements contributes to enhancing competitive advantage by analyzing the relationship between compliance with SD requirements and the attractiveness of navigation services provided by the Sana'a flight information region (FIR). A quantitative approach was employed through a questionnaire distributed to 98 employees in the Air Navigation Sector of the Civil Aviation and Meteorology Authority (CAMA). The research concluded that there is an impact of meeting international requirements for SD on the competitive advantage of Sana'a FIR. The research recommended the need to focus on achieving the environmental, economic, and social dimensions of the international requirements for SD, in addition to implementing continuous training and qualification programs for employees of CAMA to enhance their ability to understand and meet international standards for SD. Also, the a need to improve the technological infrastructure and develop smart navigation systems, as well as improve the speed of emergency response and the attractiveness to airlines.

Keywords: Flight operations; Management; Air traffic controllers; Environmental impact; Economic impact; Air traffic control.

INTRODUCTION

Organizations' commitment to sustainable development (SD) is a fundamental pillar for enhancing their competitive advantage and ensuring their long-term sustainability. Through it, the organization can build a positive image that enhances its position in the market, gains the trust of society and stakeholders, and opens new horizons for growth and innovation, through which it can adapt to economic changes and keep pace with global developments. Therefore, the SD is not just a moral obligation or an organizational burden, but rather an important opportunity to enhance institutional excellence and consolidate the success of organizations (Nejati *et al.* 2010). In the same context, Alagele *et al.* (2024) believe that SD plays a fundamental role in enhancing the competitive advantage of higher education and scientific research institutions, and confirm the existence of a close relationship between SD and competitive advantage, as SD positively affects the competitiveness of these institutions.

Sustainable development plays a vital role in enhancing the competitive advantage of many sectors, including the aviation sector, which is one of the sectors most in need of adapting to the requirements of SD in its various environmental, economic, and social aspects. Enhancing the competitiveness of aviation institutions is a key factor in ensuring their sustainable growth,

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especially in light of the many challenges facing the aviation sector in our current era, such as climate change, increased passenger traffic, and the ongoing need to enhance safety (Karpun and Yakovenko 2024).

Within the framework of the relationship between SD and competitive advantage, a study conducted by Lim (2022) revealed a positive relationship between environmental and economic sustainability performance and competitive advantage, while social sustainability performance did not have a direct impact on competitive advantage. However, social sustainability had a positive relationship with the competitive advantage of ports through the mediating effects of environmental and economic sustainability performance.

The United Nations has presented the 2030 Agenda for Sustainable Development, which, through its 17 Goals, seeks to enhance the social, economic, and environmental dimensions of SD, the implementation of which requires a more comprehensive, coherent, and integrated approach at the national, regional, and global levels (United Nations 2015).

In recent years, there has been increasing interest in the environmental impacts of aviation; accordingly, some aviation sectors have begun to address the issue more seriously. On the environmental side of SD, it reduces carbon emissions, improves resource efficiency, reduces pollution, and ensures the continuity of resources for the future (Daley 2009). On the economic side, adopting the principles of SD contributes to enhancing innovation, improving operational efficiency, and reducing long-term costs, which enhances the competitive advantage of institutions and contributes to creating sustainable job opportunities (Baumeister 2015).

Innovation and creativity are two important pillars of competitive advantage by providing products/services that meet customer aspirations in a way that exceeds their expectations. In air navigation organizations, creativity and innovation are among the most important elements of competitive advantage. Ferreira *et al.* (2020) found that creativity and innovation enhance competitive performance as they result in the development of modern navigation systems and improved air guidance techniques, in addition to providing more efficient services, such as providing safety for aircraft crossing the airspace.

Besides, there is the importance of meeting customer needs to achieve a competitive advantage, by providing distinguished services that meet their needs and expectations, especially since the customer is one of the basic criteria relied upon in determining the competitive advantage, and he is the one who realizes the importance and value of the benefits and services provided to him (Belz *et al.*, 2010).

The strategic location is an essential dimension in achieving competitive advantage, especially in civil aviation organizations, as the strategic location of the Republic of Yemen in the field of air navigation is characterized by several characteristics that make it an important hub in the international air navigation network, especially since it overlooks the Bab al-Mandab Strait, which represents a meeting point between the Asian and African continents. This makes Yemen a unique strategic location that connects the main airlines that serve transit flights between the East and West and the North and South, which indicates the importance of the strategic location in achieving competitive advantage, as it is an integral part of the logistics services in aviation authorities (Krivonosova 2024).

While the quality of services provided by civil aviation has become one of the most important factors influencing the competitiveness of airspaces, in 2019, the International Civil Aviation Organization (ICAO) presented the United Nations' 17 Sustainable Development Goals, emphasizing the need to achieve sustainable growth of international civil aviation.

It is worth noting that ICAO's vision includes ensuring the provision of air navigation services to not only contribute to achieving safety and efficiency but also play a crucial role in reducing environmental impact. This vision aligns with the principles outlined in the 1944 Chicago Convention, which defines the sovereignty of states over their airspace and regulate air traffic therein. Notably, this convention includes seven main air freedoms, most prominently the freedom of overflight (ICAO 2019).

It is important to emphasize that, in light of SD, the economic dimension plays a vital role in enhancing sustainable economic growth by improving production efficiency, reducing costs, and increasing economic opportunities, which is essential for long-term economic stability. In practical terms, in the field of civil aviation, it is represented by improving air navigation services and increasing their efficiency. In this context, the study by Bugayko *et al.* (2020) highlighted that improving the efficiency of aviation systems not only contributes to reducing fuel consumption and operating costs but also supports economic competition between air regions. This, in turn, contributes to enhancing the competitive advantage. From an environmental standpoint of SD, it is related to protecting natural resources and reducing damage, particularly in mitigating climate change. According to reports

from the ICAO (2019), one of the goals of sustainable aviation is to reduce carbon emissions by improving air routes and using environmentally friendly technologies.

The ICAO aims to achieve SD in the aviation sector through a set of economic, social, and environmental objectives, in addition to reducing greenhouse gas emissions from the aviation sector.

The main research issue is the study of the relationship between the three dimensions of SD (economic, social, and environmental) and their impact on the competitive advantage of Sana'a flight information region (FIR), which is distinguished by its strategic location in the international air navigation network, especially since it overlooks the Bab al-Mandab Strait, which represents a meeting point between the Asian and African continents.

LITERATURE REVIEW

The term “sustainable development” first appeared in August 1979 during a United Nations symposium on environment and development. At that time, environmental advocates were under fire for being accused of opposing development. In one of these discussions, one of them said: “We are not against development, we want it to be sustainable” (Veiga and Zatz 2008, as cited in Souza *et al.* 2021). This was enough to quickly attract attention, and the concept of “sustainable development” became globally recognized. This concept was adopted in the Brundtland Report, which defined SD as a framework for integrating environmental policies and development strategies. The term “development” is used here in its broadest sense. The word “development” was often viewed as referring to processes of economic and social change in developing countries. However, the integration of environment and development has become essential in all countries of the world, as the pursuit of SD requires changes in the domestic and international policies of each country, reflecting the global need to achieve a balance between the economic, social, and environmental dimensions of SD worldwide (Brundtland 1987). SD in the aviation sector also refers to achieving a balance between economic growth, environmental sustainability, and social justice by reducing the environmental impacts of aviation while ensuring its continued contribution to global economic development (Whitelegg and Cambridge 2004). The economic factors of air transport are essential in ensuring the sustainability of the civil aviation system. Civil aviation includes many activities that support the use of aircraft and consume goods and services, such as fuel and food. Investing in air transport, according to initiatives in the Civil Aviation Development Plan (CAMP), can reduce operating costs and boost productivity and economic growth. Reducing transport costs also enhances trade and expands market access. The ICAO works to increase capacity and efficiency while maintaining safety. Reports indicate that transport must be equitable, efficient, safe, and climate-responsive to ensure that current mobility needs are met without compromising those of future generations. Sound national planning is also essential to secure sustainable financing for aviation projects (ICAO 2019).

In recent years, the quality of services delivered by civil aviation has emerged as a critical factor in shaping the competitiveness of national and regional airspace. Recognizing this, the ICAO aligned itself in 2019 with the United Nations' 17 Sustainable Development Goals, reinforcing the global commitment to fostering sustainable progress in international civil aviation. ICAO's strategic direction seeks to ensure that air navigation services not only uphold safety and operational efficiency but also contribute to minimizing environmental impact. This vision aligns with the principles laid out in the Chicago Convention of 1944 and its 19 Annexes, which uphold the sovereignty of states over their airspace and set the framework for regulating air traffic. Among these provisions are the well-known “freedoms of the air,” with overflight rights being among the most fundamental (ICAO 2019).

From an SD perspective, the emphasis is placed on driving economic growth through enhanced productivity, cost reduction, and expanding economic opportunities. Within the aviation sector, this translates into optimizing air navigation services to improve performance. Bugayko *et al.* (2020) argue that increasing the efficiency of aviation operations not only lowers fuel use and operational expenses but also intensifies the economic competition between airspaces, giving rise to a stronger competitive advantage. Additionally, this efficiency supports the conservation of natural resources and helps mitigate environmental harm.

ICAO reports (2019) highlight that a key target of sustainable aviation is cutting carbon emissions through route optimization and the adoption of eco-friendly technologies. In line with this, Perryman *et al.* (2022) stress the need for aviation institutions to actively reduce their environmental footprint as a crucial step toward realizing long-term sustainability goals.

In addition, the strategic location represents an important dimension in achieving a competitive advantage, especially in civil aviation organizations, as the strategic location of the Republic of Yemen in the field of air navigation is characterized by several characteristics that make it an important hub in the international air navigation network, especially since it overlooks the Bab al-Mandab Strait, which represents a meeting point between the Asian and African continents. This makes Yemen a unique strategic location that connects the main airlines that serve transit flights between the East and West and the North and South, which indicates the importance of the strategic location in achieving a competitive advantage, as it is an integral part of the logistics services in aviation authorities (Krivonosova 2024).

With the increasing demand for air travel and the intensification of competition among air service providers, the aviation sector has become one of the most vital sectors. Demand for air travel increased by more than 8% annually from 1960 to 2005, with the number of air passengers expected to continue growing at a rate of between 4.5 and 6% over the next 20 years (Jones *et al.* 2015). This has created significant challenges for the aviation sector regarding SD and competitive advantage, especially with the increase in carbon emissions and the negative impact on climate and public health.

In addition to climate impacts, aviation contributes to air pollution, especially in and around airports, which leads to nitrogen oxide levels exceeding the World Health Organization's recommended values, causing respiratory problems. In addition, noise from aviation affects the mental and psychological health of individuals, as it is linked to sleep disturbances and impaired cognitive performance in children (Whitelegg and Cambridge 2004).

The increased demand for air transport services has prompted air navigation services organizations to strive for a more efficient, competitive position. However, increasing crises, particularly financial decline, pandemic crises, and political tensions, have resulted in significant economic challenges for air navigation services organizations (Bilotkach *et al.* 2015; Ölçen and Alnıpak 2023, cited in Tuncal 2024).

Study hypotheses

Main hypothesis: commitment to meeting the requirements of SD affects the competitive advantage of the Sana'a FIR.

- H1a: commitment to meeting the requirements of the social dimension of SD affects the competitive advantage of the Sana'a FIR.
- H1b: commitment to meeting the requirements of the economic dimension of SD affects the competitive advantage of the Sana'a FIR.
- H1c: commitment to meeting the requirements of the environmental dimension of SD affects the competitive advantage of the Sana'a FIR.

METHODOLOGY

The current research addresses the impact of SD on the competitive advantage of the Sana'a FIR. For this purpose, a quantitative research approach was used to systematically collect and analyze data from air traffic controllers working in the Civil Aviation and Meteorology Authority (CAMA) in Yemen. Given the research's particular focus on the dimensions of SD and its impact on competitive advantage, a purposive sample was used to select research participants from those directly involved in various operations of managing the aviation and Air Navigation Sector. To ensure more accurate and quality results, care was taken to select participants with knowledge and experience and who have sufficient knowledge about the requirements of SD and competitive advantage in the aviation and Air Navigation Sector.

Sampling procedure

The research targeted 98 air traffic controllers working in the CAMA – Air Navigation Sector, and the selection was based on their experience and direct participation in various operational and strategic positions within the sector.

Data collection

The primary data collection tool for the current research was a structured questionnaire designed to capture perceptions and assessments of the dimensions of SD (social, economic, and environmental) and their impact on the dimensions of competitive advantage (innovation, meeting customer needs, and strategic positioning). The questionnaire was validated by presenting it to a group of experts to ensure clarity and relevance before the data collection process.

Ethical considerations

Research participants were informed of the research objectives, and their consent was obtained before participating in responding to the questionnaire.

Data analysis

The data collected via the questionnaire tool was analyzed using statistical methods to examine the relationships between the dimensions of SD and competitive advantage. Descriptive statistics, along with inferential analysis techniques such as correlation and regression, were applied to test the research hypotheses.

Normal distribution

Data was evaluated using the skewness and kurtosis criteria, where values that fall within certain limits indicate that the data do not deviate significantly from the normal distribution, as shown in Table 1.

Table 1. Skewness and kurtosis for normal data.

Dimension	n	Skewness	Kurtosis
SD	98	0.637	-0.028
Competitive advantage	98	-0.05	-0.046

Source: Elaborated by the authors.

Table 1 shows that there is a normal distribution in the data, as all values of the skewness coefficient came between -2 and 2, and all values of kurtosis came between -7 and +7. This confirms the normal distribution of the data and enhances the reliability of the results and their generalizability. In other words, the normal distribution of the data indicates that the sample that was chosen may be a good representative of the community as a whole.

Measurement model testing (outer model)

The outer loading, Cronbach's alpha, composite reliability, and average variance extracted (AVE) values for the variables – competitive advantage and its dimensions (innovation and creativity, strategic location, meeting customer needs), and SD and its dimensions (economic, environmental, social) – can be seen in Table 2.

From Table 2, it appears that all saturation values of the indicators (dimensions) exceed 0.707, which confirms that each variable explains more than 50% of the variance in each of its dimensions, which indicates the existence of high stability for each dimension. The value of the stability coefficient (Cronbach's alpha) for all variables ranged between 0.700 and 0.950, which indicates

Table 2. Outer loading, Cronbach's alpha, composite reliability, AVE values.

Variables	Dimension	Outer loading	Cronbach's alpha	Composite reliability	AVE
Competitive advantage	Innovation and creativity	0.881	0.870	0.871	0.794
	Strategic location	0.898			
	Meeting customer needs	0.893			
SD	Social dimension	0.904	0.876	0.882	0.801
	Economic dimension	0.890			
	Environmental dimension	0.889			

Source: Elaborated by the authors.



the existence of internal consistency in each of their dimensions and confirms the overall stability of the variables. The results also showed the existence of a composite stability that exceeds 0.700 and is less than 0.950, which confirms the existence of overall stability in the variables. The results showed the existence of convergent validity between the variables and their dimensions, as all values of the average explained variance exceeded 0.500, which means that the dimensions of the variables are valid and reliable and measure their variables correctly.

Coefficient of determination R^2

Table 3 shows that the model has a high explanatory power, with the two variables, competitive advantage and SD, explaining up to 77.5% of the variance in competitive advantage, as evidenced by the coefficient of determination value of 0.775. This indicates a strong relationship between the variables within the study sample. This result highlights the importance of compliance with international SD requirements in achieving competitive advantage. The high coefficient of determination value indicates that the model can explain a significant portion of the variance in competitive advantage, providing valuable insights into the key factors that contribute to an organization's success.

Table 3. The coefficient of determination (R^2) for the independent and dependent variables.

Variables	R^2 value
SD	0.372
Competitive advantage	0.775

Source: Elaborated by the authors.

Predictive accuracy (Q^2)

It is clear from Table 4 that the Q^2 of the SD variable was 0.287, indicating a moderate level of prediction. While the predictive accuracy of the competitive advantage variable was 0.602, the Q^2 value was greater than 0.500, which reflects a relatively high level of prediction. These values indicate that the model has a good ability to predict the dependent variables, which enhances the reliability of the results extracted from the analysis.

Table 4. Q^2 of study variables.

Variable	Q^2 (1 - SSE/SSO)
SD	0.287
Competitive advantage	0.602

Source: Elaborated by the authors.

Table 5 shows the results of LM_RMSE and PLS-SEM_RMSE values, indicating the model's predictive accuracy across the different dimensions. For the social dimension (in the SD variable), the RMSE values of the two models were very close (0.819 for the linear model and 0.817 for the partial structural model), indicating similar predictive accuracy. In the economic dimension

Table 5. Prediction accuracy of PLS-SEM and LM.

Variable	Dimension	PLS-EM_RMSE	LM_RMSE
Sustainable development	Social dimension	0.817	0.819
	Economic dimension	0.908	0.908
	Environmental dimension	0.908	0.877
Competitive advantage	Innovation and creativity	0.765	0.766
	Strategic location	0.732	0.748
	Meeting customer needs	0.691	0.623

Source: Elaborated by the authors.

of the same variable, the values were equal (0.908), indicating agreement in the prediction accuracy between the two models. As for the environmental dimension, PLS-SEM was slightly less accurate (0.908) compared to LM (0.877). In the innovation and creativity dimension associated with competitive advantage, the values were very close (0.766 for the linear model and 0.765 for the partial structural model). For the strategic location variable, the partial structural model (0.732) showed slightly higher accuracy than the linear model (0.748). Finally, in the dimension of meeting customer needs, the partial structural model (0.691) was more accurate than the linear model (0.623). Overall, the partial structural model appears to be superior or equal to the linear model in predictive accuracy in most dimensions

Descriptive statistics

Table 6 shows the mean, standard deviation, relative importance, and verbal assessment for the dimensions of sustainable development, according to the research sample.

Table 6. Descriptive statistics of sustainable development.

Sustainable development dimension	Mean	Standard deviation	Relative importance (%)	Verbal assessment
Economic dimension	3.963	1.446	56.60	Moderate
Social dimension	3.417	1.149	48.80	Slightly low
Environmental dimension	2.59	1.333	37.00	Low
Total	3.323	1.135	47.50	Slightly low

Source: Elaborated by the authors.

Table 6 shows that the “economic dimension” dimension came in the highest rank in terms of the study sample’s approval, with an average of 3.963 and a standard deviation of 1.446, while the “environmental dimension” came in the lowest rank in terms of the study sample’s approval of it, with an average of 2.590 and a standard deviation of 1.333. The overall average of the variable “international requirements for sustainable development” was 3.323, with a standard deviation of 1.135. These results can be interpreted as the study sample viewing the “economic dimension” as the most compatible with the international requirements for sustainable development. This indicates that the Air Navigation Sector in Sana’a FIR contributes to achieving sustainable development goals through the economic dimension, but it does not rise to the required level, which necessitates improving mechanisms and strategies to enhance it. The participants also indicate that the sector does not pay sufficient attention to the environmental dimension to meet international requirements for sustainable development, which necessitates the development and implementation of strategies that seek to enhance the (economic, social, and environmental) aspects to ensure that the international requirements are met more effectively.

Table 7 shows the mean, standard deviation, relative importance, and verbal assessment for the dimensions of competitive advantage, according to the research sample.

Table 7 shows that the dimension of “strategic location” came in the highest rank in terms of the study sample’s approval, of it with an average of 4.747 and a standard deviation of 1.144, while the dimension of “creativity and innovation” came in the lowest rank, in terms of the study sample’s approval of it with an average of 3.120 and a standard deviation of 1.472. The overall average of the variable “competitive advantage” was 4.173, with a standard deviation of 1.096. These results can be interpreted as the study

Table 7. Descriptive statistics of competitive advantage.

Competitive advantage dimension	Mean	Standard deviation	Relative importance (%)	Verbal assessment
Creativity and innovation	3.120	1.472	44.60	Slightly low
Meeting customer needs	4.652	1.116	66.50	Moderately high
Strategic location	4.747	1.144	67.80	Moderately high
Total	4.173	1.096	59.60	Moderate

Source: Elaborated by the authors.

sample viewing the dimension of “strategic location” as the most important dimension in providing a competitive advantage for Sana’a FIR. This indicates that the study participants consider the geographical location of Sana’a FIR to be an important and major factor in enhancing the competitive advantage compared to other dimensions. On the other hand, the “creativity and innovation” dimension came in the lowest rank, which indicates a weakness of creativity and innovation and reflects the sample’s tendencies towards improving this dimension. There is a need to work on enhancing the dimension of “creativity and innovation” to achieve greater competitive advantage in the future.

Test of the study hypothesis

The results in Table 8 indicate that there is a statistically significant impact of sustainable development on competitive advantage. This is demonstrated by the regression coefficient (beta) value of 0.491 and the t value of 7.206, which is considered statistically significant at a significance level of less than 0.05. This result is supported by the positive regression coefficient value, which indicates a direct relationship between international requirements for sustainable development and competitive advantage. Thus, the results confirm acceptance of the main hypothesis that assumes a positive impact of international sustainable development requirements on competitive advantage in Sana’a FIR.

Table 8. Statistical test of the main hypothesis.

	Beta	Standard error	T-value	Significance (p-value)
Sustainable development → Competitive advantage	0.491	0.068	7.206	0.000

Source: Elaborated by the authors.

According to the statistics in Table 8, it is clear that there is a statistically significant effect of the economic dimension on competitive advantage, as shown by the regression coefficient (beta) value of 0.265 and the t value of 2.999. This means that there is a positive relationship between the economic dimension and competitive advantage. This indicates that development practices with their economic dimension contribute to enhancing competitive advantage, and this result supports the acceptance of the first sub-hypothesis.

The statistics in Table 9 also indicate a statistically significant effect of the social dimension on competitive advantage, as shown by a beta value of 0.414 and a t value of 3.911, which is considered statistically significant at a significance level less than 0.05. This indicates that the social dimension, which includes socially responsible practices and commitment to ethical standards, has a positive effect on competitive advantage. This result supports acceptance of the second sub-hypothesis.

Table 9. Statistical test of sub-hypothesis.

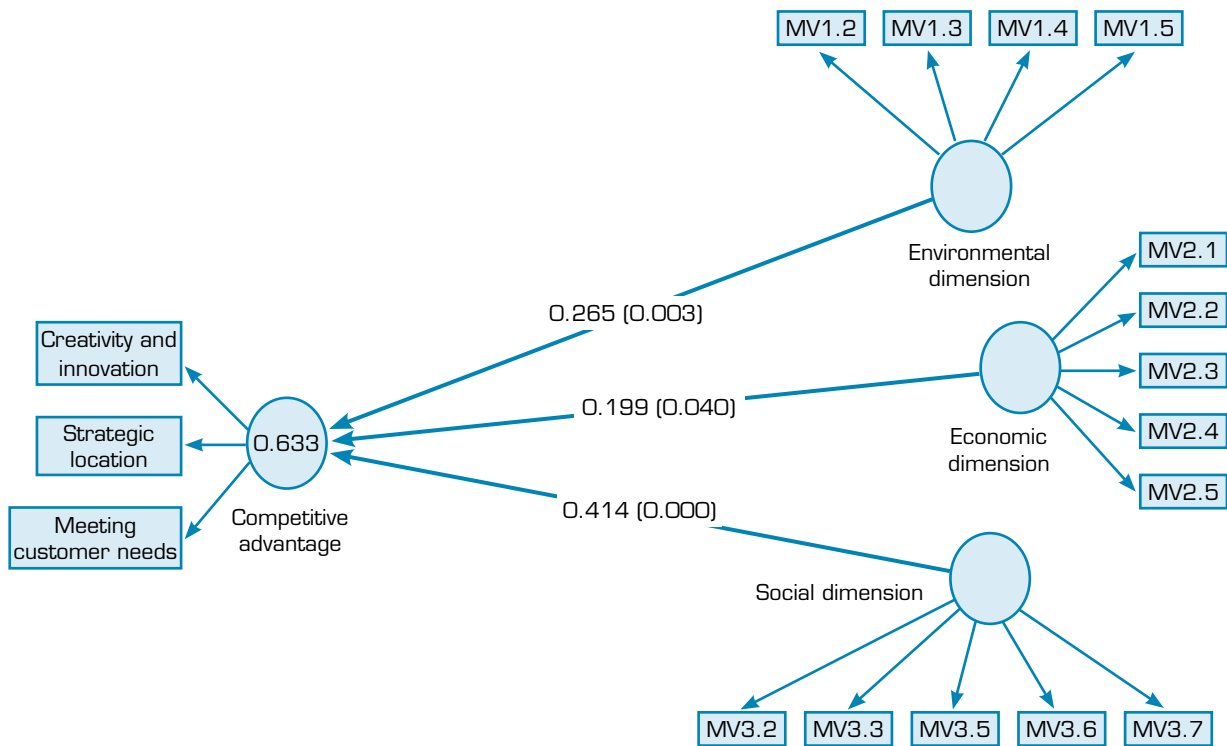
	Beta	Standard error	T-value	Significance (p-value)
Social dimension > Competitive advantage	0.414	0.106	3.911	0
Economic dimension > Competitive advantage	0.265	0.088	2.999	0.003
Environmental dimension > Competitive advantage	0.199	0.097	2.052	0.04

Source: Elaborated by the authors.

The same table above also shows that there is a statistically significant effect of the environmental dimension on competitive advantage, although it is less clear compared to other dimensions of sustainable development. This relationship is shown by the regression coefficient beta of 0.199 and a t value of 2.052, which is considered statistically significant at a significance level of less than 0.05. This indicates that development practices with an environmental focus and commitment to environmental standards contribute positively to competitive advantage, although the impact may be weaker compared to the social and economic dimensions. This result supports the acceptance of the third sub-hypothesis.

In general, these results fully support the third sub-hypothesis, indicating that the three dimensions of sustainable development, namely the social, economic, and environmental dimensions, all contribute to enhancing the organization’s competitive advantage.

These results emphasize the importance of organizations adopting sustainable and socially responsible practices to achieve competitive advantage. Figure 1 illustrates the impact of sustainable development dimensions on competitive advantage.



Source: Elaborated by the authors using SmartPLS 4.0.5.9.

Figure 1. Hypothesis tests.

DISCUSSION AND CONCLUSION

The results and presentation of practical suggestions

The study concluded that the implementation of sustainable development requirements in all its dimensions had a positive impact on enhancing the competitive advantage of Sana'a FIR. This is evident in the high value of the regression coefficient ($\beta = 0.491$) and statistical significance ($t = 7.206$). The positive impact on competitive advantage was evident even though the level of implementation of sustainable development in all its dimensions was slightly low, at 47.5%. This low level can be explained by the fact that the Air Navigation Sector faces several challenges, most notably weak infrastructure, a lack of training programs, a lack of funding and investment, and unstable security and political conditions.

These results indicate that even minimal implementation of sustainable development dimensions can contribute to improving the competitive advantage of the aviation sector.

This means that the relationship between sustainable development, with its social, economic, and environmental dimensions, and competitive advantage is not merely a direct causal relationship but rather an interactive one, shaped by the degree of integration and consistency in the implementation of these dimensions. The more sustainable development is practiced, the greater the aviation sector's ability to compete locally and regionally. Based on the results, a low implementation rate in a dimension, such as the environmental dimension one, does not mean its impact is absent. Rather, it indicates the presence of untapped opportunities whose effective investment could lead to a greater competitive advantage.

In terms of the impact of each dimension of sustainable development, the social dimension appears to have the greatest effect on competitive advantage, despite its implementation rate not exceeding 48.8%. This relationship is evident in $\beta = 0.414$, $t =$

3.911, indicating that the social dimension, which includes socially responsible practices such as fairness, healthcare, and adherence to ethical standards, has a positive impact on competitive advantage. This highlights the need to pay greater attention to the social dimension of sustainable development within the aviation sector in Sana'a.

While the economic dimension, although its application rate did not exceed 48.8%, came in second place in terms of its positive impact on competitive advantage, as shown in $\text{Beta} = 0.265$, $t = 2.999$, which means that the more the aviation sector is interested in achieving balanced economic growth and improving the efficiency of resource use, the more competitive advantage is enhanced.

As for the environmental dimension, although its application rate did not exceed 37%, it came in third place in terms of its positive impact on competitive advantage. This is evident in the value $\text{Beta} = 0.199$, $t = 2.052$, which shows that its impact was relatively less, but still significant. This means that the application of this dimension, even if partial, can achieve significant gains. This indicates that environmental measures such as reducing emissions and improving fuel efficiency contribute to raising the status of the operating entity at the international level and enhance opportunities for cooperation and compliance with the standards of international organizations such as the ICAO.

These results lead to a key conclusion: regardless of the level of implementation of sustainable development across all its dimensions within the aviation sector, these practices play an effective role in enhancing its competitive advantage. This requires a focus on adhering to sustainability goals and addressing the challenges that hinder their achievement.

Given these insights, the study offers practical guidance for stakeholders involved in Yemen's aviation industry, including policymakers, operations managers, air traffic controllers, and aviation experts. A major recommendation is the introduction of specialized training programs aimed at equipping personnel with the knowledge and tools necessary to effectively apply sustainable development principles. In addition, the study encourages the development of forward-thinking strategies that embrace long-term sustainability while capitalizing on the strategic location of Sana'a FIR to enhance the region's competitive standing. In addition, the study encourages collaboration with research institutions to foster innovation in navigation services and equipment, as well as the development of technological infrastructure through the integration of smart navigation systems and modern technologies to improve safety and efficiency in air services.

Proposals for future studies

In light of the study's findings, several avenues for future research are proposed. One potential area involves examining the impact of modern technological advancements, such as artificial intelligence and big data, on improving the quality of air navigation services, enhancing responsiveness to user needs, and strengthening air traffic safety. Another important direction would be to explore the effects of international environmental obligations on the aviation sector in Yemen and the broader region, particularly in terms of how well current air operations align with environmental sustainability standards. Additionally, future research could investigate the role of government support in advancing the aviation industry, with a focus on assessing its economic contributions to national income diversification and overall economic development.

Limitations of the study

Despite the valuable insights provided by this study, it is important to acknowledge several limitations. One of the notable constraints of this study lies in its geographical scope, as it focuses solely on the Sana'a FIR. This narrow focus may limit the ability to apply the findings to broader or different aviation contexts. To build on these findings, future research could explore similar studies in various regions or operational settings to test the consistency of the results and reinforce their relevance across different environments.

The study also limited its examination to three key pillars of sustainable development: the social, economic, and environmental dimensions. Other potentially influential factors, such as technological advancements and governance structures, were not explored, although they may play a role in shaping competitive advantage. Nonetheless, the dimensions that were selected are globally acknowledged and widely adopted, particularly within the framework of the ICAO, which lends credibility to their inclusion.

In terms of data collection, the research primarily used a questionnaire-based approach. While this method can sometimes be affected by respondents' understanding and familiarity with the topic, this was addressed through deliberate sampling. The study included 98 air traffic controllers with substantial experience across both operational and strategic functions, which added depth and trustworthiness to the insights gathered.

CONFLICT OF INTEREST

Nothing to declare.

AUTHORS' CONTRIBUTION

Conceptualization: Shenaif AYA; **Methodology:** Shenaif AYA; **Investigation:** Shenaif AYA; **Formal analysis:** Shenaif AYA; **Data curation:** Shenaif AYA; **Resources:** Shenaif AYA; **Writing – Original Draft Preparation:** Shenaif AYA; **Writing – Review & Editing:** Shenaif AYA and Alolofi NMA; **Validation:** Alolofi NMA; **Supervision:** Alolofi NMA; **Final Approval:** Alolofi NMA.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable.

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REFERENCES

Alagele HKH, Neama NH, Alobeidi AAJ, Al Dulaimi HA, Almayali HHM (2024) Impact of sustainable development on relationship between competitive advantage and organizational culture: a field study of higher education and scientific research institutions. *Ling Philos Investig* 23(1):1250-1262.

Baumeister S (2015) Environmental responsibility as a factor in gaining competitive advantage in the aviation industry. *J Geotech Transp Eng* 1(2):43-48.

Belz C, Müllner M, Zupancic D (2010) Excellence in key account management: the St. Gallen KAM concept. Munich: Finanzbuch Verlag.

Brundtland GH (1987) Our common future: report of the World Commission on Environment and Development. [Feb 10 2025]. <https://www.are.admin.ch/are/en/home/media/publications/sustainable-development/brundtland-report.html>

Bugayko D, Gurina G, Korzh M, Sydorenko K (2020) Challenges of sustainable development and safety management of world civil aviation in the conditions of globalization. Research Gate.

Daley B (2009) Is air transport an effective tool for sustainable development? *Sustain Dev* 17(4):210-219. <https://doi.org/10.1002/sd.383>



Ferreira J, Coelho A, Moutinho L (2020) Dynamic capabilities, creativity and innovation capability and their impact on competitive advantage and firm performance. *Technovation* 92-93. <https://doi.org/10.1016/j.technovation.2018.11.004>

International Civil Aviation Organization (2019) National aviation planning framework. Montreal: ICAO.

Jones S, Bennett M, Hoon SR, Richardson N (2015) The characterisation of atmospheric particulate pollution within the airport environment using magnetic measurements and geochemical analysis. [February 10 2025]. https://www.researchgate.net/profile/Stephen-Hoon/publication/277715527_The_characterisation_of_atmospheric_particulate_pollution_within_the_airport_environment_using_magnetic_measurements_and_geochemical_analysis/links/58356d9b08ae138f1c10e6a7/The-characterisation-of-atmospheric-particulate-pollution-within-the-airport-environment-using-magnetic-measurements-and-geochemical-analysis.pdf

Karpun OV, Yakovenko VV (2024) The latest approaches and technologies to increase the competitiveness of aviation enterprises in modern conditions. ResearchGate.

Krivososova A (2024) The role of aviation logistics in increasing airline competitiveness. *Int J Latest Eng Manag Res* 9(4): 57-60. <https://doi.org/10.56581/IJLEMR.9.04.57-60>

Lim S (2022) Sustainability performance and competitive advantage in container ports (PhD thesis). Cardiff: Cardiff University. Available at <https://orca.cardiff.ac.uk/id/eprint/151090/1/2022limsphd.pdf>

Nejati M, Shah Bin A, Shahbudin, Bin Amran A (2010) Sustainable development: a competitive advantage or a threat? *Bus Strategy Ser* 11(2):84-89. <https://doi.org/10.1108/17515631011026407>

Perryman M, Besco L, Suleiman C, Lucato L (2022) Ready for take off: airline engagement with the United Nations sustainable development goals. *J Air Transp Manag* 103:102246. <https://doi.org/10.1016/j.jairtraman.2022.102246>

Souza EN, de Melo Conti D, Prancic E, da Silva LF (2021) The relations between sustainability and quality in an organizational context. *J Innov Sustain RISUS* 12(4):46-57. <https://doi.org/10.23925/2179-3565.2021v12i4p46-57>

Tuncal A (2024) Comparative assessment of financial performance among air navigation service providers. *Pamukkale Univ J Soc Sci Inst* 66(35). <https://doi.org/10.30794/pausbed.1508218>

United Nations (2015) Transforming our world: the 2030 Agenda for Sustainable Development. [Feb 10 2025]. <https://sdgs.un.org/2030agenda>

Whitelegg J, Cambridge H (2004) Aviation and sustainability: a policy paper. Stockholm: Stockholm Environment Institute.