


Decoding the nexus of digital transformation and dynamic capabilities through harmonic centrality in the aviation sector

Havacılık sektöründe dijital dönüşüm ile dinamik yeteneklerin harmonik merkezilik yoluyla çözülmesi

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Abstract

The aviation sector benefits from the rise of Society 5.0 and the onset of digital transformation. These developments offer distinct prospects for improving employee well-being, quality, and retention, all while simultaneously providing societal value. This research's primary objective is to investigate digitalisation's effects on dynamic capacities in the aviation industry, with a special emphasis on airport operations. By using the analytical skills of network analysis, this study examines the significance of network analysis in comprehending the impacts of digital transformation on dynamic capacities. The primary research question examines the potential use of network analysis to get a deeper understanding of the impact of digital transformation on dynamic capacities. The study utilises Harmonic Centrality, a centrality measure derived from network research, and implements it using the NetworkX library based on the Python programming language. The study is carried out at Esenboğa Airport, located in Ankara, Turkey, with a specific focus on airport management, a crucial aspect of the aviation sector. Using network analysis in conjunction with Harmonic Centrality offers a great methodology for understanding the influence of digital transformation on dynamic capacities, hence becoming a noteworthy addition to this scholarly article.

Keywords: Digital Transformation, Dynamic Capabilities, Harmonic Centrality, Network Analysis, NetworkX

JEL Codes: M10, O33, C80

Öz

Havacılık sektörü, Toplum 5.0'ın yükselişinden ve dijital dönüşümün başlangıcından fayda sağlayabilen sektörler arasındadır. Bu araştırmanın temel amacı, dijitalleşmenin havacılık endüstrisindeki dinamik kapasitelere etkilerini incelemek, özellikle de havaalanı işletmelerine özel bir vurgu yapmaktır. Özellikle çalışmada ağ analizinin analitik yeteneklerini kullanarak, dijital dönüşümün dinamik kapasitelere etkilerini anlamak açısından ne kadar önemli olduğunu incelenmiştir. Temel araştırma sorusu, ağ analizinin dijital dönüşümün dinamik kapasitelere etkisini daha derinlemesine anlamak için bir araç olarak kullanım potansiyelini incelemek üzerine kurgulanmıştır. Bu kapsamda Ankara şehrinde bulunan Esenboğa Havalimanı'nda gerçekleştirilen çalışmada, ağ araştırmalarından türetilen bir merkezilik ölçümü olan Harmonik Merkezilik'i kullanılmış ve bunu Python programlama dili üzerine kurulu NetworkX kullanarak uygulanmıştır. Ağ analizinin Harmonik Merkezilik ile birleştirilerek kullanılması, dijital dönüşümün dinamik kapasitelere etkisini anlamak için farklı bir bakış açısı sunar.

Anahtar Kelimeler: Dijital Dönüşüm, Dinamik Kabiliyet, Harmonik Merkezilik, Ağ Analizi, NetworkX

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Introduction

In the rapidly evolving landscape of the twenty-first century, organizations must adapt and transform their structures to remain relevant in the face of technological advancements. The emergence of Industry 4.0 marked a significant shift, requiring organizations to meet specific criteria to leverage the benefits of digital transformation (Brettel, Friederichsen, Keller & Rosenberg, 2014). As we enter the era of Society 5.0, it becomes increasingly important to understand the impact of digital transformation on businesses and society. Digital transformation offers immense value to organizations, enhancing various aspects such as employee welfare, quality, and retention. It also fosters a sense of community and sustainability, opening up new opportunities for growth and development (Davenport, 2018). This factor significantly increases the value of the intellectual capital of a company, which encompasses the knowledge, skills, and innovative capabilities that contribute to a company's competitive advantage (Edvinsson & Malone, 1997).

Dynamic capabilities refer to an organization's ability to identify and seize opportunities, adapt to changes, and reconfigure its resource base to stay competitive and ensure future success (Teece, Pisano & Shuen, 1997). As organizations undergo digital transformation, they strive for agility, sustainability, and the ability to navigate the volatile, uncertain, complex, and ambiguous (VUCA) environment of Industry 5.0 (Boehe & Cruz, 2021). This transformation is not solely a matter of strategy but also entails embracing technology to drive innovation and operational excellence.

While dynamic capabilities have gained significant attention in academic research, a growing need exists to explore their relationship with digital transformation, especially in specific industries such as aviation. The impact of digital transitions on organizational dynamic capabilities varies across industries, institutions, and organizations (Wilden, Devinney & Dowling, 2013). Hence, thoroughly examining the intricacies and comprehending the distinct ramifications of digital transformation in the aviation industry, specifically in airport operations, is important. The aviation sector is now on the verge of significant disruption, mostly due to the advent of sector 5.0 and the widespread impact of digital transformation. The transformation above is not limited to technological advancements but encompasses the reconfiguration of employee welfare, improvement of service excellence, and optimisation of tactics for staff retention.

This article aims to examine the effect of digital transformation on dynamic capabilities in the aviation industry, with a specific focus on airport management. To gain insights into this relationship, we employ network analysis using the harmonic centrality metric, a non-local centrality measure, to understand the impact of digital transformation on dynamic capabilities (Al-Taie & Kadry, 2017). Using network analysis, we can uncover the underlying network dynamics and evaluate the relationship between airport digital transformation and agile management capabilities. Harmonic centrality is chosen as a metric for network analysis in this study because of its ability to provide insights into the impact of digital transformation on dynamic capabilities (Vignery & Laurier, 2020).

Harmonic centrality, a variation of closeness centrality, is particularly useful in analysing disconnected networks and allows for estimating the average distance within a network. Unlike other centrality measures that add up distances between nodes, harmonic centrality considers the inverse of distances, enabling it to handle infinite values (Marchiori & Latora, 2000). The application of harmonic centrality in this study helps uncover the most central nodes in the network and provides valuable information on the local influence of these nodes. In the context of digital transformation and dynamic capabilities, it allows for identifying nodes that play key roles in driving the effects of digital transformation (Marchiori & Latora, 2001). By examining the out-links of nodes, the study can focus on the influencer functions related to the dynamic capability effects of digital transformation. Thus, harmonic centrality is a suitable metric for this study as it provides a unique perspective on network dynamics and allows for a detailed analysis of the effects of digital transformation on dynamic capabilities in the aviation industry.

Literature review

Frequently, processes associated with identifying and seizing opportunities and reconfiguring the organisational resource base are used to explain variation in firm performance (Wilden et al., 2013). Organisations boldly venture beyond national borders to acquire the required resources by utilising open innovation techniques and models. In the context of "open innovation," the term "open" refers to sharing privileged information or tacit knowledge within an organisation. Organisations are undertaking digital transformation to achieve organisational agility, sustainability, adaptation, and resistance to volatility, uncertainty, complexity, and even ambiguity because of the opportunities presented by Industry 5.0. Therefore, digital transformation is not a matter of strategy but technology

(Rogers, 2016). Most legacy organisations, considered brick-and-mortar businesses primarily founded before the new digital age, do not yet view their business environments as digital ecosystems (Kopalle et al., 2020). Therefore, senior executives must devise strategies for monetising novel and unanticipated developments in business models that maximise customer needs and experiences.

When businesses develop more dynamic capabilities, they can ensure their future. They constantly evolve and change to maintain their existence, create value, increase their market shares and effects, and implement sustainable competitive strategies. To remain competitive, organisations undergo restructuring. They must continuously provide the change, transformation, and development that restructuring entails and be prepared for unexpected and unusual environmental scenarios (Leonardi & Treem, 2020). Consequently, strategic thinking and change appear indispensable. Over the past decade, the concept of dynamic capabilities has garnered the interest of academics. This interest can be explained by a growing understanding of the impact of dynamic capabilities on competitiveness, business practice, and performance outcomes (Giniuniene & Jurksiene, 2015). However, intellectual capital is often considered an asset. Intellectual capital is the essential component of the dynamic capabilities that facilitate the transfer of resources and information. Since intellectual capital is an organization's static asset, it substantially affects the development and expansion of dynamic capability and fundamental competency (Wu et al., 2007). The impact of digital transitions on organisational approaches' dynamic capabilities varies by industry. In other words, its impact is not uniform across all industries, institutions, and organisations.

Before continuing to graph theory, which is considered more in-depth (Al-Taie & Kadry, 2017), briefly discussing network theory may be useful. It uses this structure to illustrate a framework composed of actors (nodes and vertices) and the connections (edges) that connect them. A graph is a numerical representation of the relationships between elements. It could function as a framework for data presentation. It consists of centres that represent objects and edges that connect each vertex. The techniques required to express and visualise social configurations involving three or more on-screen individuals are provided by graph theory (Cordella & Hesse, 2015). Harmonic centrality is a measure used in network analysis to identify important nodes within a network. It was proposed as an alternative to the Closeness Centrality algorithm for estimating the average distance between nodes in a network. Unlike Closeness Centrality, which sums the distances between a node and all other nodes, harmonic centrality calculates the sum of the inverse of the distances. This allows it to handle disconnected networks and infinite values (Marchiori & Latorre, 2000).

Marchiori and Latora introduced harmonic centrality in their study "Harmony in the Small World" (2001), where they aimed to develop a rational concept of "average shortest path" in network analysis. They highlighted the limitation of the Closeness Centrality algorithm in disconnected networks and proposed harmonic centrality as an alternative approach. By considering the inverse of distances, harmonic centrality provides a measure that captures the accessibility and influence of nodes within a network (Marchiori & Latora, 2001).

The interpretation of harmonic centrality is important in understanding its significance within a network. While the most central node based on harmonic centrality has global significance, the interpretation of local centrality may vary depending on the type of connections (in-link or out-link). In the context of harmonic centrality, the focus is often on the out-link that indicates the dynamic capability effects of digital transformation (Vignery & Laurier, 2020). Harmonic centrality has been utilized in various research domains, including social network analysis, disease spread modelling, and organizational studies. Its ability to handle disconnected networks and measure node influence makes it a valuable tool for understanding network dynamics (Al-Taie & Kadry, 2017; Cordella & Hesse, 2015; Goldenberg, 2019).

In summary, harmonic centrality is a network centrality measure that calculates the sum of the inverse distances between a node and all other nodes in a network. It offers an alternative to the Closeness Centrality algorithm and is particularly useful in handling disconnected networks. Its interpretation depends on the type of connections and focuses on the influence of nodes within a network. Harmonic centrality has been applied in various research fields and provides insights into network dynamics.

This research will examine the impact of digital transformation on dynamic capability in the context of airport management in the aviation industry. Airports are the most significant symbols of the aviation industry, as they are the most complex network structures. These businesses are involved in every facet of the technological revolution, disruptive technologies, and digital transformation.

In this study, network analysis is performed. In addition to the described non-local centralities, the closeness centrality-based harmonic centrality will also be examined. Harmonic centrality (sometimes

referred to as valued centrality) is a variation of closeness centrality that was developed to address an issue with disconnected networks that the original formula encountered (Vignery & Laurier, 2020). Harmonic centrality was proposed as an alternative to the Closeness Centrality algorithm for estimating the average distance. Instead of adding the distances between a node and every other node, the procedure for harmonic centrality adds the distances' inverse. This permits it to manage infinite values (Marchiori & Latorre, 2000).

Network analysis is the study of social systems using graph theory and networks. It integrates techniques for analysing network topologies with theories intended to describe the dynamics and patterns observed in such systems. Combining social psychology, statistics, and graph theory led to its development. Therefore, it is interdisciplinary by nature. The most central elements of a network serve as centres for various network dynamics. However, the significance and applicability of centrality may vary from context to context and apply to multiple centrality metrics. The term for this phenomenon is non-local centrality (Goldenberg, 2019). Eigenvector, Degree, Closeness, and Betweenness are the most prominent and extensively employed non-local centralities.

As with the majority of centrality algorithms, it is based on social network analysis. In Harmony in the Small World, Marchiori and Latora (2001) proposed harmonic centrality while endeavouring to develop a rational concept of "average shortest path." They proposed an alternative method to the Closeness Centrality algorithm for estimating the average distance. Instead of adding the distances between a node and every other node, the procedure for harmonic centrality adds the distances' inverse. This permits it to manage infinite values (Marchiori & Latoro, 2001).

Therefore, its interpretation is equally as crucial as its analysis. Closeness Centrality is interpreted differently based on the status of the connection arriving (in-link) or leaving (out-link) the node and on whether the connection is global or local. According to the results of graph analysis-enabled harmonic centrality measures, "the most central" node has global significance. The interpretation of the local may vary depending on whether the hyperlink is in-link or out-link. This node is interpreted as "the support" for inbound links and "the influence" for outbound links. In the context of harmonic centrality, however, the out-link that indicates the dynamic capability effects of digital transformation functions is investigated. Thus, influencer functions are detected locally and interpreted.

Despite its tremendous complexity and dynamic nature, the network adapts to new digital developments. Using six indicators, we will accurately evaluate the properties generated by the organizational network. Six themes illustrate the organisational significance of the study's findings and the contribution of digital transformation to intellectual capital. These concepts include integration, driving, being driven, stability, precariousness, and criticality (Linss & Fried, 2010).

When applied to managing dynamic organisational capabilities, network analysis is expected to have a functional action-reaction or drive-driving effect. Since the intended analysis is directive, the effect of digital transformation on dynamic capability is only discussed within the context of the non-local measure of harmonic centrality

This study will examine the effect of digitization on dynamic capabilities in the aviation industry, specifically airport operations. Consequently, the research query appears: "Can network analysis be used to understand how the digital transformation has affected dynamic capabilities?" The purpose of this study is to exploit the explanatory power of networks. To our knowledge, this study will be the first to use network analysis within the context of open innovation initiatives to evaluate the relationship between airport digital transformation and flexible management capabilities.

NetworkX, a Python (Programming) application, is used to undertake network analysis for the research. The study is conducted at Esenboğa terminal in Ankara and focuses specifically on terminal administration, the flagship of the aviation sector. The 1998-established TAV Holding is a legacy company. In 2006, the company underwent a transformation and acquired subsidiaries.

Methodology

Within a rapidly changing environment, this research investigates the complex relationship between digital transformation and dynamic capacities in the aviation industry, specifically in airport operations. Airports are intricate network systems that provide a crucial function within the aviation sector. The process encompasses the collaboration of many stakeholders, decision-makers, and staff to guarantee the safety and effectiveness of air travel for passengers. The airport system operates on a zero-error philosophy, emphasising clarity and accuracy in all interactions and activities (Graham, 2020). The efficient functioning of airports is crucial for personal travel and the advancement and progress of the surrounding area (Große, 2019).

Time-sensitive transportation, such as air travel, is crucial for maintaining essential infrastructure and protecting individuals, the environment, the economy, and cultural traditions. The planning and execution of a voyage require extensive cooperation and adherence to complex regulations. The intellectual perspective of airport operators is reflected in their focus on customer service, cost reduction, employee productivity, operational efficiency, stakeholder networking, and employee retention. Understanding and analyzing networks becomes relevant in this context (Ahmadian, 2019).

This study is conducted at Esenboğa terminal in Ankara, specifically on terminal administration. Established in 1998, TAV Holding is considered a legacy company and transformed in 2006, acquiring subsidiaries. To explore the nonlinear impact of airports' digital transformation criteria on dynamic capabilities, we conducted a comprehensive study, and one-on-one interviews were conducted with various departments and managers affiliated with TAV Holding, including the Head Office, logistics and finance departments, and managers of TAV Technologies, TAV Security, HAVAS, and PRIMECLASS.

Study context

Situated within the aviation domain, our research focuses on network analysis to uncover the complex interconnections and dynamics in operation. This study focuses on network analysis to understand the complex integration of digital transformation within the dynamic capabilities framework. This study's central inquiry is whether network analysis, specifically Harmonic Centrality, may provide a perspective that allows us to understand the transformative process initiated by digital transformation significantly. Harmonic Centrality, a newly developed centrality metric that operates beyond local measures, is employed to unravel the aviation sector's complex network structure and dynamics. Hence, using the NetworkX library, which is based on Python, serves as the foundational framework for this investigation. It facilitates the examination of the interconnections inside the complex network of Esenboğa Airport, a significant entity in Ankara, Turkey.

Data collection

The study is designed with a network analysis matrix containing 37 digital transformation criteria in the row under six main headings and 35 sub-attributes of intellectual capital components under three main headings in the columns. While Customer Services, Lower Operational Cost, Increase Employee Productivity, Operations Efficiency, Strengthen Networks, and Increase Employee Retention are the main headings covering all the details of the digital transformation criteria in the rows of the matrix, the intellectual capital components occupying the columns of the matrix are Human Capital, Structural Capital, and Relational Capital. This section advances the research by interpreting each sub-attribute of intellectual capital components as a dynamic ability. The interviews and surveys conducted with TAV Esenboğa Head Office and the TAV mentioned above Holding Subsidiaries were analysed in Python NetworkX and subsequently interpreted and evaluated individually.

Main findings and contributions:

Some functions that service the organization's original purpose depend on the connections made through functional interactions. Based on these functions, the connections that comprise the entire network are established (Von Tunzelman, 2004). The functional relationships established between TAV Holding's legacy business and its subsidiaries based on digital transformation criteria evolve with the main headings of customer services, lower operational costs, increased employee productivity, increased operational efficiency, and increased employee retention. Therefore, explaining functionality using only the top-down information flow necessary for either the hierarchical internal structure or the contract-based interactions would be extremely misleading. It must be normalised before the harmonic centrality score can be applied to varying-sized networks. This is required so that it can be utilised for comparing networks. Conversations with the managers yielded significant information regarding the interview and the survey analysis. Below, Table 1, is a breakdown of participant demographics.

Table 1: Demographic Information About Participants

Company and Subsidiaries	Position	Experience	Education	Gender	Age Range	Participants
TAV Esenboğa Head Office	TAV ESB Deputy General Manager	More than 10 years	Master	Male	40-45	Interview 3
TAV Esenboğa Logistics Department	TAV ESB Logistics Manager	More than 10 years	Bachelor	Male	40-45	Interview 2
TAV Esenboğa Head Office Finance Department	TAV ESB Finance Manager	More than 10 years	Bachelor	Male	40-45	Interview 4
TAV Technologies	TAV Technologies IT Assistant Manager	More than 8 years	Master	Male	30-35	Interview 1
PRIME CLASS	Prime class Manager	More than 10 years	Bachelor	Female	40-45	Interview 5
TAV Securities	TAV Securities Manager	More than 10 years	Bachelor	Male	40-45	Interview 6
HAVAŞ	HAVAŞ Manager	More than 10 years	Bachelor	Male	40-45	Interview 7

According to the study's designed matrix analysis, TAV Holding and its subsidiaries are interconnected as socio-technical systems, and the business relationships between the TAV main offices and subsidiaries are defined based on functionality and influence. This is evident when TAV Holding and its subsidiaries are viewed collectively. Network analysis is intended to produce a functional action-reaction or drive-driving effect when applied to managing dynamic organisational capacities.

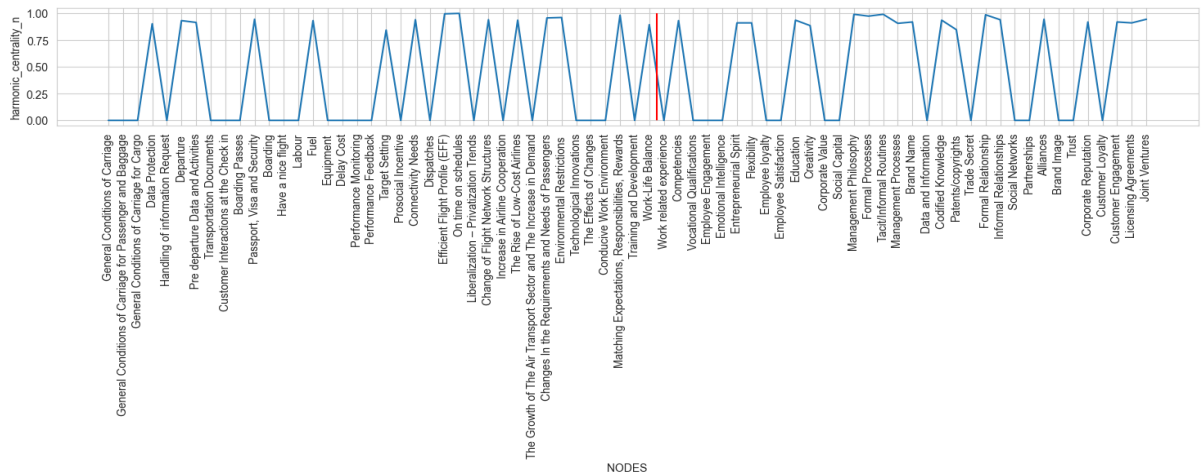


Diagram 1: Esenboğa TAV Head Office Harmonic Centrality Results

According to the Esenboğa TAV Head Office Harmonic Centrality Results, "On time and schedules" has the maximum node score of 1, as shown in Diagram-1. This node is regarded as the most prestigious node and is one of the criteria for Airport Digital Transformation's "Operations Efficiency" metric.

The findings from the Harmonic Centrality study performed on the Esenboğa TAV Head Office indicate that the "On time and schedules" achieves the greatest node score, achieving a value of 1, as seen in Diagram-1. In the scope of this investigation, it is noteworthy to mention that this specific node has the highest level of prestige among the nodes that have been detected. The prevalence of this criteria is especially related to its essential role in assessing the element of "Operations Efficiency" in the context of Airport Digital Transformation. A centrality score of 1 highlights the node's substantial impact inside the network, emphasising its vital role in enhancing the airport's operational efficiency.

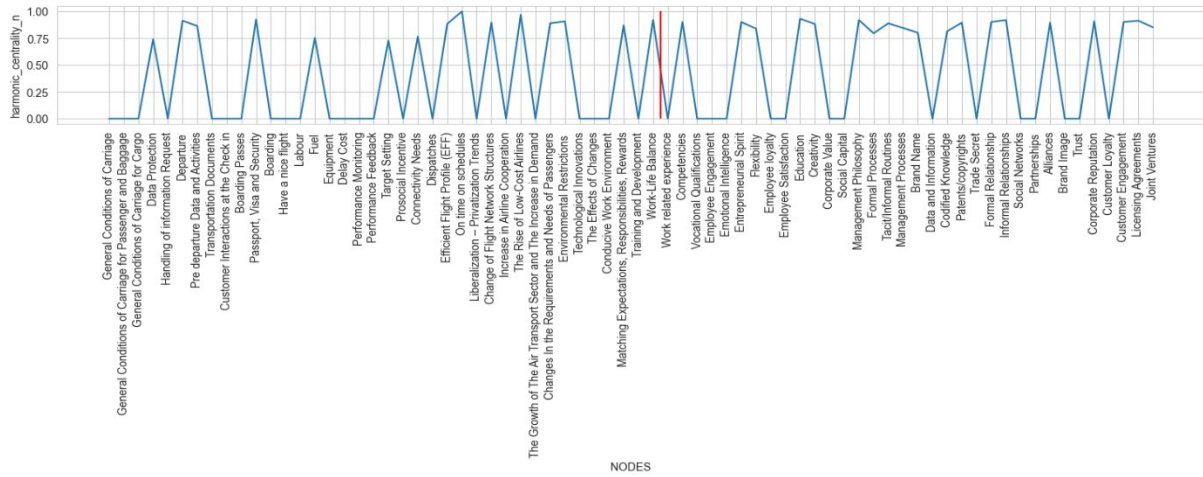


Diagram 2: Esenboğa TAV Finance Department Harmonic Centrality Results

Based on the Harmonic Centrality analysis outcomes about the Esenboğa TAV Finance Department, the attribute "On time on schedules" emerges with the highest node score of 1, as evident from Diagram-2. This specific node claims the position of utmost prestige within the network analysis. Notably, it aligns with the "Operations Efficiency" category, a significant criterion encapsulated within the broader framework of Airport Digital Transformation. The centrality score of 1 accentuates the exceptional influence wielded by this node within the network structure, underscoring its pivotal role in advancing the operational efficiency of the airport in question.

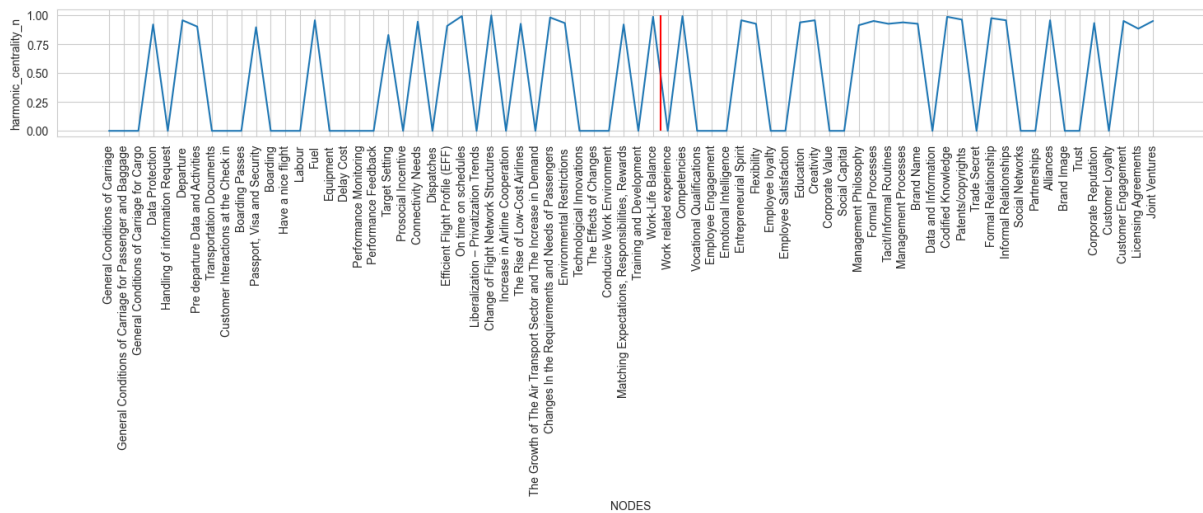


Diagram 3: Esenboğa TAV Logistics Department Harmonic Centrality Results

According to the findings shown in Diagram-3, the attribute "Change of Flight Network Structures" exhibits a notable node score of 1 within the framework of the Harmonic Centrality Results for the Esenboğa TAV Logistics Department. This specific node has the highest score inside the network, indicating its prominent rank. Within the analytical framework, it may be categorised as "Strengthen Networks," a crucial criterion within the broader scope of Airport Digital Transformation. A centrality score of 1 underscores the node's significant impact within the network's configuration, accentuating its vital role in enhancing the resilience and effectiveness of network structures in the operational context of the airport.

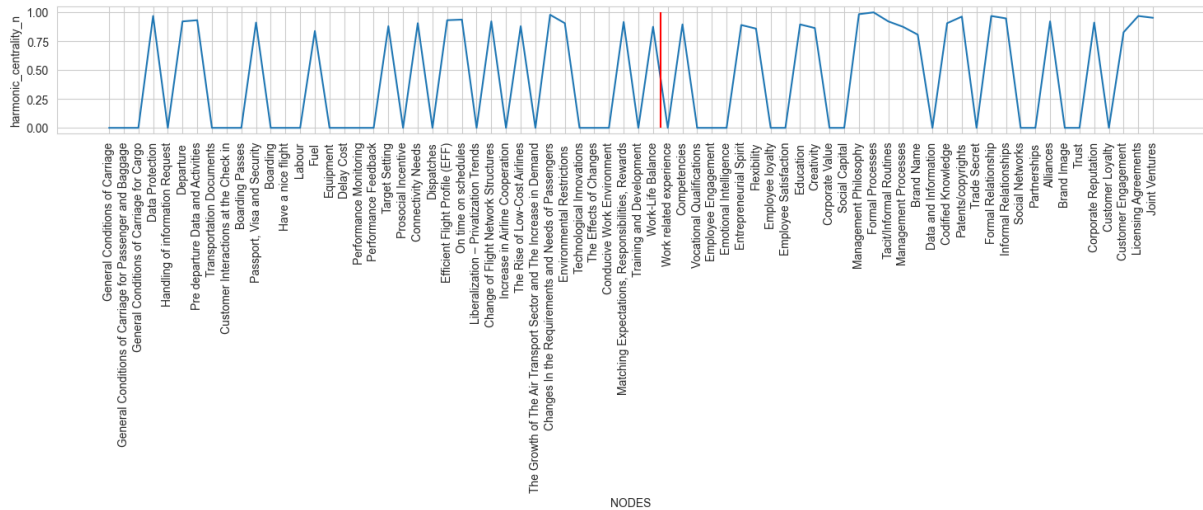


Diagram 4: Esenboğa TAV Technologies Harmonic Centrality Results

Diagram 4 visually represents the results of the Harmonic Centrality study on the Esenboğa TAV Technologies Department. In this situation, the characteristic labelled "Formal Process" has the greatest node score, reaching 1. This specific node asserts its position of highest prestige within the complicated dynamics of the network. The concept in question falls under the "Structural Capital" classification, a prominent aspect within the wider domain of intellectual capital. The assignment of a centrality value of 1 to this particular node highlights its remarkable impact on the overall structure of the network. This highlights its crucial significance in supporting the organisational structure via its unique contribution to structural capital. The centrality of the characteristic highlights its significance in influencing the operational environment of the department, facilitating streamlined and effective procedures that enhance the department's strategic worth as a whole.

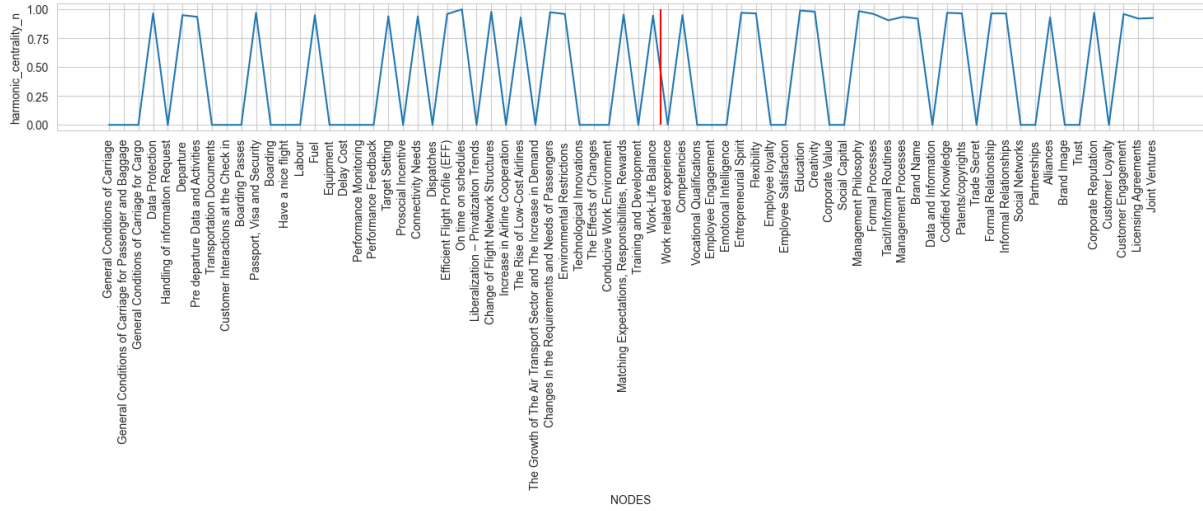


Diagram 5: Esenboğa PRIMECLASS Harmonic Centrality Results

Based on the Harmonic Centrality Results shown in Diagram-5 for Esenboğa PRIMECLASS, it is evident that the attribute "On time on schedules" exhibits the most prominent node score of 1. This denotes its prominent place within the field of network analysis. Significantly, this characteristic is classified as "Operations Efficiency," a vital element covered within the wider framework of Airport Digital Transformation. The attribute's centrality value of 1 highlights its significant influence on the overall structure of the network. This highlights the significance of its function as a primary catalyst for enhancing operational efficiency within the framework of Esenboğa PRIMECLASS. The centrality score of this characteristic underscores its crucial significance in maintaining timeliness and adherence to schedules, hence making a substantial contribution to the overall operational performance of the organisation.

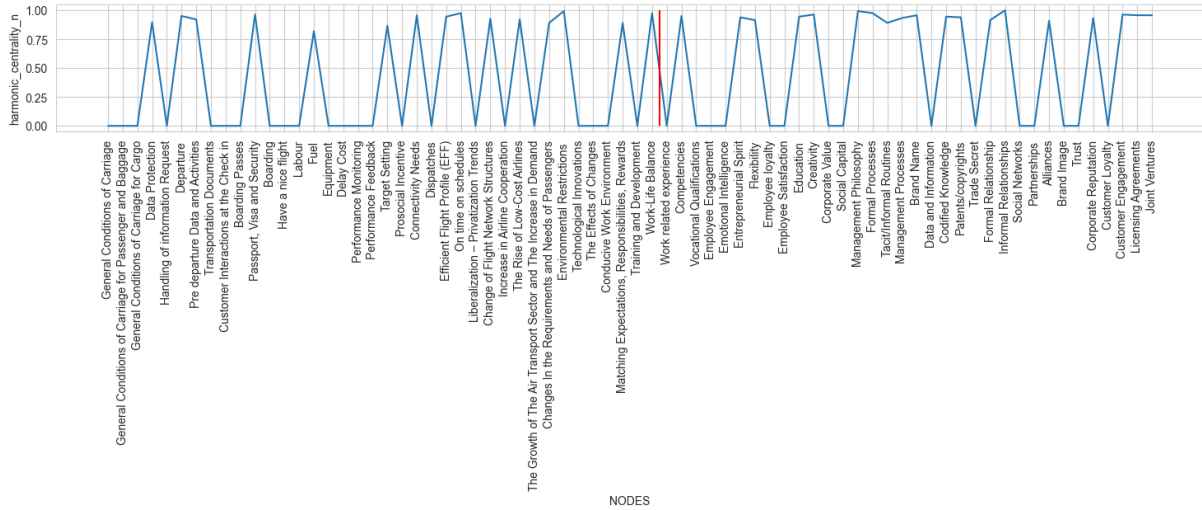


Diagram 6: Esenboğa TAV Securities Harmonic Centrality Results

Based on the observations outlined in Diagram 6 about the Harmonic Centrality examination of the Esenboğa TAV Securities Department, the attribute labelled "Informal Relationship" has the highest node score of 1. This result indicates its significant position inside the network analysis. Significantly, this characteristic demonstrates unity within the "Relational Capital" domain, a crucial aspect of intellectual capital. The assignment of a centrality value of 1 to this feature highlights its significant impact on the network's structure. This highlights the significance of its function as a pivotal element in fostering and fostering informal connections, which contribute substantially to the organization's relational capital. The centrality score highlights its significant role in promoting connections, establishing rapport, and encouraging meaningful interactions among persons within the Esenboğa TAV Securities Department. The larger intellectual capital framework is supported by these relationship dynamics, which contribute to the department's operational success and strategic influence.

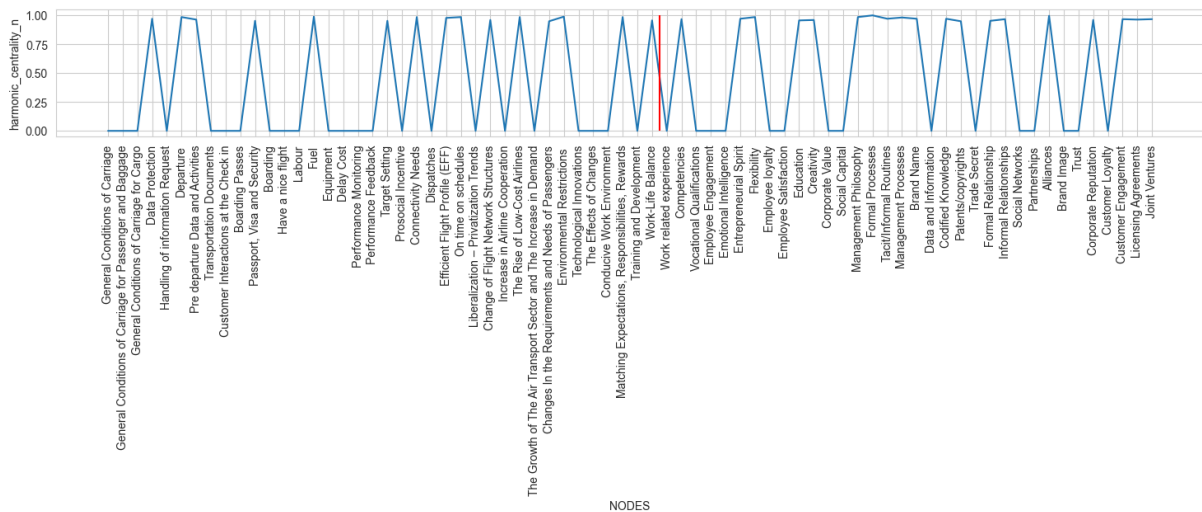


Diagram 7: Esenboğa HAVAŞ Harmonic Centrality Results

According to the study conducted on Diagram-7, which illustrates the Harmonic Centrality of Esenboğa HAVAŞ, the characteristic labelled as "Formal Process" stands out as the node with the greatest centrality score of 1. This indicates its highest level of prominence within the field of network analysis. Significantly, this characteristic corresponds to the classification of "Structural Capital," which has importance as a component of intellectual capital. The attribute's centrality value 1 highlights its significant impact on the network structure. This further solidifies its position as a fundamental element in influencing established procedures, substantially contributing to the department's structural assets. The significance of this feature highlights its crucial role in creating and sustaining efficient and standardised procedures within Esenboğa HAVAŞ. The above activities improve the department's operational coherence and strategic basis, emphasising the significance of formalisation in strengthening structural capital and enhancing overall organisational performance.

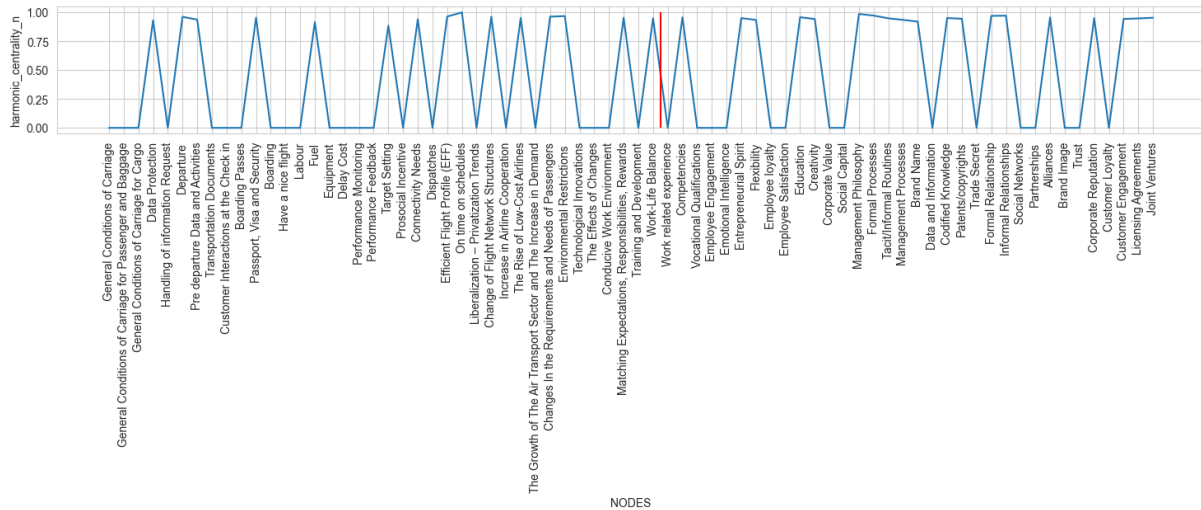


Diagram 8: Esenboğa TAV Terminal Management Harmonic Centrality Results

According to Diagram-8, which illustrates the results of the Harmonic Centrality study conducted on Esenboğa TAV Terminal Management, the attribute "Matching Expectations, Responsibilities, Rewards" emerges as the most prominent, with a node score of 1. This discovery indicates its prominent position within the field of network analysis. Significantly, this characteristic pertains to the "Enhancing Employee Retention" classification, a fundamental criterion within the wider domain of Airport Digital Transformation.

The centrality score of 1 assigned to this attribute underscores its potent influence within the network structure. This underscores its central role in orchestrating a harmonious alignment between employee expectations, responsibilities, and rewards, culminating in a strategy that amplifies employee retention. The centrality score emphasizes its crucial contribution to enhancing employee satisfaction, engagement, and overall retention levels within the Esenboğa TAV Terminal Management. This, in turn, underscores the intricate connection between this attribute and the overarching goal of cultivating a high-performing workforce through targeted digital transformation initiatives.

The research results elucidate the complex network of functional relationships that form the fundamental basis of the organization's core purpose. The imperatives of digital transformation criteria influence the functional interdependencies discussed in this context. These interdependencies can be categorised under overarching themes that include enhancing customer service, optimising operational costs, increasing employee productivity, improving operational efficiency, and strengthening employee retention. The intricate network of linkages solidifies into a complex web, representing the precisely constructed socio-technical fabric established by TAV Holding and its subsidiary businesses.

The use of network analysis, specifically using harmonic centrality with the aid of Python's NetworkX library, has served as an enlightening tool, shedding light on the intricate significance and impact that each node has inside the complex structure of the network. The research results highlight the nodes identified as the exemplars of prestige within each department and subsidiary. The nodes in question, highlighted because of their high harmonic centrality ratings, confer significant importance to the overall network. As an example, it can be seen that the node denoted as "On time and schedules" achieves a pinnacle of excellence inside the confines of Esenboğa TAV Head Office, attaining the highest possible node score of 1. The numerical representation mentioned highlights its significant importance in the context of "Operations Efficiency," which symbolises the wider domain of Airport Digital Transformation.

Consistent patterns of findings emerge among several departments and subsidiaries. The highest node ratings are obtained by distinct nodes matched with different Airport Digital Transformation features. These nodes enhance networks, reinforce structural capital, and foster relational capital. In conclusion, this complex compilation of research outcomes enhances our comprehension of how network analysis, combined with harmonic centrality, offers a guiding tool to traverse the complicated interrelationships and power dynamics inside the ever-changing environment of TAV Holding and its affiliated companies. These findings enhance the understanding of the dynamic capabilities that flow through the organisational structure and illuminate the interaction of functional dynamics. Each information and its impact initiate a series of coordinated responses and reactions.

Conclusion

The overwhelming majority of legacy organisations, also known as brick-and-mortar businesses, were predominantly founded before the advent of the digital era. These companies do not currently perceive their business environments as digital ecosystems. Therefore, top executives should devise methods for monetising novel and unforeseen changes in business models that optimise the gratification of client needs and experiences.

In this paper, we examine digital transformation's impact on the dynamic capabilities of the aviation industry, specifically airport operations. Consequently, the following research question has been posed: "Can network analysis be used to comprehend how digital transformation has affected dynamic capabilities?" Table 2 displays the findings of the analysis conducted to answer this query. By this, the nodes and attributes that disclose the primary characteristics of the companies are shown in Table 2.

Table 2: Out-link Nodes and Digital Transformation Functions

	The Most Prestigious Node (Influence To Other Nodes)	The Most Central Function (Influence on other functions)	Interpretation
TAV Head Office	On-time on schedules	Operations Efficiency	In the context of harmonic centrality, the most prestigious node indicates the dynamic capability impacts of digital transformation functions are examined. Thus, influencer functions are detected and interpreted locally.
Esenboğa TAV Finance Department	On-time on schedules	Operations Efficiency	
Esenboğa TAV Logistic Department	Change of Flight Network Structures	Strengthen Networks	
Esenboğa TAV Technologies	Formal Processes	Structural Capital	
Esenboğa PRIMECLASS	On-time on schedules	Operations Efficiency	
Esenboğa TAV Security	Informal Relationships	Relational Capital	
Esenboğa HAVAŞ	Formal Processes	Structural Capital	
Esenboğa TAV Terminal Management	Matching Expectations, Responsibilities, Rewards	Increase Employee Retention	

According to NetworkX Harmonic centrality, the data about all companies participating in the study were analysed and displayed in diagrams 1 through 8. The driving effect of a node and graph within a system is the activation of other nodes and graphs. In other terms, it indicates the ability to shape nodes and graphs. It illustrates both the structural and dynamic aspects of a network's characteristics.

One of the objectives of this analysis is to exploit the explanatory potential of the networks. To the best of our knowledge, this study is the first to use network analysis within the framework of open innovation programmes to investigate the relationship between airport digital transformation and flexible management capabilities. Because of the analysis, it is evident that combining network analysis with harmonic centrality is one method to comprehend how the digital transformation has affected dynamic capacities.

The metric of harmonic centrality arises as a discriminating measure that reveals the underlying dynamics of nodes within the scope of the study. The significance of a node's ability to initiate activations across the network becomes apparent inside the complex framework of linked nodes and graphs. This characteristic is closely associated with its ability to influence the structure of nodes and graphs. Nodes with this distinctive power exceed the limitations of passive communication, exhibiting active communication principles that surpass their inert counterparts. The capacity for active communication, inherent in nodes that have significant influence and occupy important positions, plays a crucial role in regulating the dissemination of information within networks. This highlights the deep importance of engaging in effective communication to foster the inherent dynamic capacities of a flourishing network.

Moreover, effective communication may be clearly understood via the harmonic centrality framework. The manifestation of this characteristic is significantly amplified in the most highly regarded node, functioning as a precursor to network cohesion. Underlying this basic notion is a fundamental implication—the average network distance has significant consequences for the effectiveness of the

network. The importance of the harmonic concept of the system, at both a global and local scale, is extended to include topological and metrical networks. Nevertheless, it is crucial to acknowledge that this topological approximation is a resilient though basic portrayal, as Marchiori and Latora (2000) emphasised.

Upon further investigation, the research establishes airport management as a central focus, providing a miniature representation that reflects the wider scope of the aviation business. Using our analytical framework, we analyse the emergence and influence of certain functions and nodes that drive the ongoing digital transformation process. The impact of their influence may be seen in the enhancement of operational efficiency, the strengthening of structural capital, and the cultivation of relational capital. These fundamental principles are integral to the concept of dynamic capacities.

Our research explores the intersection of digital transformation and dynamic capacities, focusing on Harmonic Centrality as a valuable tool for analysing complex relationships. The aviation industry, particularly Esenboğa Airport, provides a valuable setting that offers significant insights with broader implications. This study highlights the significance of Harmonic Centrality as a means of connecting the domains of digital transformation and dynamic capabilities. It is a crucial tool for organisations navigating the ever-changing terrain.

The main purpose of this study is to provide a comprehensive understanding of the impact of digital transformation on the dynamic capacities of established organisations, specifically focusing on airport administration as an illustrative example. In conjunction with using NetworkX in the Python programming language, the intentional pursuit of harmonic centrality outcomes is our set of methodologies for interpreting and expressing these observations. However, within academia, a significant constraint becomes apparent - the lack of research that differentiates between harmonic centrality and its closely related concept, closeness centrality. This statement presents an opportunity for more investigation and improvement, as our paper aims to enhance and broaden the discussion at the intersection of digital advancement and organisational effectiveness. Considering this objective and methodology, future research will be conducted.

Considering the impact digital technologies have had on the organization's dynamic capabilities: This topic may investigate how digital technologies influence how organisations manage and evaluate their intellectual capital and the significance of creating and capturing value from it with dynamic capabilities. One could research the creation and utilisation of these new forms of intellectual capital and their impacts on organisational performance.

Examining the role of digital technology in protecting and managing intellectual property: Disruptive technologies make it easier to imitate, trade, and utilise intellectual property, but they also make it more difficult to protect and manage it. Future research may investigate digital technologies' role in preserving and managing intellectual capital within a dynamic capabilities framework.

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The digital transformation has brought significant changes to the dynamic capabilities of legacy organizations, particularly in the aviation industry and airport operations. This study employed network analysis and harmonic centrality to explore the impact of digital transformation on dynamic capabilities. The findings shed light on the relationships and functions within the network of TAV Holding and its subsidiaries.

The analysis identified key nodes representing influential functions in each department or subsidiary, providing insights into the digital transformation criteria and their effects on dynamic capabilities. The most prestigious nodes, such as "On time and schedules" and "Formal Processes," were associated with operations efficiency, structural capital, and relational capital.

The combination of network analysis and harmonic centrality proved to be an effective approach for understanding the impact of digital transformation on dynamic capabilities. It revealed the

interconnections and driving effects of nodes and graphs within the network, highlighting the system's structural and dynamic aspects.

This study contributes to the field by utilizing network analysis within the context of open innovation programs to investigate the relationship between airport digital transformation and flexible management capabilities. It offers valuable insights into how information flows and how nodes shape and influence the network.

While the study demonstrates the potential of harmonic centrality, it is important to note the limitations, such as the need for further exploration and distinction between harmonic centrality and closeness centrality. Future research could delve deeper into these concepts and explore the role of digital technologies in managing intellectual capital and protecting intellectual property.

In conclusion, this research emphasizes the significance of digital transformation processes in shaping the dynamic capabilities of legacy organizations, with specific implications for the aviation industry. By understanding and leveraging the potential of digital technologies, organizations can optimize their operations, enhance customer experiences, and adapt to the evolving business landscape.

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