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The relationship between digital transformation, financial support, and innovation in higher education institutions: evidence from Peruvian universities

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Abstract

Both public and private institutions have been affected by the impact of the pandemic. This situation has pushed these institutions to move to a virtual environment where multiple digital tools have been developed to improve the performance of teaching and administrative staff. However, not all institutions have the same resources and support to successfully engage in these projects. This study aims to determine whether financial viability and support influence the digital transformation process in universities, and whether the latter impacts on their innovation capacity. To empirically verify these relationships, this study collected data from 24 Peruvian universities through an online survey. Data were analyzed with a principal component analysis (PCA) technique to generate a digital transformation index. The results showed that financial viability and support have a positive impact on universities' digital transformation index, and that this index further impacts positively on universities' innovation levels. Both theoretical and practical implications are discussed.

Keywords: Digital transformation index, innovation, higher education, financial viability and support

Introduction

Educational systems have been developed as tools for knowledge transmission, and their evolution has occurred at the same pace as the evolution of society. Thus, if a society acquires more knowledge and successfully transmits it to younger generations, greater prosperity and development are expected in the future (Bridgeland et al., 2009). Educational systems initially focused on knowledge about hunting and harvesting (Cañedo Andalia & Karell Marí, 2004). Over the years, these systems have covered more human knowledge fields, while a larger proportion of the population has had access to it (Carvajal, 2019). Nowadays, education is considered a universal right (UNESCO, n.d.). Hence, regardless of the tools used for knowledge transmission, there is an expectation of quality education; however, it is not always possible due to limited resources (Carvajal, 2019).

Higher education institutions, like other sectors, have been using information technologies (IT) to improve their processes and added value (Torres Cañizález & Cobo Beltrán, 2017). This IT-based trend is known as digital transformation, which refers to the adoption of new technologies within the processes and activities of an organization that leads to the construction of new business models, delivery of higher quality services to customers, and the exploitation of new opportunities (Ochoa, 2016). To be able to measure institutions' digital-transformation-related capacities, digital maturity models emerge. A high digital maturity implies a continuous improvement strategy. Organizations capable of achieving these high levels of digital maturity may receive the benefits associated with innovation culture (Moreno Gómez et al., 2022). However, not all

organizations (or educational institutions specifically) have the same resources or are managed with the same motivation and support (Casalet, 2021); variability in terms of digital maturity is thus expected among these institutions.

The Covid-19 pandemic may have accelerated universities' digital transformation. Indeed, during the pandemic, people had to stay at home due to lockdowns and similar measures that restricted the mobility of the population as well as the number of people who could gather in one place. Thus, universities had to change from face-to-face classes to virtual classes in order to keep up their activities and knowledge transfer. IT enables universities to deliver classes in a remote, synchronous mode, and staff could also move to home-office activities (Velasco Castañeda & Gómez Rodríguez, 2021). Although these virtual systems were not entirely new (previously, there were some universities that provided a few courses through virtual platforms), virtuality has never in human history been implemented at a global scale. In 2020, 98% of universities worldwide decided to move classes online (Roberts, 2021).

Most educational centers chose to transfer their physical spaces to digital environments, where students would be offered various services including remote, synchronous classes. A good internet connection and electronic devices were required for this task, otherwise, students' performance could be adversely affected. Even though the use of IT-based solutions within higher education institutions started two decades ago, the pandemic pushed these institutions to implement and invest in a digital environment to offer not only virtual classes but also various services supported by technologies such as cloud computing, collaboration tools, and so on. These solutions not only benefit students and teaching staff, but also administrative staff in general (Velasco Castañeda & Gómez Rodríguez, 2021).

Based on the above discussion, this study aims to determine the impact of financial viability and support on digital transformation, and the impact of this last on innovation. The association among these concepts is expected to improve innovation culture within higher education institutions in the long term. It is expected that this study's results may be of interest to government institutions, higher education institutions, and students, who may need this information before applying to a university. Finally, theoretical and practical implications are provided.

Literature review

A literature review about prior research on digital transformation in organizations was conducted. Three digital maturity models were found for assessing digital transformation status. The features of these models are discussed in the following paragraphs in order of complexity, considering the number of dimensions of each model.

The first model, proposed by Pachón Molina (2022), suggests two dimensions to assess the digital maturity of organizations: strategic and technological dimensions. The strategic dimension refers to the set of capabilities that an organization has in order to offer its services and respond to market needs. The technological dimension refers to the tools that this organization has in order to complement and offer the best quality of its services. Pachon (2022) surveyed 55 Colombian universities, and classified them into four levels according to how mature they are in terms of digital transformation: beginners, adopters, experts, and digital masters. However, its main weakness is that it is limited to only two general dimensions, without providing more details about the digital transformation status of these organizations.

The second model, proposed by Rodríguez-Abitia and Bribiesca-Correa (2021), undertook three data collection stages. The first stage covered 30 organizations in seven countries, while the second focused on 37 organizations in eight countries. The third stage covered a larger sample consisting of 182 organizations

in 11 countries. It should be highlighted that this model included Latin American countries in its analysis, and, to improve its external validity, also considered commerce, manufacturing, and services organizations in addition to educational institutions.

This model then proposed five organizational dimensions to assess digital transformation capabilities in universities: digital strategy, leadership and culture, market digitization, strengthened logistics, and dynamic and digital capabilities. Along with these dimensions, three transformational objectives are proposed in this model: value creation, technological benefit, and structural agility. In addition, this model proposed innovation and financial aspects as cross-sectional variables applying to the complete framework, although it neither presented any empirical evidence nor developed further the relationship of these cross-sectional variables and the five dimensions of universities' digital transformation.

The third model, proposed by Rossman (2018), surveyed 240 executives responsible for digital transformation in three different countries: Germany, Austria, and Switzerland. This maturity model proposed eight dimensions: strategic dimension, leadership dimension, market dimension, operations dimension, people and skills dimension, cultural dimension, governance dimension and technology dimension. This model, however, does not included Latin American countries and was proposed for general organizations, and thus may not capture universities' specific needs.

The first model was discarded due to its simplicity. Between the second and third models, the one proposed by Rodríguez-Abitita and Bribiesca-Correa (2021) was chosen for this study because of the following three criteria. First, it is a model designed for universities and was assessed including Latin America countries, and thus it is a good match for the context under study. (The third model was applied to a broader range of organizations and included only European countries). Second, it is a more recent model than the third one, and thus it reflects the state of the art in this field. Third, it included 11 countries in its analysis, and thus it may have a better external validity than the third one, which only included three. Hence, the second model was used to elaborate a measurement instrument adapted to the Peruvian higher education context.

Finally, given that the weakness of the second model is that it did not develop further the relationship between its proposed cross-sectional variables—innovation and financial support—and the five proposed dimensions of digital transformation, this study will contribute to the existing literature with a theoretical proposal for these relationships, and an empirical validation of their existence, all in a new context: Peruvian higher education institutions.

Conceptual framework and hypotheses

The digital transformation model proposed by Rodríguez-Abitia and Bribiesca-Correa (2021) is presented in Figure 1. The vertical axis is divided into three transformational objectives: value creation, technological benefit, and structural agility. Value creation refers to the way in which universities take advantage of their available resources to formulate new ways to provide their services (Amit & Zott, 2001); technological benefit captures the way in which universities adopt technological applications to improve their activities (Sampson, 2017); and structural agility reflects the independence of the university members to speed up the decision-making process (Ilieva et al., 2018).

The horizontal axis of the model considers five organizational dimensions: digital strategy, leadership and culture, market digitization, strengthened logistics, and dynamic and digital capabilities. These five dimensions will measure universities' digital maturity in the present study. In addition, there are two cross-sectional variables (namely, financial viability and support, and innovation); their relationship with the five

dimensions of digital transformation will be proposed and empirically assessed in this study. These seven concepts are developed and explained here.

Dimensions of digital transformation

The proposed five dimensions are conceptualized as follows.

Digital strategy (DS)

In this study, following Gobble's definition (2018), DS refers to the decision of universities to adopt a priority path that leverages the changes and opportunities of a mix of digital technologies to support their activities, processes, and competencies. Hence, DS has a special relationship with innovation because a university may adopt technological applications throughout its internal and external value chain, seeking a flexible structure which continuously generates new products and services (Correani et al., 2020).

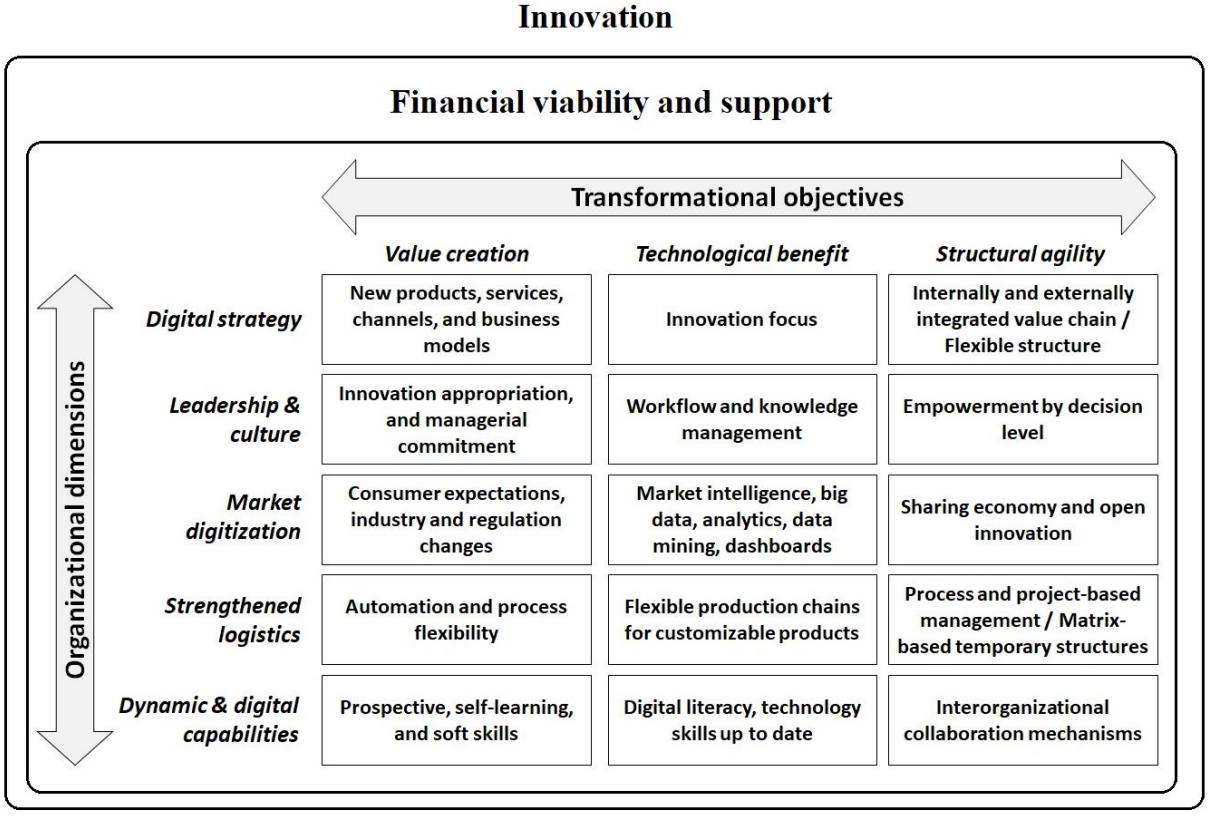

Figure 1. Digital transformation model proposed by Rodríguez-Abitia and Bribiesca-Correa (2021)

Leadership and culture (LC)

In the context of digital transformation, organizational representatives taking decisions must demonstrate that they work for the interests of their organizations rather than for their own (Gubernatorov et al., 2021). Hence, instead of taking decisions authoritatively, they are encouraged to empower their work teams. Also, considering that ideas may be generated at any level of the organization, it is recommended that all these initiatives be considered and assessed by managers in order to generate a culture rooted in strategic orientation, workers' skills, and an administration open to promoting innovation, commitment, and

knowledge management (Isensee et al., 2020). On that basis, in this study, LC will be evaluated in terms of universities' technical, pedagogical, administrative, and organizational challenges (Håkansson Lindqvist & Pettersson, 2019).

Market digitization (MD)

Technology adoption enables improvement in the performance of an organization only to the extent that the organization can adopt these technologies at the same speed as its consumers do (Sanchez-Riofrio et al., 2022). Although technological development improves efficiency in the transactions of an organization, these changes may face resistance from users.

In the Peruvian context, for example, the National Superintendence of University Education (SUNEDU, its acronym in Spanish) has been assessing higher education institutions, which resulted in many of them losing their authorization to operate because they did not meet the minimum required infrastructure to offer such services. In addition, the Covid-19 pandemic has forced universities to move to an unplanned virtual service, leading them to face new challenges. All these changes and regulations may encourage universities to be prepared with contingency plans to deal with potential disruptions in the market.

Strengthened logistics (SL)

Organizational logistics can be strengthened through the adoption of technologies to gather information effectively and in real time. In addition, technologies enabling automatic processing for services may reduce the associated operating costs and improve their quality (Jiang & Su, 2013). Hence, SL refers to the extent to which universities involve new technologies throughout their processes in order to offer better quality service to their students and staff. For example, portals in which students can verify their academic progress, teaching staff can automatically upload reports and assignments, and staff members can manage their projects will lead to an optimal logistic performance.

Dynamic and digital capabilities (DDC)

In this study, DDC refers to the extent to which a university promotes inter-organizational collaborative mechanisms, encourages continuous training in technological skills for its members, and focuses on self-learning. When a university starts a process to adopt new technologies, a tension commonly occurs between the emerging strategy and the available resources (Yeow et al., 2017). To solve this tension, it is important to train the workers and also offer them some freedom to be self-reliant and proactive in problem solving (Yeow et al., 2017).

Cross-sectional variables

The proposed two cross-sectional variables are conceptualized as follows:

Financial viability and support (FVS)

In this study, the cross-sectional variable FVS refers to the extent that a university is prepared to financially respond to the changing market in the most efficient way, being aware of the financial viability for the adoption of a new technology and the associated project details (Leong et al., 2022). Universities, like organizations in any other field, must be economically prepared to ensure their subsistence when facing any disruption in the market (Prince & Sullivan, 2000).

Innovation (INN)

This cross-sectional variable promotes the management of technology and knowledge for the creation of a technological ecosystem (García-Peñalvo, 2016). It seeks to create an environment in which new products and services are continually proposed in accordance with the needs of the market. Even in the event of scarcity of resources, a spirit of openness in the face of new opportunities strengthens the sense of innovation (Del Moral Pérez et al., 2014).

Research hypothesis

Digital transformation requires the implementation of technology in organizational processes, and thus financial resources are needed to undertake these technology-based projects. The need of financial resources can be seen in the fact that micro and small companies are the less digital mature companies (Priyono et al., 2020). Indeed, Priyono et al. (2020) differentiates the pattern of digital transformation of those companies with liquidity from those without it. Hence, we argue that the existence of financial resources may facilitate and increase the probability that universities may invest more in digital transformation initiatives, which further impacts positively on their digital maturity. This study hypothesizes:

H1: *Financial viability and support has a positive impact on digital transformation.*

Innovation literature has recognized the importance of digital maturity to achieve both innovation and competitive advantages (Blichfeldt & Faullant, 2021). Indeed, the use of technology in organizational processes changes the way in which organizations create and deliver products and services (Blichfeldt & Faullant, 2021). Now, according to the fourth edition of the Oslo Manual, business innovation is defined as "a new or improved product or business process (or a combination thereof), that differs significantly from the firm's previous products or business processes and that has been introduced on the market or brought into use by the firm" (OECD & Eurostat, 2018, p. 20). Hence, those organizations that are re-defining their processes continuously either to improve the products or services they produce, or the way in which they are delivered, are more innovative than those that are not changing their processes (Blichfeldt & Faullant, 2021). Based on these arguments, this study proposes that those universities that are digital mature are more innovative than those that have low levels of digital maturity. This study also hypothesizes:

H2: *Digital transformation has a positive impact on innovation.*

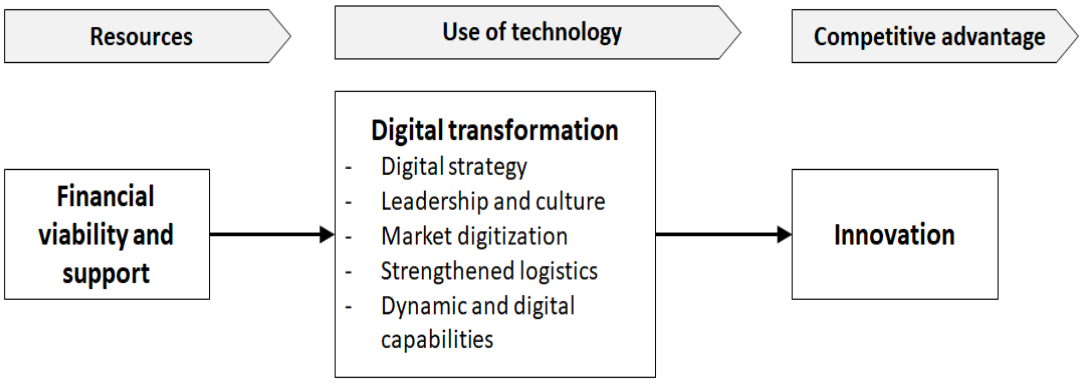

Figure 2. Research model

Methodology

Measurement instrument

Figure 2 shows the proposed research model. Each of the seven variables proposed by the model (five digital transformation dimensions and two cross-sectional variables) was measured with four indicators adapted from Rodríguez-Abitia and Bribiesca-Correa (2021). These indicators cover the three objectives proposed in Figure 1 in each dimension (Rodríguez-Abitia & Bribiesca-Correa, 2021). In addition, these indicators were adapted to fit the specific context of Peruvian universities, and were measured using a 5-point Likert scale from "strongly disagree" to "strongly agree". Table 1 shows all the indicators that are part of this study's measurement instrument.

Table 1: Survey items

Code	Indicator
Dimension: Digital strategy (DS)	
DS1	My university carefully plans the creation of new products and services that include technology as an integral part of the experience that the students receive.
DS2	My university plans projects that would not be possible without the support of information and communications technologies.
DS3	My university uses technology to make our administrative processes more efficient and integrated.
DS4	Our organizational structure is modified as required by our strategies.
Dimension: Leadership and culture (LS)	
LC1	Innovative ideas are welcomed from workers, carefully studied by management, and supported to become investment projects.
LC2	We have systems that enable us to share work experiences so that other workers can take advantage of them.
LC3	We have technology that enables us to communicate and jointly generate solutions (e.g., use of cloud management tools).
LC4	There is a high level of empowerment for all workers.
Dimension: Market digitization (MD)	
MD1	My university takes student expectations and behaviour into account when defining products and services.
MD2	My university takes actions based on the changes that occur in the current regulations.
MD3	We take advantage of internal and external data to understand what is happening in the market and facilitate decision making (e.g., use of big data and data mining).
MD4	My university collaborates with many private, educational, or government entities to generate innovations.
Dimension: Strengthened logistics (SL)	
SL1	The processes at my university are flexible.
SL2	Technology enables us to personalize the products and services we handle.
SL3	Technology (e.g., email, social media, learning management system) enables us to reach students anytime and anywhere.
SL4	My university has matrix organizational structures.
Dimension: Dynamic and digital capabilities (DDC)	
DDC1	The staff at my university have good digital skills (e.g., computer literacy, data entry, social media, word processing, secure information processing).
DDC2	My university keeps workers up-to-date in the use of new technologies.
DDC3	Employees at my university know where and how to learn on their own about emerging technologies (e.g., artificial intelligence, virtual reality, augmented reality, 3D printing).
DDC4	Staff at my university know how to apply technology to their working activities.

Cross-sectional variable: Financial viability and support (FVS)	
FVS1	Strategic planning always includes the financial aspects necessary for its execution.
FVS2	Whenever we need to buy new technology, we have the resources to do so.
FVS3	My university allocates resources by project or process, as needed.
FVS4	My university formally monitors the financial resources used in technological innovation projects and the teams that carry them out.
Cross-sectional variable: Innovation (INN)	
INN1	My university always seeks to generate value based on innovation.
INN2	My university constantly creates innovative products, services, and business models.
INN3	My university innovates in internal processes and with business partners.
INN4	Whenever an innovation proposal is made, it is based on technology.

Data Collection

This study used a survey methodology for data collection. The survey was divided into eight sections. The first section captured universities' features such as number of workers, number of students, whether it is public or private, whether it is generalist or specialist, its age, its main location, and number of subsidiaries. Each section from the second to the eighth captures one of the digital transformation dimensions and cross-sectional variables proposed in the theoretical framework.

This study used a non-probabilistic sampling technique, sending an invitation to those that are more accessible because of location (most of them are located in Lima) and those that have a contact email on their website or social media. It is important to highlight that this study targeted only licensed universities. Once the communication was established, the survey was delivered and answered by the representatives of each university. A final sample of 24 universities was obtained. Table 2 shows the sample characteristics.

Table 2: Sample characteristics

Respondents n=24		
Characteristic	**Frequency**	**Percent**
Number of workers		
200 - 400	4	17%
401 - 600	3	13%
601 - 800	3	13%
801 - 1,000	1	4%
More than 1,000	13	54%
Number of students		
4,000 - 12,000	12	50%
12,001 - 20,000	5	21%
20,001 - 28,000	1	4%
28,001 - 36,000	2	8%
More than 36,000	4	17%
Public/Private		
Private	8	33%
Private non-profit	8	33%
Public	8	33%

Characteristic	Frequency	Percent
Type		
Generalist	10	42%
Specialist	14	58%
Age (years)		
10 - 20	7	29%
21 - 30	5	21%
31 - 40	1	4%
41 - 50	2	8%
Over 50	9	38%

Data Analysis

First, a digital transformation index was calculated using a principal component analysis (PCA) to reduce the variables measuring the five dimensions of digital transformation to one value. Second, the two hypotheses were assessed by using a linear regression analysis to check if there is empirical evidence of the relationship between financial viability and support, digital transformation index, and innovation levels.

Results

Principal component analysis (PCA)

A global value for each of the five dimensions of digital transformation was calculated as the average of its four indicators. Then, a PCA was conducted with these five variables as input. Bartlett's test of sphericity was performed to assess the suitability of PCA. This test was statistically significant (p-value < 0.05), which means that PCA is feasible. Further results revealed that only one component has an eigenvalue greater than one (eigenvalue of the first component = 3.918), and that it explains 78% of the total variance in these five dimensions. Hence, a digital transformation index was developed by using the value of this first component.

Linear regression

In the case of the first hypothesis, financial viability and support (FVS) serves as the independent variable, whereas the digital transformation index of the universities (estimated in the previous sub-section) plays the role of dependent variable. It was necessary to check if the linear regression assumptions are met. First, a Durbin-Watson test was performed to check that there is no correlation among errors. The value of this test was 2.156 (close to 2), which means that this first requirement is met. Second, absence of multicollinearity is met considering that all VIF values were under the value of 5. Third, the normal distribution of errors and constant variance of errors (i.e., homoscedasticity) were both assessed by visual inspection (figures omitted for brevity), suggesting that these two assumptions are met. In the case of linearity between variables, this assumption was assessed directly by checking the coefficient of the independent on the dependent variable. This coefficient was statistically significant ($\beta = 1.117$, p-value < 0.01), suggesting a linear relationship between both variables and providing support for H1. In addition, FVS explains 52.2% of the variance in digital transformation.

In the second hypothesis, the independent variable is the universities' digital transformation index, and the dependent variable is innovation. The same procedure was followed as in H1 to check the linear regression

assumptions. First, the Durbin-Watson test shows that there is no correlation among errors, considering that its value was 2.069 (close to 2). Second, there is no evidence of multicollinearity considering that all VIF values were under the threshold of 5. Third, the assumptions related to the normal distribution of errors and homoscedasticity were both assessed by visual inspection, suggesting that these two requirements are met (figures omitted for brevity). Finally, in the case of the assumption of linearity between variables, it was directly analysed by checking the coefficient of the independent on the dependent variable. This coefficient was statistically significant ($\beta = 0.545$, p-value < 0.01), meaning that there is evidence of a linear relationship between both variables, and giving support for H2. In terms of variance explained, the digital transformation index captures 75.5% of the variance in innovation. Table 3 shows a summary of the results for both hypotheses.

Discussion

The development of a digital environment provides a new set of tools to improve the quality of higher education services. With the spread of information technologies, the activities between teaching staff and students have been reinforced. In addition, universities' administrative processes have also been improved with this set of digital tools. The objective of this study is to determine if the financial viability and support received by projects and activities by higher education institutions has an impact on digital transformation, and if the latter has an impact on universities' levels of innovation. To measure digital transformation in universities, five organizational dimensions were considered, and with them a single index was generated using principal component analysis (PCA). Then, the proposed relationships among variables were empirical validated by statistically assessing data collected through surveys. The associated results showed that financial viability and support have a positive impact on digital transformation, and that digital transformation has a positive impact on innovation. In short, the two hypotheses in this study were verified.

Table 3: Linear regression results

Variables	H1	H2
Independent variables		
Financial viability and support	1.117*	N/A
Digital transformation index	N/A	0.545*
Explained variance		
R2	52.2%	75.5%

* p-value < 0.01, N/A = Not applicable

Theoretical implications

Through a literature review, this study found that, although previous studies called for attention to financial support and innovation, proposing these two concepts as cross-sectional variables relating to digital transformation at universities, the connection between them and the five dimensions of digital transformation were not further developed either theoretically or empirically. Accordingly, this study contributes to the literature with a theoretical conceptualization of the relationship between those cross-sectional variables and digital transformation. In addition, this study provides empirical evidence of the existence of these relationships.

Practical implications

To evaluate the status of universities' digital transformation, a digital transformation index was built using principal component analysis (PCA), grouping five organizational dimensions proposed by Rodríguez-

Abitia and Bribiesca-Correa (2021). Therefore, managers could use these dimensions and the associated PCA results to estimate their own digital transformation index. In addition, managers can check the status of each dimension to decide which strategies they may propose to improve each of them as well as the index as a whole.

It is important to highlight that for a continuous improvement, it is necessary to have some indicators that allow universities to check whether they are achieving their goals. Digital transformation is a need nowadays, particularly at higher education institutions considering the disruptive context faced in recent years. Thus, there is a real need to monitor universities' levels of digital transformation in general, and of each dimension in particular.

In the case of financial viability and support, it is important to establish not only a strategy to guide universities' digital transformation but also to find support for implementing the associated technology-based projects. Prior literature has highlighted the importance of finding an adequate sponsor for projects of this kind. For example, Iriarte and Bayona (2020), in their systematic literature review, found that top management support is a critical factor for the success of technology-based projects. Then, if universities have financial resources, managers should identify an adequate sponsor for their projects, who should understand about technological issues and the importance of technology for the business success. In the case of universities with budget restrictions, it is important to identify public funds that can be used for innovation activities.

For example, *Innovate Peru*, the Peruvian innovation agency, has been conducting technological missions that are programs for technology adoption in micro, small, and medium enterprises (Innovate Peru, 2019). Some small-sized universities may explore if they are eligible for this program, or they are suggested to search for other similar programs that may fit better their needs. By accessing these public funds, universities may be able to invest more in their digital transformation process. Considering that funds may also come from private institutions, it would be important for universities to partner some companies that can jointly invest in projects.

In addition, financial resources and innovation may have a non-recursive relationship. That is, organizations need financial resources to achieve high levels of innovation, but in a long-term view of this relationship, high levels of innovation may further provide more financial resources. For example, universities may use their research capabilities to create patents and work with companies for technology transfer (Aboal & Garda, 2016). Patent creation represents organizations' level of innovation, while technology transfer may represent an improvement in their income. Also, it is possible that universities use their laboratories to provide services to other companies, or people in general. For example, universities are investing these days in the implementation of Fab Labs.

Although Fab Labs imply large investments of financial resources, these laboratories may generate their own resources through the provision of services to third-parties (Osunyomi et al., 2016). This practice may lead universities to establish selfsustained laboratories, and thus be able to assign their financial resources to improve other services in their digital transformation process.According to the type of universities (e.g., research-based or lecture-based, engineering or business), these institutions may identify their core services that may be demanded by the society and establish a strategy to launch these services to the general public for being able to generate more financial resources.

Limitations and future research

First, this study uses a small sample, consisting of universities from only one country. Future studies may

collect a larger sample, including universities from various countries to improve the external validity of these results. In addition, future studies may also include other organizations and not only universities, which also may improve the associated external validity.

Second, considering the statistical limitations associated with a small sample, this study was able to verify the impact of a digital transformation index, but was limited to assessing the impact of each of the five dimensions on innovation, or the impact of financial viability and support on each of these dimensions. Hence, future studies may assess the individual impact of each dimension to delve deeply into the dynamics of more specific relationships, which may open further evidence on specific strategies to be followed according to the importance of each dimension.

Finally, future studies can include new antecedents and consequences of digital transformation beyond financial viability and support (as antecedent) and innovation (as consequence). These new variables may improve the understanding of the scope of universities' digital transformation levels by providing a complete framework that gives weight to the significance of this trend in the higher education sector.

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