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Abstract: In any new technology in the traditional education system, risks are always associated with it. When left unattended, these risks may pose misuse of technology, if not cause overall inefficiency. Therefore, stakeholders of higher education institutions strive to ensure that risks are well addressed across the entire process of technology adoption from pre-setting to its operational stage. To aid in the analysis, this paper presents a Multi-Criteria Decision-Making (MCDM) approach through the Best-Worst Method (BWM) in analysing the risks involved in technology adoption among higher educational institutions. A case study is performed to attain this objective. Results showed that risks under the pre-setting stage are prioritised over other risks involved in technology adoption. Such results reflect the real-life situation in technology adoption, which puts the most emphasis on preparing the send-off of a technology prior to its actual implementation.

Keywords: best-worst method; higher educational institutions; multi-criteria decision-making; risks; technology adoption.

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1 Introduction

Academic institutions constantly face uncertainties when adopting a new technology (Sendstad and Chronopoulos, 2021). Such risks span across various concerns including technological operations, resources in budget and time, skill-wise preparations, security and overall organisation risks, to name a few (Belanova, 2023). Given the wide array of risks in technology adoption, in general, scholars have explicitly considered such risks as a construct in typical technology management scenario. For example, Tsai et al. (2019) considered risk as a perspective in understanding physician adoption of electronic medical records. Such perspective is analysed with healthcare technology self-efficacy and service level to ensure a more holistic view of the decision problem. On the other hand, Asif et al. (2023) investigated the role of risk in the adoption and diffusion of technologies in Sub-Saharan Africa, while Musyoki et al. (2022) looked into the link between risk attitudes, diversification and adoption in smart agriculture technologies in South-Western Kenya. Along this premise of taking risks as a separate construct to understand the adoption behaviour of users, Jain et al. (2022) integrated perceived risk along with environmental concerns and government support to the traditional Unified Theory of Acceptance and Use of Technology (UTAUT) model in order to understand the driving factors to the adoption intention of electric vehicles in India. Interestingly, ambiguity is coupled with the role of risk in the general technology adoption among Midwestern farmers in a research conducted by Barham et al. (2014). Similarly, risk and ambiguity in technology adoption are also focused on by Crentsil et al. (2020) in the context of aquaculture technologies in Ghana. On another take, Li et al. (2021) explored the risks of smart home adoption as well as its motivation and barriers by performing a systematic literature review and a conceptual framework to aid in smart home adoption. The same line of thought is followed by Belanova (2023) in exploring the risks of IT technology adoption across various stages. By far, these are the only research works that specifically look into the function of risk in the decision-making process. To reiterate, risks form part of the ultimate technology adoption decision and suggest better technology management in the long run.

Among these research works involving risks in technology adoption, it is noteworthy to emphasise the work of Belanova (2023), which categorises risks into adoption stages, including pre-setting, installation, initial operation and operational stages. This explicit differentiation of adoption stages further strengthens the fact that simply looking at the pre-adoption stage, which largely includes technology adoption, the remaining stages are significantly left out in the decision-making process. Such ruling out of other stages can oversimplify the adoption analysis and, at the same time, provide less reliable policy initiatives for decision-makers to apply. Furthermore, the work of Belanova (2023), although rawly presents the risks of adopting IT technology, is the only work in the literature to date that explicitly lays down the actual risks involved in each stage of technology adoption. The other research works touched on the concept of risk as a floating concept without supplementary characterisations of such risks. Therefore, with a more explicit presentation of risks involved in the technology adoption decision, it becomes rather convenient and straightforward for decision-makers to develop the most appropriate policies and guidelines in the adoption.

The technology adoption spectrum covers a relatively large consideration from the pre-setting, installation, initial operation and operational stages. As an innovative technology implementation promises excellent improvements in process efficiency and

user satisfaction, certain risks also need to be accounted for in order to make a more comprehensive decision of ultimately adopting new technology. These risks are clustered according to their stages, as shown in Table 1.

Table 1 Risks involved in every technology adoption stage

<i>Stages</i>	<i>Risks of adopting a technology & its code</i>
Pre-setting stage	<i>R1: Adoption planning errors</i>
	<i>R2: Risks related to changes in the project budget</i>
Installation stage	<i>R3: Miscalculations in the choice of technology and its installation</i>
	<i>R4: Poor integration with existing technology</i>
	<i>R5: Risks of failing to complete the project on time</i>
Initial operation stage	<i>R6: Delay in technology start-up after implementation</i>
	<i>R7: Unpreparedness of faculty members and students to use new technology</i>
	<i>R8: Insufficient qualification of faculty members</i>
	<i>R9: Functional inconsistency in actions of different departments and colleges</i>
	<i>R10: Failure to meet the expectations of administrators</i>
Operational stage	<i>R11: Risks of reduced information security</i>
	<i>R12: Risks of reduced productivity and capacity of the technology</i>
	<i>R13: Organisation risks</i>
	<i>R14: Innovation risks</i>

Source: Adopted from Belanova (2023).

Since these risks are not yet widely tackled in the literature, this section proceeds with the conceptual development of each risk and how it affects the technology adoption process. Note that the discussion is tailored to fit the views in the educational setting and technology management as a whole, although follows the major clustering provided by Belanova (2023):

- *Adoption planning errors:* The planning process in technology adoption is essentially patterned after well-established frameworks, including the Technology Acceptance Model (TAM) (Liao et al., 2022), the Technology-Organisation-Environment (TOE) framework, and the diffusion of innovation (DOI) theory (Hiran and Henten, 2020), and Unified Theory of Acceptance and Use of Technology (UTAUT) (Monteiro et al., 2022). However, these frameworks only guide decision-makers in adopting a certain technology based on some factors and considerations. In short, these frameworks remain a go-or-no-go type of tool that dictates the eventual adoption of a technology. The planning process not only revolves around the constructs of these frameworks but should also consider the vast planning horizon before and after the actual adoption. Any errors in the process can result in losses in investments and even misuse of technology (Guan et al., 2022). Considering that the investment of any technology is huge and should be carefully thought of, decision-makers make it a point to introduce some risks in uncertain decision-making processes such as technology adoption.

- *Risks related to changes in the project budget:* An often-neglected portion of the decision-making process involved in technology adoption is the inclusion of other costs related to the adoption, including installation and maintenance costs. It is a common notion that when technologies age, an increased maintenance cost must be allocated regularly to ensure a smooth flow of technology operations (Belanova, 2023; Mallingu et al., 2020). At a more specific level, a significant relationship is found between the capital budget's proportion and the acquisition of new technology (Mallingu et al., 2020). This implies that external formal funding sources must be prioritised by owner-managers when implementing any form of innovation strategy. While several technologies promise to reduce costs with its adoption (Elia et al., 2021), the acquisition decision-making process is still deemed of grave importance.
- *Miscalculations in the choice of technology and its installation:* In a technology adoption scheme, it is equally important to assess the acceptability of technology as well as its appropriateness in the context of the application. Although most research works in the literature focus on the acceptability of technology in the adoption decision, the appropriateness of technology, including its fitness for use also defines the experience of users and its eventual future adoption. To do this, an in-depth analysis of the choice of technology must be employed by decision-makers to ensure maximised benefits. As an example, universities offer opportunities for start-ups, technology incubation and other venture facilities to test out technology before commercialisation (Alkhazaleh et al., 2022).
- *Poor integration with existing technology:* Owing to the complexity of the functional capabilities of any technology, it is often developed together with other technologies to complement one another. One example is blockchain technology and Radio Frequency Identification (RFID), which needs complementary technology to make its function more practical and valuable (Li et al., 2022).
- *Risks of failing to complete the project on time:* When organisations decide to adopt new technology and embed it as a project under the organisation, a variety of factors threatens the success or failure of such action. These factors include loss of time, among many others, in terms of completing the project (Barghi and Sikari, 2020). In fact, in the specific context of IT project implementation, even with excessive time pressure to ascertain that the project finishes on time, it often leads to failure as a whole (Vaughan, 1996; Sobieraj, 2017; Sobieraj, 2020).
- *Delay in technology start-up after implementation:* As technologies are being implemented, the actual start-up may be delayed due to some factors including users who do not fully accept the innovation (Brown et al., 2002), unavailability of a technique to ensure no delays in project implementation (Krzos, 2011) and errors detected by the development team and repair of such errors (Wysocki et al., 2022), among others. These factors, although probable, still pose significant risks in hindering the full operations of a new technology adopted.
- *The unpreparedness of faculty members and students to use new technology:* Although implementing a new technological innovation appears to have more benefits than costs, decision-makers must also consider the technical preparations before the actual implementation, including the users of technology. In the case of the educational setting, technology innovations fail due to the fact that the users are

not well aware of how to operate such technologies based on its intended functions (Fitzgerald et al., 2014). In fact, during the time of the global pandemic due to the coronavirus disease (COVID-19), when a sudden shift in learning mode occurred, it became more apparent how faculty members and students were unprepared for this new mode of teaching delivery (Zubairi et al., 2021; Alismaiel et al., 2022).

- *Insufficient qualification of faculty members:* While the idea of implementing technologies into the education setting has long been well-considered, major roadblocks in curriculum design remain to hamper such implementation, especially one that points out to the qualifications of faculty members (Calder and Otreel-Cass, 2021). It is believed that faculty members are responsible for learning the operationalisation of embedding a technology, i.e., information and communication technology, into the students. Otherwise, incompetence in using technology as a learning mode may result in still adopting teacher-centred learning and having difficulties adapting to changes (Ramli and Nor, 2018). To address the lack of qualification, faculty members are exposed to Technological Pedagogical Content Knowledge (TPACK) and encouraged to have a positive behavioural orientation to the use of technology (Stinken-Rösne et al., 2023).
- *Functional inconsistency in actions of different departments and colleges:* The users of technology, usually governed by higher units, accomplish a certain set of actions in the attainment of their goals. However, due to the differences in these goals, departments and colleges in the educational setting in specific, there is a risk of inconsistency in actions across departments and colleges. In fact, these forms of inconsistency may be evident between attitude and behaviour, which then serves as a major barrier to technology use (Yuan et al., 2023).
- *Failure to meet the expectations of administrators:* Technologies are explicitly designed to cater to the needs of its users. When technologies function as expected, it dramatically affects the competitiveness of the implementing institution as well as the improvement of operations among its users (Gungor et al., 2013; Michailidis et al., 2011; Opara, 2003; Ozer, 2004; Stočes et al., 2016; Bala Subrahmanya et al., 2010). In the context of higher educational institutions, administrators act as the key decision-maker in technology adoption. It is, therefore, essential for its goals to be achieved such that the leverage of the educational pedagogy will be attained as desired. Aside from a supportive educational platform, future needs can also be predicted based on how a certain technology can fulfil its customers' expectations (Denison et al., 2006).
- *Risks of reduced information security:* Similar to any type of technology, information security remains one of the most pressing concerns when it comes to adopting new technology. In online banking where supposed stringent security is adopted, customers continue to perceive scepticism into the very nature of online banking (Hasan and Al-Ramandan, 2021). Even in the context of the Wearable Internet of Medical Things (WIoMT), risks pertaining to security, including privacy, pose a significant standpoint, particularly due to the continuous collection of users' personal health information making them subject to threats of misuse of their medical information (Bansal et al., 2010). Under such possibilities of security threats, it has become an important move to develop comprehensive measures and

policies to protect users' data and ensure the continuity and stability of services (Tawalbeh et al., 2020).

- *Risks of reduced productivity and capacity of the technology:* One of the many benefits of technological innovation is its potential to improve the productivity of users, which results in a strengthened competitive advantage (Ghobakhloo et al., 2010). Over time, as the technology is utilised, an expected reduction in productivity and capacity can be observed due to limited resources and degrading functionality (Mallinguh et al., 2020; Kunaifi et al., 2020).
- *Organisation risks:* These organisational risks include organisational structure changes or organisational management (Belanova, 2023). When technology is embedded into the operations of any organisation, including higher educational institutions, risks of restructuring the organisation may also loom. Particularly, these organisational risks become barriers to adopting new technology. Such barriers may be classified as inter-organisational or intraorganisational (Choi et al., 2020). These barriers include risks of information loss or degradation due to technological operations and changes in foundation prior to the adoption among others (Almatrodi et al., 2023; Almatrodi and Skoumpopoulou, 2023). In fact, the entire notion of digital transformation not only revolves around the adoption of technology but also considers the fitness for implementation in an organisation (Almatrodi and Skoumpopoulou, 2023).
- *Innovation risks:* Owing to the rapid emergence of more advanced technologies across various applications, the risk of updating even a recently adopted technology becomes evident and necessary to cope with competition (Tu et al., 2023). Some technologies are designed to be complementary to one another, making decision-makers simultaneously take into account a number of technologies in order to reach its maximum potential. Given such risks, decision-makers must recognise the appropriate timing of the adoption as well as its auxiliary innovative components.

1.1 Research gap analyses

Most research works in the literature focus on the preparation stage of implementing a new technology in the educational setting, which is extremely helpful to not only the technology users but also the decision-makers in terms of investment opportunities (Kalko et al., 2023; Ley et al., 2022; Wan et al., 2022; Weissenberger-Eibl and Hampel, 2021). However, the post-adoption stage of technology adoption is rarely ever explored in the literature. In fact, only too few studies look into the post-adoption scope of technology use, even from the greater perspective outside education (Yousaf et al., 2021; Gupta et al., 2020; Ng, 2020; Cho and Lee, 2020; Jia et al., 2017; Obal, 2017) despite the equally substantial impact it has on the continuance of adoption in future use. Without the proper understanding of the factors that influence the post-adoption of technology, it becomes very difficult for stakeholders to ensure that the technology serves its purpose and can be well improved for increased utilisation and efficiency (Jia et al., 2017; Cho and Lee, 2020). This scenario remains alarming given that the gap between pre-adoption research works in the literature and post-adoption ones is very high. To put it simply, there are no research works so far that consider the post-adoption of technology in the educational setting. However, the dynamics of technology adoption in such an

environment are increasingly becoming more evident. When the stakeholders of educational institutions understand the post-adoption aspect of technology management, risks can be better managed across all stages of the overall adoption process.

Among the objective means of analysing risks in the literature, the most pressing and outstanding methodology points to the use of a Multicriteria Decision-Making (MCDM) approach. For instance, Duan et al. (2021) performed a risk evaluation of electric power grid investments using the Bayesian Best-Worst Method (BBWM) and Improved Matter-Element Extension Model (IMEEM). The results showed that the power grid involved in the case study belonged to the medium grid. The overall methodology is considered to be effective and practical as well. On a similar note, a risk evaluation is also performed by Ahmed and Van Looy (2020), this time to assess blockchain implementation in enterprise systems. The risk evaluation is done using an intelligent MCDM-based model comprised of Single Valued Neutrosophic Sets (SVNSs), Analytic Hierarchy Process (AHP) and Decision Making and Trial Evaluation Laboratory (DEMATEL) methods. It has been found that security risk is an important risk to consider, but energy costs and data leaks are correspondingly important in its sub-levels. As a different take on risk analysis, Boral et al. (2021) worked on prioritising risks relating to casting defects in brake units of coaches using fuzzy MCDM-based Failure Mode and Effects Analysis (FMEA). Specifically, the MCDM methods employed are Buckley's fuzzy Analytic Hierarchy Process (fuzzy AHP) and fuzzy technique for order of preferences by similarity to ideal solution (fuzzy TOPSIS). The key findings of this work are further subject to sensitivity analysis for validation.

Considering the variety of MCDM tools that can function analyse risks, a recent one, the Best-Worst Method (BWM) by Rezaei (2015), proves to be a viable tool. In fact, BWM can handle the inconsistency issue of the Analytical Hierarchy Process (AHP) (Rezaei, 2015) and obtain weights of criteria, among other advantages. Unlike DEMATEL, BWM can provide weights of factors that represent their priority ranking in the decision-making process using pairwise comparisons. Although the capability of DEMATEL to distinguish factors based on its causal or effect nature is important, the ranking of factors can better give a clear perspective to decision-makers in terms of prioritising scarce and limited resources involved in the decision-making process. On the other hand, an extension of AHP, that is, Analytic Network Process (ANP), is also known to identify the priority ranking of factors in the decision making. However, ANP requires factors to have a known network of relationships for it to better facilitate in the analyses. The factors involved in technology adoption (i.e., risks in adoption) do not have an established network of relationships, thus, making it an unsuitable tool to generate the priority vector of such risks. Considering these limitations from other MCDM tools that can also analyse factors, BWM proves to be a fitting approach in identifying the priority ranking of factors. Several applications of BWM have been found across various problem areas such as manufacturing setting (Sofuoğlu, 2020), healthcare (Ming et al., 2020), the energy sector (Kazemitash et al., 2021) and smart product service systems (Chen and Ming, 2020). BWM can specifically evaluate criteria based on its representation in the decision process.

Therefore, this work advances the proposed set of risks in technology adoption presented by Belanova (2023) and further implements it in the context of the HEI environment. By offering a novel perspective of analysing risks under the lens of MCDM, the priority of these risks can be better established which will pave the way for stakeholders to understand how such risks should be managed for a smoother technology

adoption process. This paper is believed to advance the knowledge in managing educational technology by evaluating the risks involved in technology adoption.

2 Methodology

In the context of educational technology adoption, there are risks involved in the decision-making process that hamper, if not delay, the actual implementation of a technology. To overcome such limitations in the decision-making process of technology adoption, this paper provides a methodological framework for understanding the priority of risks under the lens of stakeholders in an HEI, which also serve as decision-makers. To illustrate the BWM approach, a case study was performed at Cebu Technological University (CTU), Cebu City, Philippines. Among the various colleges of the university, the College of Education is selected as the research environment due to its rampant call for technological innovations in terms of instruction delivery. With the consistent call for innovations, decision-makers are faced to carefully evaluate the factors that affect the adoption of technology. Furthermore, with the very limited financial and operational resources allocated to the college, the technology adoption decision process becomes more important.

Under this college, there are six departments which are headed by their respective chairpersons who serve as key entities that take part in any decision-making process in the university. These chairpersons generally establish the needs of their corresponding departments in terms of technology adoption. Since the extent of participation of these chairpersons with respect to analysing the factors that affect technology adoption is essential, they are considered as experts in this paper. These experts have been employed in the university for 2 to 24 years (mean=9.83 years, standard deviation=7.65years) with ranks ranging from Instructor to Associate Professor 3. Do note that this paper observes the viewpoint of Yin (1994) on analytic generalisation and the fact that MCDM approaches, including BWM, work best when experts of the field are tapped as subjects rather than pooling a handful of respondents who are not necessarily experts in the subject matter. In other words, the traditional statistical generalisation that broadly represents the population from a well-specified randomly produced sample pales compared to the analytical generalisation in terms of defending, disputing, extending, refining, or expanding theoretical arguments. Since analytical generalisation addresses theoretical premises, it allows for the theoretical generalisability of this work's conclusions (Ocampo and Promentilla, 2016; Medalla et al. (2020). By having a small group of decision-makers (in this case, six experts) is adequate to produce key insights on the risks involved in technology adoption.

These experts evaluate the risks involved in technology adopted following the thought process introduced by Rezaei (2015).

The methodology carried out is as follows:

Step 1 (Selecting the best and worst risks): An electronic questionnaire is deployed to the experts to assist with the evaluation process. In this step, the experts identified which of the risks summarised in Table 1 is the best and worst risk to be considered in technology adoption. As an example, the evaluation of expert 1 is shown in Table 2 which points out 'Adoption planning errors (R1)' as the best risk and 'Risks related to changes in the project budget (R2)' as the worst one.

Table 2 Sample evaluation of expert 1 in the pre-setting phase

<i>Risk type</i>	<i>Evaluation</i>
Best risk	Adoption planning errors (R1)
Worst risk	Risks related to changes in the project budget (R2)

Step 2 (Evaluating the best and worst constructs to and from the others): This step is carried out by identifying the preference of the best risk over all the other risks using a scale rating of 1 to 9, with 1 being the lowest and 9 being the highest. The generated best-to-others vector, A_B , is represented by equation (1) where a_{Bn} reflects the preference score of the best risk to n other risks.

$$A_B = (a_{B1}, a_{B2}, \dots, a_{Bn}) \quad (1)$$

Following the initial evaluation of expert 1 in Table 1, the best risk, ‘Adoption planning errors (R1)’, is evaluated to the other criterion, in this case, is ‘Risks related to changes in the project budget (R2)’.

It can be seen in Table 3, that the best risk, ‘Adoption planning errors (R1)’, is preferred over other risks being ‘Risks related to changes in the project budget (R2)’ by a scale rating of 5. On the other hand, the others-to-worst vector is represented in equation (2) where A_w is the worst risk and a_{nw} is the rating of n other risks against the worst, w , risk. The results in Table 4 indicate that ‘Adoption planning errors (R1)’ is preferred by a scale rating of 7 over ‘Risks related to changes in the project budget (R2)’.

$$A_w = (a_{1w}, a_{2w}, \dots, a_{nw})^T \quad (2)$$

Table 3 Sample evaluation of expert 1 for best-to-others vector in the pre-setting phase

	<i>Other risks</i>
	Risks related to changes in the project budget (R2)
<i>Best risk</i>	
Adoption planning errors (R1)	5

Table 4 Sample evaluation of expert 1 for others-to-worst vector in the pre-setting phase

	<i>Worst risk</i>
	Risks related to changes in the project budget (R2)
<i>Other risks</i>	
Adoption planning errors (R1)	7

The same steps are carried out to evaluate the risks under each stage (i.e., pre-setting, installation, initial operation and operational stages). After the evaluation is complete for all stages, the next step then commences.

Step 3 (Obtaining the priority weights of constructs): In this step, the base optimisation model presented in equation (3) is run with the model components from the evaluations made by the experts in the prior steps. In order to arrive at the optimal weights for each risk, take, e.g., a pair of $\frac{w_B}{w_j}$ and $\frac{w_j}{w_w}$ with the following relations expressed as

follows $w_B/w_j = a_{Bj}$ and $w_j/w_w = a_{jw}$. The maximum absolute differences $\left|w_B/w_j - a_{Bj}\right|$ and $\left|w_j/w_w - a_{jw}\right|$ for all j is minimised. In consideration to the non-negativity and sum condition for the weights, the following expression can be generated:

$$\min \max_j \left\{ \left| w_B/w_j - a_{Bj} \right|, \left| w_j/w_w - a_{jw} \right| \right\} \quad (3)$$

subject to:

$$\sum_j w_j = 1$$

$$w_j \geq 0, \text{ for all } j.$$

Then, equation (3) is transformed into equation (4) with an objective to minimise ε :

$$\min \varepsilon^* \quad (4)$$

subject to:

$$\left| w_B/w_j - a_{Bj} \right| \leq \varepsilon, \text{ for all } j$$

$$\left| w_j/w_w - a_{jw} \right| \leq \varepsilon, \text{ for all } j$$

$$\sum_j w_j = 1$$

$$w_j \geq 0, \text{ for all } j.$$

After running the model, the optimal weights $(w_1^*, w_2^*, \dots, w_n^*)$ and ε^* are then obtained.

Considering the evaluation of expert 1 to the pre-setting stage, a sample weight of risks is shown in Table 5. A higher weight represents a higher preference according to experts. The weights generated from each expert perspective are then arithmetically aggregated by solving for the grand mean as in Table 8.

Table 5 Sample weights of criteria

<i>Risks</i>	<i>Weights</i>
Adoption planning errors (R1)	0.8571
Risks related to changes in the project budget (R2)	0.1429

The same procedure is carried out for all the experts and stages involved in the evaluation of risks in technology adoption given the context of the case study. For brevity purposes, the code for each risk shown in Table 1 is used to present the results in the succeeding sections.

3 Results and discussion

The analysis of risks involved in the technology adoption provides an opportunity for decision-makers to allocate limited and scarce resources to the eventual implementation of the technology. The use of BWM as a tool to evaluate such risks is able to point out the priority weights of risks with respect to the stage of technology implementation. Table 6 shows the raw weights computed for each risk from the perspective of each expert. Note that these weights for every risk are with respect to each stage; that is, R1 and R2, being under the pre-setting stage, is computed separately from that of the other stages. The weight of risks is measured from a closed scale interval of 0.0000 to 1.0000 where 0.0000 is the least priority and 1.0000 is the highest priority. It can be seen from the resulting weights in Table 6 that the perspective of experts does vary from one risk to another. As an example, R14 has a relatively low weight with respect to expert 1, expert 2, expert 4 and expert 6, with a rating of 0.0761 to 0.1683, while expert 3 and expert 5 viewed this risk with a higher weight of 0.6667 and 0.6731, respectively. This variety of weights across experts implies that the university's decision-makers, although having the same goal of adopting technology for the benefit of the students and faculty members, can view certain risks differently. Such differences in perspectives lead to chaos in the decision-making process and, thus, need to be reconciled accordingly.

Table 6 Weights of risks for each expert

<i>Stages</i>	<i>Risks</i>	<i>Expert 1</i>	<i>Expert 2</i>	<i>Expert 3</i>	<i>Expert 4</i>	<i>Expert 5</i>	<i>Expert 6</i>
Pre-setting stage	R1	0.8571	0.3333	0.5000	0.1538	0.8333	0.1538
	R2	0.1429	0.6667	0.5000	0.8462	0.1667	0.8462
Installation stage	R3	0.1624	0.1948	0.1786	0.0833	0.7778	0.7143
	R4	0.7607	0.7143	0.0714	0.1771	0.1508	0.1948
	R5	0.0769	0.0909	0.7500	0.7396	0.0714	0.0909
Initial operation stage	R6	0.1286	0.1286	0.1163	0.0570	0.1186	0.1517
	R7	0.5571	0.5571	0.5817	0.1077	0.1186	0.1084
	R8	0.1286	0.1286	0.1163	0.1077	0.1186	0.1517
	R9	0.1286	0.1286	0.0499	0.5767	0.5932	0.5418
Operational stage	R10	0.0571	0.0571	0.1357	0.1508	0.0508	0.0464
	R11	0.1515	0.1683	0.1333	0.1698	0.1346	0.1630
	R12	0.6364	0.5941	0.1333	0.6132	0.1346	0.5978
	R13	0.0606	0.0693	0.0667	0.0755	0.0577	0.1630
	R14	0.1515	0.1683	0.6667	0.1415	0.6731	0.0761

Note: The code for each risk pertains to the following: R1: Adoption planning errors, R2: Risks related to changes in the project budget, R3: Miscalculations in the choice of technology and its installation, R4: Poor integration with existing technology, R5: Risks of failing to complete the project on time, R6: Delay in technology start-up after implementation, R7: Unpreparedness of faculty members and students to use new technology, R8: Insufficient qualification of faculty members, R9: Functional inconsistency in actions of different departments and colleges, R10: Failure to meet the expectations of administrators, R11: Risks of reduced information security, R12: Risks of reduced productivity and capacity of the technology, R13: Organisation risks, R14: Innovation risks.

Taking into account the individual weights of risks generated from the individual perspective of experts, Table 7 summarises the weights of risks by computing the aggregated local weights and global weights. The aggregated local weights of risks are computed by taking the grand mean of the weights assigned to each risk per expert. On the other hand, the global weights are computed by taking the ratio of each local weight with respect to the grand sum of all the risks' weights. Finally, the priority ranking is assigned to each risk depending on the global weights computed; that is, a higher global weight being ranked first.

Table 7 Aggregated local weights and global weights of risks for each expert

<i>Stages</i>	<i>Risks of adopting a technology & its code</i>	<i>Local weights</i>	<i>Global weights</i>	<i>Priority ranking</i>
Pre-setting stage	<i>R1</i> : Adoption planning errors	0.4719	0.1180	2
	<i>R2</i> : Risks related to changes in the project budget	0.5281	0.1320	1
Installation stage	<i>R3</i> : Miscalculations in the choice of technology and its installation	0.3519	0.0880	4
	<i>R4</i> : Poor integration with existing technology	0.3448	0.0862	5
	<i>R5</i> : Risks of failing to complete the project on time	0.3033	0.0758	9

Table 8 Aggregated local weights and global weights of risks for each expert (continued)

<i>Stages</i>	<i>Risks of adopting a technology & its code</i>	<i>Local weights</i>	<i>Global weights</i>	<i>Priority ranking</i>
Initial operation stage	<i>R6</i> : Delay in technology start-up after implementation	0.1168	0.0292	12
	<i>R7</i> : Unpreparedness of faculty members and students to use new technology	0.3385	0.0846	6
	<i>R8</i> : Insufficient qualification of faculty members	0.1253	0.0313	11
	<i>R9</i> : Functional inconsistency in actions of different departments and colleges	0.3364	0.0841	7
	<i>R10</i> : Failure to meet the expectations of administrators	0.0830	0.0208	13
Operational stage	<i>R11</i> : Risks of reduced information security	0.1534	0.0384	10
	<i>R12</i> : Risks of reduced productivity and capacity of the technology	0.4516	0.1129	3
	<i>R13</i> : Organisation risks	0.0821	0.0205	14
	<i>R14</i> : Innovation risks	0.3129	0.0782	8

The priority ranking of risks shown in Table 7 provides several interesting policy implications. For one, notice that the top two rankings are R1 and R2, both under the pre-setting stage. These results greatly emphasise the fact that decision-makers in a university, particularly in the case of CTU being a state university in the Philippines, are very critical of risks involving the pre-setting stage. Although the adoption of technology promises to improve the delivery of learning and instruction in the educational setting, there is an associated risk of adoption planning errors and those that relate to changes in the project budget. The university decision-makers cannot afford to make errors in the

planning phase given that the university may only have a strict, and otherwise, low allocation of budget resources due to innovation activities. Furthermore, any disruptions to the budget projection can mean delays in the implementation of the technology, if not a total halt of the implementation. Another interesting insight that can be drawn from the results in Table 7 is that R10 and R14 are risks due to failure to meet the expectations of administrators and organisation risks including changes in the structure within the university. These two risks are the last two in rank, which indicates that the least priority is given to such risks in the context of technology adoption. It can be noted that the expectations of administrators and risks in organisation restructuring do not greatly put the decision-makers in a difficult position. To be more specific, the technology adoption scenario already involves the perspectives of administrators being the chairpersons of departments; therefore, there is little amount of risk priority tagged into this type since the administrators are anticipated to manage its expectations in the technology adoption. Such anticipation is doable and not far from administrators' established goals, including department chairpersons. Owing to that, this risk falls into the last priority of the decision-makers in this case study.

Overall, the results of Table 7 can provide a guideline to the university stakeholders in addressing risks involved in the adoption of technology. Instead of looking into all of the risks simultaneously, the priority ranking can adequately assign which to focus on so that the decision-making process does not take up much of the university's resources. For a state university similar to CTU, it is very important for decision-makers to make wise use of the resources, including the budget, manpower and capacity of the technology. The results make sense, given that the risks involving the pre-setting stage, which requires most funding resources, are considered the most important risks to address.

To give more meaning to the risk priority ranking, the average ε^* of each stage per expert evaluation is shown in Table 8. The ε^* -value as the objective function of the optimisation model which the BWM model is based on dictates the consistency of rating among experts. Take note that the average ε^* is within 0.2155 to 0.3808, which means that the experts' comparisons in their risk evaluation are fairly reliable. When the ε^* -value is high, this further implies that the consistency ratio of responses is also high. With a higher consistency ratio, comparisons among risks become less reliable. In the case of this paper, the ε^* -value stayed below 0.5000 which indicates strong reliability of responses.

Table 9 ε^* of each stage per expert perspective

<i>Stages</i>	<i>Expert 1</i>	<i>Expert 2</i>	<i>Expert 3</i>	<i>Expert 4</i>	<i>Expert 5</i>	<i>Expert 6</i>	<i>Average</i>
Pre-setting stage	0.1429	1.6667	0.3214	0.0769	0.0000	0.0769	0.3808
Installation stage	0.3761	0.2597	0.3214	0.3229	0.2778	0.2597	0.3029
Initial operation stage	0.2143	0.2143	0.2327	0.1774	0.2373	0.2167	0.2155
Operational stage	0.2727	0.2475	0.2667	0.2358	0.2692	0.2174	0.2516

4 Theoretical and practical implications

In this paper, BWM is applied to assess the risks associated with technology adoption across various planning stages, from pre-setting to operational stages. While the original

BWM developed by Rezaei (2015) has not been modified in the case of this paper, a new case application involving risk analysis in technology adoption is put forward. Owing to the methodological prowess of BWM in assessing multiple criteria, it has been a rather population decision-making tool explored in the literature. In fact, BWM is applied to various domains, including air traffic control (Bongo and Seva, 2023), sustainable supply chain (Yadav et al., 2020), sustainable landfill site selection (Rahimi et al., 2020), bioethanol facility location analysis (Kheybari et al., 2019), industry 4.0 implementation (Moktadir et al., 2018), to name a few. However, with the numerous research works in the literature that applied BWM, including its close variant (i.e., fuzzy BWM), none has been able to consider implementing the tool in the context of assessing the risks involved in technology adoption, and more so, distinguishing the risks according to the stages of technology adoption. Such research gap in the literature is advanced in this paper. Outlining the risks associated with technology adoption in terms of the stage these occur provides more in-depth insights to decision-makers, especially on how each risk will be dealt with according to its priorities. For instance, when it is objectively identified that the most pressing risk falls under the operational stage of technology adoption, the decision-makers can put forward the most effort in this stage to address such a risk. Recognising which risk to prioritise realistically aids in the resource allocation of decision-makers, especially when there are apparent and expected limitations of available resources.

Aside from the theoretical implications of this work in the literature, this paper also contributes significantly to the field of technology adoption. It is a well-known position in the literature that most research on technology adoption generally focuses on analysing the phenomena based on established frameworks, barriers and drivers of adoption and risk preferences, among others. However, little to no research works have accounted explicitly for the risks of adopting a new technology in an academic setting. Without an objective manner of understanding these risks, likely, scarce and limited resources may not be put to proper allocation according to the priority of risks. As such, implementing the BWM in the case of analysing risks in technology adoption at a state university has reached a consensus of risk priorities with respect to the insights of key experts in the case considered. These criteria with identified priorities can help university administrators, decision-makers, point out which to focus on most over other risks. Additionally, distinguishing the stage of adoption of which each risk falls under, creates a layer of preparation and understanding for decision-makers to undertake appropriate steps in addressing the risks.

5 Conclusions and future directions

The overall dynamics of technology management have been a longstanding topic of interest in the literature, specifically in the context of technology adoption. In fact, a plethora of research works have been directed towards technology adoption and its specificities ranging from qualitative works to sophisticated analysis of factors involved in technology adoption. Despite its proliferation in the literature, little to no emphasis is evident on the risks associated with the technology adoption process. Since risks play a huge role in the eventual success of technology adoption, it is imperative to analyse such risks in-depth. In response to this research gap, this paper investigated the risks involved in technology adoption in an actual higher educational institution in Cebu, Philippines,

using the Best-Worst Method (BWM). To ensure a more organised means of accounting for the risks, it is arranged according to the stage to which it belongs.

The key results of this investigation pointed out the following insights. First, all of the risks involved in the pre-setting stage are found to be the most prioritised risks to be addressed in the event of technology adoption in the case study. Such results align with the goals of higher educational institutions, especially those with scarce and limited resources. It is imperative to consider the pre-setting stage as a whole in adopting new technology, particularly in the higher educational institution involved in this paper, since investments in human, financial and other relevant resources are capped at a certain level and limit the spread of resources in the entire technology adoption process. Second, while multiple stakeholders in the case study served as experts in the multi-criteria decision-making analysis, the consistency ratio revealed high reliability, suggesting that even with probable diverse and conflicting interests among stakeholders, risks are analysed uniformly and consistently.

Such realisations of insights drawn from the case study further lead the way for future research directions involving risks in technology adoption. Other statistical and analytic approaches can be employed to better understand the interrelationships among factors so as to deal with each more efficiently. Furthermore, risks involved in each stage may be expanded based on the needs of any sector, even outside the educational setting, to delve deeper into the impact of such risks in the decision-making process.

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