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The assessment of the key success factors for digital transformation based on MCDM method: The case study of an automotive company

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Abstract: Fostering development as a driving force of the economy, based on information and technology, is important for survival and is required in establishing strong relationships within the globalized world of business. Innovation and technological growth necessitate a network of interconnected organizational relationships between the public and commercial sectors. These firms' activities and relationships are the driving forces behind digital transformation. Following tactics are critical in businesses such as the automobile industry, which has complicated characteristics, costly, and time-consuming operations. Considering the business environment and recognizing success factors is a critical first step in implementing digital transformation strategies and preparing for technological advancement. The purpose of this essay is to assess the important success elements in the automotive industry's technological transformation. The Best-Worst approach was utilized in this article, which is regarded as one of the most prominent and effective MCDM strategies. The essential success elements of the technical transformation of the automotive sector in Morocco were identified based on a case study and a survey of the existing and relevant literature. The important success variables were then assessed and prioritized using the "Best-Worst" method and expert opinions. Finally, some recommendations are offered based on the study's findings.

Keywords : Technology, Smart devices, MCDM, innovation, Automotive.

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1. Introduction

The introduction of a new idea, device, or method is commonly referred to as "innovation". According to Black & Lynch (2004), from a management standpoint, innovation is a change that creates a new dimension of performance, and from an institutional standpoint, it is the successful implementation of new ideas. In a constantly changing environment, institutions can more easily adapt to their surroundings thanks to the flexibility provided by innovation (Classen et al., 2014). Innovativeness is most used as a scale to assess the degree of newness of an innovation. Products with a high degree of novelty are regarded as "highly innovative," while those with a low degree of novelty are regarded as "low innovative." The term "technological innovation" is defined by the classification of innovation types. There are distinct definitions of innovation in economics, management, marketing, and engineering (Codagnone & Martens, 2016). Technological innovation processes are not made up of specifi c steps, but rather are exploited and utilized by complex adaptive systems of interconnected actors, including institutions ranging from local to global.

Obstructions appear at every stage of the innovation process, from the invention of technology through its retirement. Economic growth and improved human welfare are only a few of the significant societal goals that technical innovation has helped to attain. However, large power discrepancies characterize innovation systems that are primarily guided by market pressures and well-resourced individuals (Hartwell, 2017). With the support of specialists from Moroccan`s automotive industry, a foresight research was done on the sector. According to the findings of the survey, the development of the automotive industry is the second most significant strategic goal, and the manufacturing of automotive is the third most important strategic goal, according to experts.

Strategic management is critical for any organization or industry to coordinate plans and objectives with the conditions of the business environment, and the automotive industry is no exception, with their complex characteristics, costly, and time-consuming processes. The weights of the success elements in technological transformation vary. In other words, different weights should be applied depending on the circumstance and context of each item. To combine different contributing criteria, Multiple Criteria Decision Making (MCDM) approaches should be used.

Using one of the most unique MCDM methodologies, the Best-Worst method, the goal of this study is to offer a model for prioritizing critical success variables in digital transformation in Moroccan's Automotive industry. Most previous research has focused on key success determinants of innovation at the business level, however the researchers in this study want to look at the key success variables from a larger industry viewpoint. This article also includes an application of one of the most cutting-edge decision-making methodologies.

2. Literature revue

Disruptive innovation implementation and commercialization success is determined not just by the firm's conceptualization and development of the innovation, but also by its ability to penetrate beyond a small market of innovators-early adopters. To put it another way, it must bridge the gap while also overcoming the innovator's conundrum (Classen et al., 2014). An overwhelming number of definitions for categories of innovation have produced ambiguity in the operationalization and use of terminology like "innovation" and "innovativeness" in new product development literature. Technical, market, and financial risks are all highlighted as being present in product development projects. In an environment where these uncertainties exist, a senior product development manager must make decisions. As a result, gathering enough knowledge and information before and during a new product development project is critical to project success (Bukht & Heeks, 2017).

According to research, none of the success criteria can guarantee favourable outcomes on its own, and a mix of them is required to create success (Agrawal et al., 2015; Hartwell, 2017; Choy, 2020; Caiado et al., 2021). The focus of functional analysis is on the procedures that are required for effective innovation system performance. The functions of innovation systems are used to classify these processes. Furthermore, they aid in the understanding of the dynamics of innovation systems (Ebel et al., 2016; Almaazmi et al., 2020). Table 1 shows a comprehensive list of major success elements identified from a survey of the literature to identify and assess important success factors in technological transformation.

In addition to the studies cited above, other research has also emphasized the importance of considering multiple success criteria in technological transformation efforts. For example, a study by Kim et al. (2018) found that a combination of technical, organizational, and environmental factors were important predictors of success in technological innovation projects. Similarly, a review by Li et al. (2019) identified a range of factors that can impact the success of technological transformation, including leadership, culture, resources, and market demand. These findings highlight the need to consider a diverse set of success factors when planning and implementing technological transformation initiatives.

Criteria	Sub-criteria	Reference
• **Factors related to the associates (C1)**	• Smart technologies investment (A1) • Smart devices usage (A2) • Orientation of academic institutions towards digitalisation (A3) • Implementation of cooperation, networking methods, and communication routes between research firms, suppliers, and users (A4) • Training related to advanced technologies (A5) • Incubators regarding technology and digitalisation (A6) • Autonomous systems (A7) • Professional forums for experts and elites in the business (A8) • Integration of all supply chain actors on digital transformation basis (A9)	*(Kang et al., 2016)* *(Backhaus & Nadarajah, 2019)* *(Degryse, 2016)* *(Bhatti et al., 2016)* *(Almaazmi et al., 2020)* *(Bieser & Hilty, 2018)* *(Grimes & Yang, 2018)* *(Pagani & Pardo, 2017)* *(Cohen, 2019)*
Factors related to the organisation (C2)	• Supportive regulations and guidelines to support digitalisation (B1) • Legal and security procedures against cybersecurity (B2) • Intellectual property system (B3) • Rules, requirements, standards, and licenses for smart devices usage (B4) • Determining the digital transformation technical strategy (B5) • Choosing a benchmark for technology policy adoption in the Automotive sector (B6) • The government's thoughtful and committed support for technological development in the Automotive industry (New Technology Development Fund) (B7)	*(Degryse, 2016)* *(Finnemore & Hollis, 2016)* *(Bose, 2008)* *(Lee et al., 2018)* *(Almaazmi et al., 2020)* *(Grimes & Yang, 2018)* *(Zavadskas & Turskis, 2011)*
Factors related to the technology (C3)	• Implementing interactive learning mechanisms among enterprises, suppliers, and users (to improve national technical skills) (D1) • Forum related to the advances of similar field regarding digital transformation (D2) • Research related to the advances of different sectors in digitization(B3) • Existence of specialist research laboratories for various Automotive industrial sub-sectors (as well as ensuring that these facilities are accessible to industry actors) (D4) • Documentation of knowledge and experience gained from previous digital transformation projects, as well as the reasons for their failures (documentation of various experiences in the country's specialized Automotive industries, such as composites, image processing, design, and production of on-ground stations) (D5)	*(Carvalho et al., 2019)* *(Barholomae, 2018)* *(Szalavetz, 2019)* *(Al-Doori, 2019)* *(Berman, 2012)*

Table 1 : Key success factor for digital transformation based on literature

Welna was the first to coin the phrase "key success and failure factors" in 1960. In social sciences, she looked at the reasons of success and failure factors in mathematics courses. Starting from the basis of social sciences later on researches insisted on the importance of organizational structure for the success and failure of projects (Burger et al., 1967). Larson & Gobeli, (1989) realized that the project team and project matrix are among the most effective organizational models. According to Ford & Randolph (1992), the sector in which the project is set up has an impact on the project's success factors. According to Freel (2003) external elements such as political, economic, social, and sectorial issues, have an impact. Belassi & Tukel (1996) divided the success factors into strategic (project mission, executive support, and appropriate scheduling) and technical (consultation with the employer, personnel selection, and training), and claimed that the importance and relevance of each of these factors varies depending on the project life cycle in their subsequent studies. Several studies in various nations have looked at the impact of environmental factors on the success of innovation projects. These studies all stressed that industry, economic development, business size, and environmental factors all influence success, and that there is no common pattern for obtaining success. According to Almaazmi et al. (2020), university R&D, investment strength, strong local rivalry, local suppliers, and connected enterprises' capabilities are all aspects that contribute to the effective digital transformation.

3. Research methodology

In this study, a novel multiple criteria decision-making (MCDM) model based on the BWM (benefits, willingness, and multiplicity) method was developed to address the challenge of investigating and evaluating key success factors in technological innovation development. This research was applied in terms of goal and used a descriptive and survey approach for data collection. The proposed MCDM technique is shown in Figure 1 as a flowchart. The goal of the research was to discover and characterize the key success factors in technological innovation development, and the use of the MCDM model based on BWM allowed for a systematic and structured evaluation of these factors. The descriptive and survey data collection methods provided a comprehensive understanding of the factors that contribute to success in technological innovation development.

The challenge of investigating and evaluating Key Success Factors in Technological Innovation Development is addressed in this part by presenting a novel MCDM model based on BWM. Because it seeks to discover and characterize the Key Success Factors in Technological Innovation Development, this research is applied in terms of goal and descriptive and survey in terms of data collecting. The proposed MCDM technique is depicted in Fig. 1 as a flowchart.

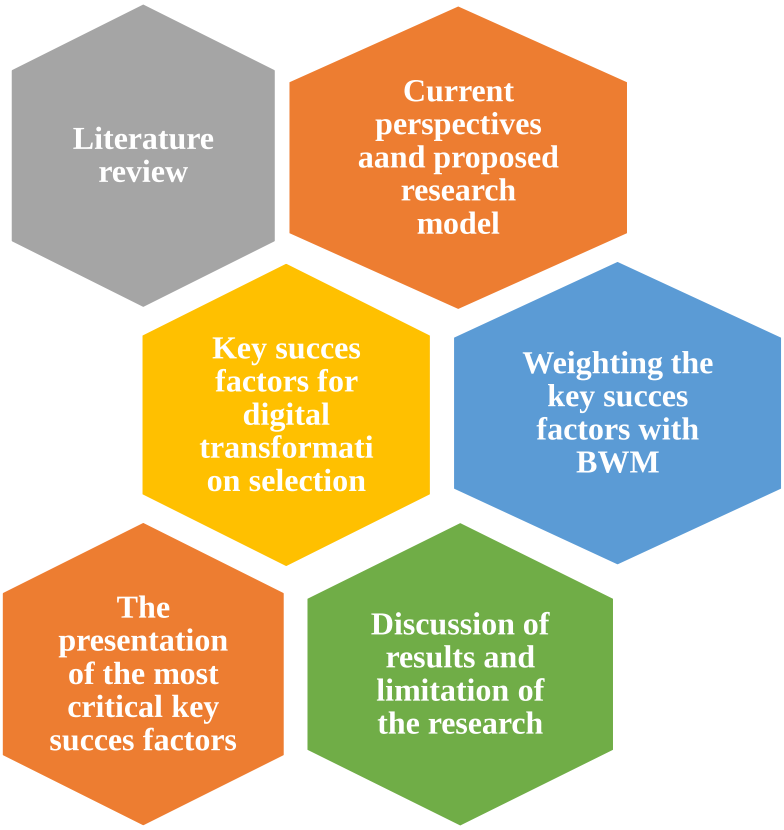

Figure 1 : Developed MCDM Model

The documentary technique (books, papers, and internet texts) was employed to determine the essential components in this study. Questionnaires were sent among specialists and experts in the Moroccan automotive industry (5 experts, including the CEO and Vice President of Research and Technology) to rank the elements using the field study approach. A case study of the Moroccan automotive industry is offered to demonstrate the efficacy of the research approach.

3.1.The best Worst Method

BWM is a Comparison-Oriented MCDM method in which the best criterion is compared to all other criteria, and all other criteria are compared to the worst criterion. The purpose is to use a basic linear optimization model built by the comparison system to identify the optimal weights and consistency ratio (Rezaei, 2015). Some articles have used this unique MCDM technique in the literature.

The processes of BWM to compute the weight of the criterion are described below (Rezaei, 2015):

1) Decide on a set of decision criteria for decision-makers $\{C_1, C_2, \ldots, C_n\}$

2) Choose the best and worst criteria for the decision-making environment: From their point of view, decision makers select the best and worst criterion from the list of criteria identified in Step 1. The most significant criteria are represented by the best criteria, while the least important factors are represented by the worst criteria.

3) Determine the preference of the best criteria over all the other criteria: A number between 1 and 9 (1: equally important, 9: extremely more important) is used to indicate this value. The resulting Best-to-Other vector would be as, $A_B = (a_{B1}, a_{B2}, \ldots, a_{Bn})$ Where a_{Bj} indicates the preference of criteria B (best criteria) over criteria j and $a_{BB} = 1$

4) Determine which of the other factors you prefer over the worst criteria: This scenario is also allocated a number between 1 and 9. The Others-to-Worst vector would be as follows: $A_W = (a_{1W}, a_{2W}, \ldots, a_{nW})^T$ Where is the preference of the criteria j over the worst criteria W and $a_{WW} = 1$.

5) Determine the best weights $(W_1^*, W_2^*, \ldots, W_n^*)$: The best weights for the criteria will be determined by solving problem (1). The maximum absolute disparities $\{|W_B - a_{Bj}W_j|, |W_j - a_{jwW_w}|\}$, for every j, should be minimized in order to obtain the best weights of the criteria.

$$\min \max_j \left\{ \left| \frac{W_B}{W_j} - a_{Bj} \right|, \left| \frac{W_j}{W_w} - a_{jw} \right| \right\}$$

$$\text{s.t} \quad \sum_j W_j = 1$$

$$W_j \geq 0, \text{for all j}$$

This model can be solved by transferring it to the linear programming formulation (2) (Rezaei, 2015b):

$$\min_{s.t} £$$

$$|W_B - a_{Bj}W_j| \leq £, \text{for all j}$$

$$|W_j - a_{jW}W_W| \leq £, \text{for all j}$$

$$\text{s.t} \quad \sum_j W_j = 1$$

$$W_j \geq 0, \text{for all j}$$

By solving this problem, the optimal weights $(W_1^*, W_2^*, \ldots, W_n^*)$ and the optimal value of $£^*$ $*$are obtained. $£^*$is defined as the consistency ratio of the comparison system. It means that the closer $£^*$is to a zero value the more consistent the comparison system provided by the decision makers. Eq. (3) is used to check the consistency of the comparisons (Rezaei et al., 2016a):

$$\text{Consistency Ratio} = \frac{£^*}{\text{Consistency Index}}$$

The consistency index can be retrieved from Table 2. The lower the consistency ratio, the higher the reliability of the comparisons.

a_{BW}	1	2	3	4	5	6	7	8	9
Consistency Index	0.00	0.44	1.00	1.63	2.30	3.00	3.73	4.47	5.23

Table 2 : Consistency index table (Rezaei, 2015)

4. Real world case study

This stage uses BWM, which was discussed in section 3, to determine the importance weights of critical success elements in technological innovation development.

(1) Determination of the criteria set

The criteria are based on a thorough literature analysis and interviews with research participants, as shown in the table (1).

(2) Determination of the best and the worst criterion

The second step in the BWM is the determination of the best and the worst criterion. The best criterion is the one selected by each respondent as the most important key success factor for technological innovation development, while the worst criterion is the one which is the least important key success factor for technological innovation development based on the opinion of each expert. Contributors of this research selected factors related to associates (C1) as the best criterion and factors related to organisation (C2) as the worst criterion. Also contributors in this research selected clear definition of Smart technologies investment (A1) and Professional forums for experts and elites in the business (A8) in factors related to associates, The government's thoughtful and committed support for technological development in the Automotive industry (New Technology Development Fund) (B7) and intellectual property system (B3) in factors related to organisation, Documentation of knowledge and experience gained from previous digital transformation projects, as well as the reasons for their failures (documentation of various experiences in the country's specialized Automotive industries, such as composites, image processing, design, and production of on-ground stations) (D5) and Forum related to the advances of similar field regarding digital transformation (D2) in factors associated with science and technology as the best and worst sub-criteria respectively.

(3) Determination of the preference of the best criterion over all others

This phase entails determining the best criterion's preference above all other criteria. This information was gathered utilizing a BWM-specific questionnaire. Experts are asked to compare their best criterion to each of the other criteria and rank their preference on a scale of one to nine. A score of 1 indicates that the other criteria are of equal importance. A score of 9 indicates that the most significant criterion is far more important than the others. The aggregated Best-to-Others (BO) vector was then built by calculating the arithmetic mean of the five experts' surveys, as shown in Table 3. Tables also display sub-criteria aggregated Best-to-Others (BO) vectors (4-6).

Best criterion	C1	C2	C3
C1	0.99	1.7	0.8

Table 3 : Criteria BO vector

Best criterion	A1	A2	A3	A4	A5	A6	A7	A8	A9
A2	6.7	0.99	3.7	1.7	2.7	5.7	1.1	7.7	5.1

Table 4 : Associates sub-criteria BO vector

Best criterion	B1	B2	B3	B4	B5	B6	B7
B7	3.7	5.7	7	4.7	1.1	2.7	0.99

Table 5 : Organisation sub-criteria BO vector

Best criterion	D1	D2	D3	D4	D5
D5	3.7	8	5.7	1.7	0.99

Table 6 : Technology sub-criteria BO vector

(4) Determination of the preference of all criteria over the worst criterion

The contributors are asked to declare their preferences for all other criteria over the least important criterion in this stage, which is like the preceding step. A value between 1 and 9 is used, same like in the previous step. The aggregated Other to Worst (OW) vector was then generated by calculating the arithmetic mean of the five experts' surveys, as shown in Table 7. Tables also display sub-criteria aggregated Others-to-Worst (OW) vectors (8-10).

Worst criterion	C2
C1	1.7
C2	0.99
C3	0.1

Table 7 : Criteria OW vector

Worst criterion	A8
A1	1.1
A2	7.7
A3	3.7
A4	5.7
A5	4.7
A6	1.7
A7	6.7
A8	0.97
A9	2.7

Table 8 : Associates sub-criteria OW vector

Worst criterion	B3
B1	2.7
B2	1.1
B3	0.95
B4	1.7
B5	6.7
B6	4.7
B7	8

Table 9 : Organisation sub-criteria OW vector

Worst criterion	D2
D1	3.7
D2	0.90
D3	1.7
D4	6.1
D5	8

Table 10 : Technology sub criteria OW vector

(5) Determination of the digital transformation Key Success Factors Weights

A linear model (2) of BWM is used to calculate the weights of digital transformation critical success variables. The optimal values of criteria and sub-criteria weights, as well as $£^{*}$, may be determined by solving this linear model. Table 11 displays the results.

Criteria	Weight	Sub-criteria	Local weight	Global weight	Rank
C1	0.417	A1	0.0378	0.01478	1
		A2	0.205	0.055737	18
		A3	0.0683	0.030812	14
		A4	0.025	0.060707	19
		A5	0.099	0.0417	16
		A6	0.045	0.018457	10
		A7	0.062	0.080233	21
		A8	0.018	0.004202	4
		A9	0.050	0.021107	11
C2	0.107	B1	0.0856	0.010003	7
		B2	0.0572	0.003105	3
		B3	0.0233	0.006044	6
		B4	0.0700	0.005550	5
		B5	0.100	0.032777	15
		B6	0.011	0.014265	9
		B7	0.276	0.070385	20
C3	0.153	D1	0.018	0.023045	12
		D2	0.034	0.00077	2
		D3	0.080	0.013013	8
		D4	0.110	0.047233	17
		D5	0.403	0.024585	13

£*	0.041
Consistency Ratio	0.047

Table 11 : Digital transformation key success factors weights

As can be seen from this result, in this case, ‘factors related to associates (C1)’, ‘factors related to technology (C3)’ and ‘factors related to organisation (C2)’ are the most important digital transformation key success factors criteria respectively. Also ‘clear definition of Smart devices usage (A2)’, ‘Documentation of knowledge and experience gained from previous digital transformation projects, as well as the reasons for their failures (documentation of various experiences in the country's specialized Automotive industries, such as composites, image processing, design, and production of on-ground stations) (D5)’ and ‘Autonomous systems (A7)’ are the most important technological innovation development key success factors sub-criteria and, ‘intellectual property system (B3)’, ‘Forums related to the advances of similar field regarding digital transformation (D2)’ and ‘Legal and security procedures against cybersecurity (B2)’ are the least important technological innovation development key success factors’ sub-criteria respectively.

Furthermore, ‘clear definition of Smart devices usage (A2)’, ‘Autonomous systems (A7)’ and ‘Implementation of cooperation, networking methods, and communication routes between research firms, suppliers, and users (A4)’ are the most important actors and networks sub-criteria. ‘The government's thoughtful and committed support for technological development in the Automotive industry (New Technology Development Fund) (B7)’, 'Determining the digital transformation technical strategy (B5)' and 'Choosing a benchmark for technology policy adoption in the Automotive sector (B6)' are the most important institutions sub-criteria and ' Documentation of knowledge and experience gained from previous digital transformation projects, as well as the reasons for their failures (documentation of various experiences in the country's specialized Automotive industries, such as composites, image processing, design, and production of on-ground stations) (D5)', 'existence of specialized research laboratories for different sub-sectors of automotive industry (D4)' and 'implementing cooperation, networking mechanisms and implementation of interactive learning mechanisms among firms, suppliers and users (D1)' are the most important science and technology sub-criteria. As shown in table 11, the comparisons show a very high consistency as the value of consistency ratio of criteria and sub-criteria is close to zero (the consistency ratio for criteria and sub-criteria comparisons were 0.047, 0.001, 0.003 and 0.01 respectively).

5. Discussion

Morocco has moved its economy's priority to knowledge and technology since entering the period of its "digital strategic plan." The innovative automotive sector has a huge impact on the country's path to achieving its goals, and innovation plays the most important role in the economy. The identification and study of important success elements in technological transformation can greatly aid in the resolution of existing issues and the development of a dynamic and successful sectorial innovation system.

This article presented a clear framework for identifying critical success elements in the Moroccan automotive industry's technological development. Given the scarcity of capital and the short time frame for success in the automobile business, the most critical aspects have been prioritized so that more attention may be paid to them. The major success elements in the automotive sector were found and classified into three categories with 21 criteria in this article. The selected characteristics were then prioritized based on expert opinions and the Best-Worst technique. The findings show that elements connected to associates, technology, and organizational characteristics were the most essential critical success factors in technological change in the automotive business.

Furthermore, clear definitions of Smart devices usage (A2), Documentation of knowledge and experience gained from previous digital transformation projects, as well as the reasons for their failures (documentation of various experiences in the country's specialized

Automotive industries, such as composites, image processing, design, and production of on-ground stations) (D5), Autonomous systems (A7), The government's thoughtful and committed support for technological development in the Automotive industry (New Technology Development Fund) (B7), Professional forums for experts and elites in the business (A8), Finally, some suggestions are provided for further exploitation of the findings. The following are the researchers' recommendations:

- The variables are shown to show that the challenge in this emerging business in Morocco is not a lack of actors, but rather the quality, number, and depth of interactions and relationships that must exist among the actors in order to assist the digital transformation process. Given the importance of the Moroccan automotive sector, this can be accomplished by establishing policies that encourage networking and relationship development among manufacturing and research enterprises, suppliers, and customers. Furthermore, accurately identifying criteria and ensuring that they are compatible with existing collaboration capabilities across manufacturing and research organizations, suppliers, and customers is critical.
- The main challenge here is not project financing, but rather appropriately directing the government's financial resources toward digital transformation. As a result, establishing a comprehensive project performance review system and defining critical decision-making points for continuing or terminating the project is a critical and vital stage.
- In Morocco's automobile industry, there are several unfinished or half-finished projects. Future projects and teams can benefit from a comprehensive database of these prior failures. Because most of the industry's concentration is on defence, one of the research organizations must accept the task of systematic documentation of prior project experiences with the cooperation of senior management.

For further research, multiple ideas can be taken under account, to mention:

- Examining the current state of prioritized aspects among automotive corporations and organizations in order to identify any gaps.
- Inspecting the government's innovation development initiatives as the most essential and powerful source of policy.
- Using various MCDM methodologies to identify and prioritize the critical success elements.

- Using fuzzy sets theory to analyse the data in order to avoid or lessen the uncertainties and ambiguities that come with this type of research.
- Examining the barriers to digital transformation in the automotive sector and comparing the findings to existing studies.

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