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Guidelines for Managing Creative Innovation of the Machinery and Metalwork Industry

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Abstract
Creative innovation in the machinery and metalworking industry group is critical in this era. Therefore, this research aimed to study the management approach to creative innovation in the machinery and metalworking industry group to improve a Structural Equation Model according to qualitative and quantitative aspects. Moreover, in-depth interviews were conducted with nine experts to develop a quantitative instrument section. Furthermore, focus group discussions were used with eleven qualified experts to reach a consensus and validate the research model. For the quantitative research, data were collected through a questionnaire administered to 500 business executives, operating Descriptive, Inferential, and Multivariate statistics for analysis. The results found the innovation management approach in the machinery and metalworking industry group, ranked in order of importance across four components, which are: Innovation-Transforming Organization had the highest average score of 4.34, Knowledge Creation and Resource Preparation, averaging 4.27, and Contemporary Technology of 4.17. Furthermore, the analysis of the Structural Equation Model demonstrated a good fit with the evaluation criteria and empirical data, showing a chi-Square probability of 0.133, a relative chi-square of 1.096, a comparative fit index (CFI) of 0.955, and a Root Mean Square Error of Approximation (RMSEA) of 0.014 repectively.

Keywords: *Innovative Organizational Transformation, Knowledge Creation, Resource Preparation, Contemporary Technology, Innovation Management, Machinery and Metalworking Industry*

INTRODUCTION

Nowadays, the operations of both public and private organizations are facing numerous changes and challenges due to various crises. The recovery from COVID-19 continues to affect the global supply chain system. This is further complicated by the prolonged conflict between Russia and Ukraine, as well as the escalating war in the Middle East, all of which have severely impacted global and national environments, economies, societies, and politics. In addition, climate change, the instability of the global economic system to manage high inflation, and dual-edged advancements in technology, especially those applied in warfare, are contributing to an increasingly complex and volatile landscape. As a result, organizations must adapt to current changes and proactively prepare for future challenges and crises. One key strategy that organizations use to gain a sustainable competitive advantage is innovation (Suksumek et al., 2023).

Typically, various technologies and innovations follow an innovation lifecycle, often illustrated by an S-S-curve, a graph that depicts the growth of a technology over time. This curve is used to describe how the efficiency and cost- cost-effectiveness of a technology evolve. In the early stages, when a technology is newly invented, it often requires significant efficiency improvements, demanding both time and investment. As the technology progresses, its efficiency steadily increases until it reaches a point of maturity. At this stage, organizations must seek new technological innovations or embark on a new S- S-curve to sustain development. Otherwise, they risk stagnation or falling behind (Madhavan et al., 2022).

Research and development, as a product of creativity, is essential for enhancing production processes, creating added value, and reducing future production costs. However, the application of knowledge and creativity to extend product development and drive innovation remains limited, representing a disadvantage for the organization. This suggests that the organization still needs to place greater emphasis on and actively promote innovation management. In addition, there is a need to upskill personnel, as their current capabilities do not align with technological changes, particularly the ability to work alongside robots and artificial intelligence (Sutrisno et al., 2023).

Table 1. Thailand's Performance in the Global Innovation Competitiveness Rankings

Year	2019	2020	2021	2022	2023	2024
Rank	43	44	43	43	43	41
Score	38.60	36.70	37.20	34.90	37.10	36.90

Source : The World Intellectual Property Organization, 2024

According to the innovation competitiveness rankings reported by the World Intellectual Property Organization (WIPO), Thailand's innovation capability scores have shown a fluctuating trend over the years, with rankings rising and falling slightly without significant change. Although the innovation index ranking improved in 2024, the overall pattern remains relatively stable. This improvement results from advancements in general infrastructure, an increasing number of knowledgeable personnel in the country, knowledge absorption, and a supportive business environment, all of which are critical foundations for the development of social and economic, same for increasing population quality of life. While Thailand's ranking has improved, it is still insufficient to compete with countries like Singapore or Malaysia. Therefore, Thailand should urgently address its weak points, particularly in the areas of human capital development, research, and the integration and expansion of existing innovations. Strengthening these areas is essential to achieving a higher level of innovation development, which will be a key factor in driving the country out of the middle-income trap (The World Intellectual Property Organization, 2024).

Objectives of the Research

1. To study the creative innovation management components in the machinery and metalworking industry.
2. To develop the creative innovation management with a Structural Equation Model in the machinery and metalworking industry.

Literature Review

1. Creative Innovation

Creative innovation involves the creation of something new to meet needs and make life more convenient by improving and modifying existing methods or introducing new approaches into processes to achieve higher efficiency than before. It enhances the production process and adds value to the product, while also reducing the cost of producing prototype products (Gouvea et al., 2021) by using research and technology alongside innovation to make the production process more efficient. Furthermore, innovation is a crucial tool for business development and creating unique products that enable companies to compete sustainably in the long term (Arici and Uysal, 2021).

2. Creative Innovation of the Machinery and Metalwork Industry

Creative innovation in the machinery and metalworking industry involves management practices that guide the organization to success by introducing new ideas and methods. This includes adjusting the organizational structure to facilitate innovation development, ensuring that innovation processes are not hindered by restrictive thinking among personnel (Oluwatimilehin, Yunus, and Damilare, 2023). The organization establishes a vision, mission, and goals to define the guidelines for innovation development. This also includes creating motivation and focusing on innovation, integration, or the creation of new approaches to add value to products and processes, making them distinct from the original and continuously improving efficiency (Ajie, Osoh, and Thomas, 2022).

3. Innovation-Transforming Organization

Adapting to an innovative organization involves changing the management structure to be more flexible, improving work processes by integrating both traditional and modern management approaches, and developing the application of technology and innovation (Brunetti et al., 2020). It also requires encouraging innovative habits among organizational members, encouraging the use of new ways of working. This transformation aims to align industrial business organizations with the demands of the digital society, as creativity serves as the foundation of innovation within the organization. Creativity is an intangible intellectual property (Intangible Asset) that holds greater value than physical assets (Tangible Assets) (Dupont et al., 2023).

4. Resource Preparation

Resource preparation refers to the management of resources in response to changes and demands from the external environment of the organization. It involves managing various organizational factors and activities that promote knowledge, research, or experience, including practical abilities and skills gained from knowledge or experience. In addition, it encompasses the use of resources within the organization to support the management of machinery and materials in the work process, as well as structuring the organization for maximum efficiency and allocating personnel with the necessary knowledge and skills for innovation. It is an element of competitive advantage or an operational approach that leads to achieving goals. Executives must assess the resources, capabilities, and opportunities available to the organization to invest in businesses they identify as opportunities (Ingaldi and Ulewicz, 2024).

5. Contemporary Technology

Contemporary Technology is the application of scientific knowledge to processes and creates efficiencies that improve the quality of products or services, thereby increasing productivity. It involves studying and researching efficient technologies and applying them appropriately within organizations to increase and develop work processes, encouraging progress and enabling competitiveness in the current market. In addition, technology and innovation are crucial drivers of new business concepts (Mahardhani, 2023). Businesses that identify opportunities or problems affecting many people and find new solutions for customers by creating business models with appropriate technology or innovation can address various challenges in different ways, achieving goals quickly in a short period. This approach also generates profits and continuously boosts productivity (Chaiyo, Pongsiri, and Wattanakomol, 2023).

6. Knowledge Creation

Knowledge creation is an activity that promotes knowledge, research, or experience, including practical abilities and skills gained from understanding or experience. It involves creating understanding or information acquired through seeing, hearing, listening, thinking, practicing, or studying specific fields. The current economic system relies on the principles of comprehensive knowledge in decision-making. Knowledge has become a valuable asset, playing a key role in wealth creation and driving economic growth. It is beneficial to daily life, work, and the overall economic development of the country (Pongsuwan, Sukhawatthanakun, and Sanrach, 2024). In organizations, knowledge is crucial for working efficiently and achieving set goals. Knowledge can be further developed or created to strengthen the organization and increase its competitive advantage. As a result, many organizations have adopted knowledge management strategies to encourage innovation within the organization (Tseng et al., 2021).

Conceptual Framework of the Research

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The researcher has studied and reviewed concepts, theories, documents, and related research on creative innovation management approaches within the industrial and metalworking sectors to increase competitiveness through creative innovation. These approaches can be synthesized into four areas: the components of transforming into an innovative organization (Innovation-Transforming Organization), the components of resource preparation (Resource Preparation), the components of contemporary technology (Contemporary Technology), and the components of knowledge creation (Knowledge Creation), as presented in Figure 1.

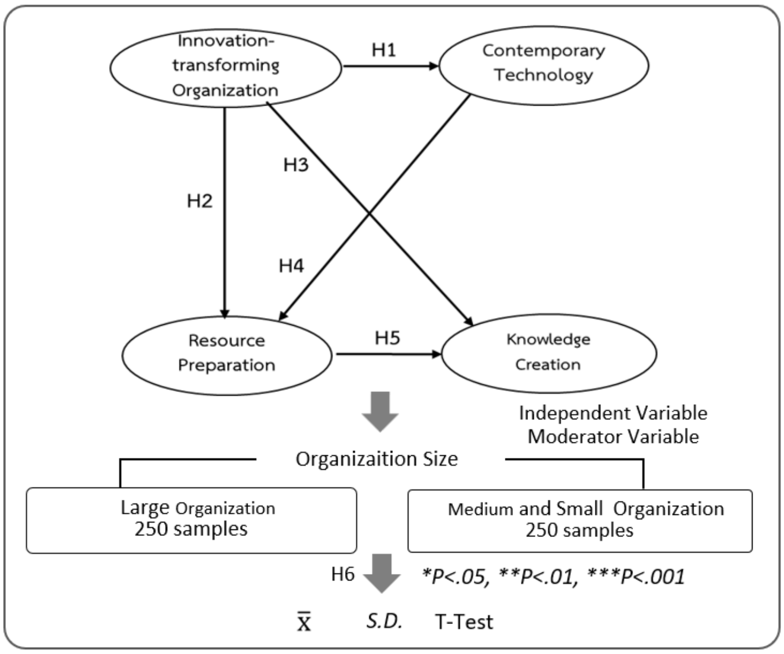

Figure 1: The Framework of this study

The conceptual framework of the study (Figure 1) shows how organizations within the industrial and metalworking sectors can gain a competitive advantage through creative innovation management. Within this framework, the four key components are innovation-transforming organization, contemporary technology, resource preparation, and knowledge creation. It hypothesizes that an organization's capacity for innovation transformation directly influences the adoption of contemporary technology (H1), the readiness of organizational resources (H2), and the creation of new knowledge (H3). Additionally, resource preparation will have implications for modern technology (H4), which will, in turn, impact knowledge creation (H5). The study also investigates the moderating role of organization size (H6) through comparisons between large and small/medium organizations (organization size comparisons using means comparisons, standard deviation, T-tests). Using case-based narratives, the framework highlights the dynamic interplay between organizational innovation, technological capability, and knowledge-generating processes in the organization and how these vary with organizational scale.

Methods

Inductive Research was conducted in this study, employing a mixed-methods approach with following details:

1. The qualitative section was conducted by In-Depth Interview with nine experts, divided into 3 groups which are: entrepreneurs or executives from successful business organizations, 3 people; representatives from government and related organizations, 3 people; and academicians, 3 people. This study created interview guidelines based on 4 components: 1) Innovation-Transforming Organization, 2) Resource Preparation, 3) Contemporary Technology, and 4) Knowledge Creation.

2. The quantitative study used a questionnaire with the assessment form, which was given to five experts to evaluate the quality of the instrument, checking the index of alignment of IOC and questions. The values ranged from 0.60 to 1.00 (> 0.50) (Sirima, 2024). The questionnaire was then pre-tested, and the analysis of the discriminant power of each item ranged from 0.31 and 1.32 (> 0.30). The measured using cronbach's alpha coefficient, was for the reliability of questionnaire at 0.98 (> 0.80) (Sirima, 2024). The population for this research consisted of 2,126 business operators or supervisors responsible for the research and development of products or services in the machinery and metalworking industry. The sample size was fixed using the evaluation for research in the pattern of factor analysis or the Structural Equation Model, and the size of the samples at 500, considered a very good level (Comrey and Lee, 1992). The Lottery Method was used to collect data from 250 individuals per group. General demographic data were analyzed using descriptive and inferential statistics with SPSS, while structural equation modeling was performed using multivariate statistics.

The qualitative part was operated using the focus group discussion technique. And to validate the model, the population consisted of 11 qualified experts selected by Purposive Sampling to provide suggestions and validate the structural equation model. The focus was on the guidelines for managing creative innovation in the industrial and metalworking sectors, and the structural equation model was unanimously approved. Conducting the AMOS program (Thanin, 2024), and the evaluation used for assessing the consistency of the Structural Equation Model included the following four values: 1) Chi-square probability (CMIN–p) > 0.05. 2) Relative Chi-square (CMIN/DF) < 2, 3) Goodness of Fit Index (GFI) > 0.90, and 4) Root Mean Square Error Approximation (RMSEA) < 0.08 (Arbuckle, 2016).

RESULTS

The research results found that, overall, large businesses place more importance on the creative innovation management approach in the machinery and metalworking industry than medium and small businesses, with the highest importance level, reflected by an average value of 4.39. Moreover, research results in each area revealed that large businesses placed more importance on the creative innovation management approach in the machinery and metalworking industry than medium and small businesses, with the Innovation-Transforming Organization receiving the highest importance, reflected by an average value of 4.47. The statistical analysis comparing the differences in the level of importance, specified by the size of the industrial business, found statistically significant differences at the level of 0.05, as shown in Table 2.

Table 2: Importance Level of Creative Innovation Management Approaches in the Machinery and Metalworking Industry Group. Categorized by industrial business size.

Management Approach Elements of Creative Innovation in the Machinery and Metalworking Industry Group.	small and medium-sized		Large size		T-value	P-value
	$\bar{X}$	S.D.	$\bar{X}$	S.D.		
Overall results	4.16	0.34	4.39	0.30	-8.18	0.00*
1. Innovation-Transforming Organization	4.22	0.36	4.47	0.30	-8.47	0.00*
2. Knowledge Creation	4.18	0.40	4.45	0.35	-7.81	0.00*
3. Resource Preparation	4.15	0.40	4.39	0.34	-7.14	0.00*
4. Contemporary Technology	4.08	0.38	4.26	0.40	-5.30	0.00*

*Statistically significant at the 0.05 level.

The Chi-Square Probability Level of 0.133, CMIN/DF of 1.096, GFI of 0.955, and RMSEA of 0.014, these statistical values were used to assess the consistency of the structural equation model after improvements. Overall, four statistics met the assessment criteria for fit with the empirical data (Figure 2) in the Standardized Estimate mode.

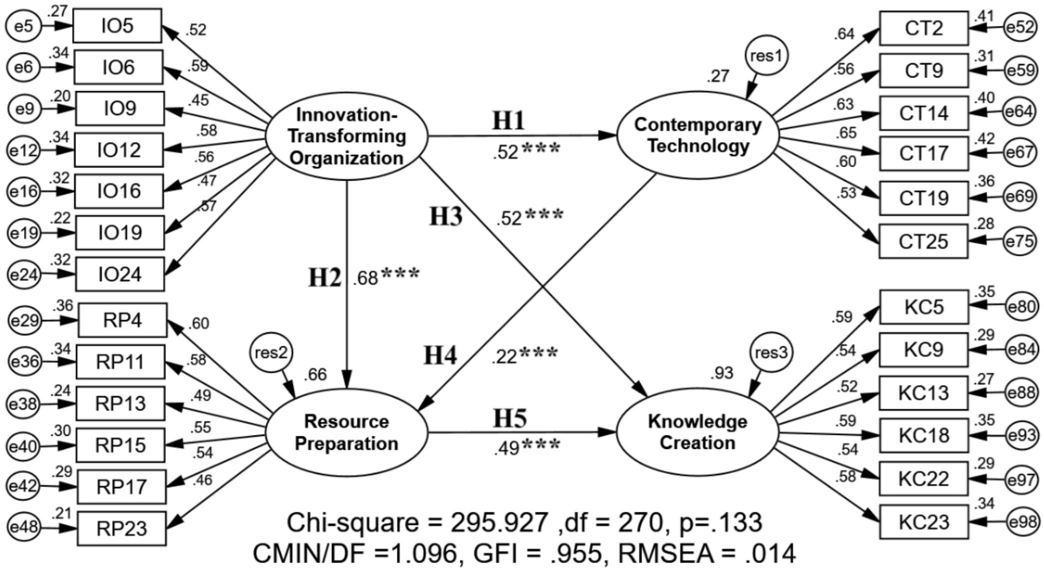

Figure 2: Structural equation model after model improvement.

According to Figure 2, the hypothesis testing for the causal influence between latent variables in the Structural Equation Model of creative innovation management in the machinery and metalworking industry group shows 5 hypotheses, with the following results:

H1: The Innovation-Transforming Organization component statistically significantly directly influences the Contemporary Technology component at 0.001, standardized regression weight of 0.52, by the research hypothesis.

H2: The Innovation-Transforming Organization component statistically significantly directly influences the Resource Preparation component at 0.001, standardized regression weight of 0.68, by the research hypothesis.

H3: The Innovation-Transforming Organization component statistically significantly directly influences the Knowledge Creation component at 0.001, standardized regression weight of 0.52, by the research hypothesis.

H4: The Contemporary Technology component has a statistically significant direct influence on the Resource Preparation component at 0.001, standardized regression weight of 0.22, by the research hypothesis.

H5: The Resource Preparation component has a statistically significant direct influence on the Knowledge Creation component at 0.001, standardized regression weight of 0.49, by the research hypothesis. The details are presented in Table 3.

Table 3: Statistical values from the Structural Equation Modeling analysis after model improvement.

Variables	Estimation		R^2	Variance	C.R.	P-value
	Standardized	Unstandardized				
Innovation-Transforming Organization				0.13		
Contemporary Technology	0.52	0.73	0.27	0.19	7.006	***
Resource Preparation	0.68	0.82	0.66	0.06	7.381	***
Knowledge Creation	0.52	0.61	0.93	0.01	4.831	***
Contemporary Technology			0.27	0.19		
Resource Preparation	0.22	0.18	0.66	0.06	3.379	***
Resource Preparation			0.66	0.06		
Knowledge Creation	0.49	0.48	0.93	0.01	4.705	***
Innovation-transforming Organization				0.13		
IO5	0.52	1.00	0.27	0.35		
IO6	0.59	1.16	0.34	0.33	9.296	***
IO9	0.45	0.87	0.20	0.39	7.747	***
IO12	0.58	1.10	0.34	0.31	9.247	***
IO16	0.56	1.07	0.32	0.32	9.081	***
IO19	0.47	1.01	0.22	0.47	8.031	***
IO24	0.57	1.07	0.32	0.31	9.090	***
Contemporary Technology			0.27	0.19		
CT2	0.64	1.00	0.41	0.38		
CT9	0.56	0.83	0.31	0.39	10.006	***
CT14	0.63	0.95	0.40	0.35	10.991	***
CT17	0.65	0.97	0.42	0.33	11.200	***
CT19	0.60	0.92	0.36	0.39	10.563	***
CT25	0.53	0.78	0.28	0.40	9.643	***
Resource Preparation			0.66	0.06		
RP4	0.60	1.00	0.36	0.34		
RP11	0.58	0.92	0.34	0.31	10.151	***
RP13	0.49	0.84	0.24	0.42	8.950	***
RP15	0.55	0.89	0.30	0.35	9.722	***
RP17	0.54	0.88	0.29	0.36	9.576	***
RP23	0.46	0.74	0.21	0.37	8.499	***
Knowledge Creation			0.93	0.01		

KC5	0.59	1.00	0.35	0.33		
KC9	0.54	0.90	0.29	0.35	9.800	***
KC13	0.52	0.89	0.27	0.37	9.589	***
KC18	0.59	0.99	0.35	0.33	10.519	***
KC22	0.54	0.87	0.29	0.33	9.797	***
KC23	0.58	0.99	0.34	0.33	10.444	***

*** Statistically significant at the 0.001 level.

Table 3, the structural equation model, after model improvement, included 4 latent variables, which are: An exogenous latent variable, which includes Innovation-Transforming Organization, and three endogenous latent variables, including Contemporary Technology, Resource Preparation, and Knowledge Creation. Moreover, the Innovation-Transforming Organization influences Resource Preparation directly, with a standardized regression weight of 0.68, statistically significant at the 0.001 level, resulting in a multiple correlation coefficient (R^2) of 0.66 and a variance of 0.06. Furthermore, Contemporary Technology and Knowledge Creation, standardized regression weights of 0.52, each significant at the 0.001 level. The R^2 values for these influences are 0.27 and 0.93, with variances of 0.19 and 0.01, respectively. In addition, Contemporary Technology directly influences Resource Preparation, with a standardized regression weight of 0.22, significant at the 0.001 level, R^2 of 0.66, and a variance of 0.06. And the Resource Preparation has a direct influence on Knowledge Creation, with a standardized regression weight of 0.49, statistically significant at the 0.001 level, R^2 of 0.93, and a variance of 0.01.

Innovation-Transforming Organization, including 7 observational variables, arranged by standardized regression weight from highest to lowest:

Promotion and motivation of personnel in innovation creation by focusing on process and innovation outcomes (IO6) showed a standardized regression weight of 0.59, statistically significant at the level of 0.001, R^2 of 0.34, and a variance of 0.33. Promoting personnel self-learning by guiding them through encountered problems and providing consultation at every step of the work process (IO12) demonstrated a standardized regression weight of 0.58, statistically significant at the level of 0.001, R^2 of 0.34, and a variance of 0.31. Establishing coordination and close monitoring of all problems (IO24) with a standardized regression weight of 0.57, statistically significant at the 0.001 level, R^2 of 0.32, and a variance of 0.31. Managing production planning, quality control, and developing personnel's technology skills efficiently (IO16) showed a standardized regression weight of 0.56, statistically significant at the level of 0.001, R^2 of 0.32, and a variance of 0.32. Determining appropriate responsibilities for personnel at all levels of the innovation development project (IO5) demonstrated a standardized regression weight of 0.52, R^2 of 0.27, and a variance of 0.35. Executives are role models in analyzing data to create innovation and develop technology for the organization (IO19) with a standardized regression weight of 0.47, statistically significant at the level of 0.001, R^2 of 0.22, and a variance of 0.47. Systematically determining the change management process, which can be followed step by step (IO9), showed a standardized regression weight of 0.45, statistically significant at the level of 0.001, R^2 of 0.20, and a variance of 0.39.

Resource Preparation, including 6 observational variables, arranged by standardized regression weight from highest to lowest:

Providing sufficient machinery, equipment, and tools, and always maintaining them ready for use (RP4) showed a standardized regression weight of 0.60, R^2 of 0.36, and a variance of 0.34. Creating a central data storage for storing data from multiple sources both inside and outside the organization, serving as a data warehouse for further analysis and management (Data Warehouse) (RP11) demonstrated a standardized regression weight of 0.58, statistically significant at the 0.001 level, R^2 of 0.34, and a variance of 0.31. Recruiting sufficient strategic personnel for digital technology to drive business advantages and sustainable development (RP15) with a standardized regression weight of 0.55, statistically significant at the 0.001 level, R^2 of 0.30, and a variance of 0.35 was achieved. Finding subcontractors to take on specific jobs or those requiring special expertise to work for the organization, ensuring job success and long-term cost reduction (RP17) with a standardized regression weight of 0.54, statistically significant at the 0.001 level, R^2 of 0.29, and a variance of 0.36 was observed. Regularly testing the knowledge and skills of personnel in creating innovations in the machinery and metalworking industry (RP13) showed a standardized regression weight of 0.49, statistically significant at the 0.001 level, R^2 of 0.24, and a variance of 0.42. Recording the performance of personnel to create a knowledge database on industrial innovations from work (RP23) showed a standardized regression weight of 0.46, statistically significant at the 0.001 level, R^2 of 0.21, and a variance of 0.37.

Contemporary Technology consists of 6 observational variables, ranked by standardized regression weight from highest to lowest:
Selecting machinery that can produce products in various forms to help reduce operating costs (CT17) achieved a standardized regression weight of 0.65, statistically significant at the level of 0.001, an R^2 of 0.42, and a variance of 0.33. Providing workflow management and an electronic approval assistant program that can be integrated with the email system for communication between departments within the organization (CT2) demonstrated a standardized regression weight of 0.64, an R^2 of 0.41, and a variance of 0.38. Developing an intelligent system (Smart System) to control operations, issue commands, and manage intelligent public systems, including information access, enabling the organization to continuously develop its products (CT14) achieved a standardized regression weight of 0.63, statistically significant at the 0.001 level, an R^2 of 0.40, and a variance of 0.35. Creating an implementation plan for the project through collaboration between innovation development networks (CT19) observed a standardized regression weight of 0.60, statistically significant at the level of 0.001, an R^2 of 0.36, and a variance of 0.39. Implementing an IT system to support work that allows personnel to work from anywhere, with continuous access to the organization's data (CT9) achieved a standardized regression weight of 0.56, statistically significant at the level of 0.001, an R^2 of 0.31, and a variance of 0.39. Establishing guidelines for integrating innovation development networks through personnel representatives in collaboration with the network and determining steps for diagnosing problems that lead to innovation development (CT25) demonstrated a standardized regression weight of 0.53, statistically significant at the level of 0.001, an R^2 of 0.28, and a variance of 0.40.

Knowledge Creation consists of 6 observational variables, ordered by standardized regression weight from highest to lowest:
Enabling personnel to exchange roles encourages the generation of new knowledge for innovation (KC5) with a standardized regression weight of 0.59, unstandardized regression weight of 1.00, R^2 of 0.35, and a variance of 0.33. Regular innovation management training by external experts (KC18) provided a standardized regression weight of 0.59, unstandardized regression weight of 0.99, which was statistically significant at the 0.001 level, R^2 of 0.35 with a variance of 0.33. Promoting learning through hands-on activities to uncover root causes, resolve problems, and increase work efficiency (KC23), which demonstrated a standardized regression weight of 0.58, was significant at the 0.001 level, with R^2 of 0.34 and a variance of 0.33. Conducting training programs in creativity and innovation management, guided by a structured training plan (KC9), resulted in a standardized regression weight of 0.54, a C.R. of 9.800, statistically significant at the 0.001 level, R^2 of 0.29, and a variance of 0.35. Sharing knowledge

management activities through the organization's information boards (KC22) presented a standardized regression weight of 0.54, a C.R. of 9.797, statistically significant at the 0.001 level, R^2 of 0.29, and a variance of 0.35. Creating a dedicated unit for systematic knowledge management (KC13) had a standardized regression weight of 0.52, statistically significant at the 0.001 level, R^2 of 0.27, and a variance of 0.37.

DISCUSSION

Innovation-Transforming Organization is the element with the highest average, indicating empirical evidence that the drive toward becoming an innovative organization involves the integration of all internal components to transform organizational management into a new form. This transformation emphasizes creating an atmosphere within the organization that consistently develops new ideas and supports innovation in product development and improved work processes. These efforts aim to meet customer needs and create a competitive advantage for the organization (Boger et al., 2021).

The most important item in the innovation management approach of the machinery and metalworking industry group is setting key performance indicators (KPIs) that challenge all personnel to improve their work performance in line with set goals. This may be because KPIs are measurable indicators that reflect an organization and its progress toward improving its strategic objectives. Innovation management in this context, the KPIs give insights effectiveness of innovation initiatives, processes, and outcomes.

Performance indicators encourage organizations to assess innovation capabilities, identify subjects for achievement, also informed decisions. The critical aspect of assessing innovation performance extends entire innovation management process, from start to finish. Organizations must take a holistic approach that encompasses every stage, from environmental exploration to idea generation and implementation, which should be continuously monitored (Suwignjo et al., 2022).

The analysis results showed that the highest overall influence was on the Innovation-Transforming Organization, which had a significant impact on Knowledge Creation. Empirical data indicated that creating core organizational innovations was a key strategy that provided the organization with a competitive advantage. This included encouraging a culture of service innovation, continuously striving for product development, and consistently improving work processes. For this approach to succeed, personnel within the organization must understand and align with the organizational culture in a unified direction. To create a concept that aligns with the organization's strategic plan, human resource managers must possess the ability to think strategically and develop personnel with knowledge and skills that are in line with the organization's objectives. This involves shaping a strategic plan for human resource management that can be effectively implemented and achieved (Bianchi and Machado, 2022).

The hypothesis testing results, categorized by the size of the business organization, show a statistically significant difference at the level of 0.05. This may be because large businesses have applied technology and innovation by utilizing digital technology to manage data for forecasting and planning. They use knowledge from these processes, which enables the industry to compete and create sustainable performance, while also giving importance to personnel development and innovation. By focusing on building critical thinking skills and developing software personnel, SME entrepreneurs are not ready to invest in high-cost work such as automation systems, including high-value machinery and equipment, due to limitations and a lack of confidence in the return on investment. To support and develop the potential of SMEs, cooperation from all sectors, including the government, private sector, and educational institutions, is required to assist and nurture the capabilities of SME entrepreneurs (Muller, Buliga, and Voigt, 2021).

Several research biases need to be controlled to ensure that the results of this study are reliable. The key issue is the selection bias, which occurs when the sample population used is not representative of the larger population or target demographic. For example, if participants from a specific geographic area or socioeconomic background dominate the sample, the results may not be generalizable to the entire population. Additionally, confirmation bias may occur when researchers unconsciously focus on data that supports their hypotheses while disregarding data that contradicts their expectations. Addressing these biases through careful sampling and rigorous data analysis methods is essential to enhance the study's integrity.

The implications of this study's findings are significant, particularly in informing practices and policies within the field of business administration. If the findings reveal consistent patterns or strong correlations, they can serve as a foundation for how organizations approach decision-making, resource allocation, or strategic planning. Conversely, if biases have influenced the results, false conclusions may lead practitioners to adopt inappropriate or counterproductive action strategies. Therefore, it is crucial to identify and correct any potential biases before drawing conclusions from this study to ensure that the insights presented can be trusted and applied in real-world scenarios.

CONCLUSION

The research results concluded that the components of the creative innovation management approach for the machinery and metalworking industry group were of high importance, with the Innovation-Transforming Organization being the most important. This component emphasized the determination of key performance indicators (KPIs) that were challenging for all personnel to drive changes in work performance according to the set goals. When comparing the differences in the level of importance using the t-test, the results were statistically significant at the level of 0.05. After the structural model was improved, overall, all 4 statistical indicators met the evaluation criteria and were in line with the empirical data. The hypothesis testing results, which examined the causal relationships among latent variables in the structural equation model, supported all 5 research hypotheses.

RECOMMENDATIONS

Industrial entrepreneurs should define the responsibilities of personnel at all levels of the innovation development project appropriately, encourage personnel to engage in self-learning, guided by problems encountered, and provide consultation at every step of the work process. They should also record personnel's work performance to create a knowledge base on industrial innovation. Entrepreneurs should model the analysis of data to create innovation and develop technology for the organization, and ensure sufficient machinery, equipment, and tools are available and ready for use at all times. In addition, they should manage production planning and quality control efficiently, develop personnel's technology skills, specify coordination, and closely monitor all problems. Furthermore, personnel should be allowed to rotate and change jobs to create new knowledge related to innovation creation.

LIMITATIONS

1. In the qualitative section, with 9 experts using in-depth interview techniques, some experts rescheduled their interview appointments due to important commitments, requiring adjustments to their schedules.
2. The quantitative research procedures involved distributing, collecting, and compiling questionnaires within a limited time frame time from August to November 2024.
3. The sample group for the questionnaire, consisting of business operators or respondents in the machinery and metalworking industry group, experienced several instances where the responsible person changed, causing delays or cancellations in data collection at some locations.

Suggestions for Future Research

1. Research on the Human Resource Management Approach to Creative Innovation in the Machinery and Metalworking Industry Group.
2. Research on the Causal Factors Influencing Creative Innovation Management for Competitive Advantage in the Machinery and Metalworking Industry Group.
3. Research on the Management Approach to Creative Innovation in Learning Organizations within the Machinery and Metalworking Industry Group.

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