



The Quantum-Driven Sustainable Entrepreneurial Readiness: An Empirical Model of Intrinsic Motivation and Characteristics Technology

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Abstract. This study highlights the role of QML which is a convergence of the artificial intelligence and the quantum computing in foresting the data-driven sustainable entrepreneurship. This study aims to examine how QML affects the intrinsic motivation and how much the motivation itself shapes QDSER among the digital native entrepreneurs. Referring to a Self-Determination Theory, the study also explores the direct and moderating effects of the technology characteristics, namely the perceived usefulness and novelty. Data were collected through the purposive sampling of undergraduate students, engaged in the entrepreneurial practice, while these data were analyzed using SmartPLS 3.0. The results reveal that QML positively affects intrinsic motivation and QDSER. This research introduces the novel construct of QDSER and enriches the digital entrepreneurship literature by integrating psychological and technological dimensions within the quantum era.

Keywords: Quantum Machine Learning, Intrinsic Motivation, Technology Characteristic, Sustainable Entrepreneur, QDSER

1 Introduction

Quantum technology is based on the principles of quantum mechanics, namely the physics of sub/atomic particles and the theories of superposition and entanglement. [1] Integration of the Artificial Intelligence (AI), as supported by the quantum technology to be a Quantum Machine Learning (QML), is a transformative force that reshapes the sustainable entrepreneurship, affecting the changing strategies, market dynamics, and Consumer Expectations. [2] [3]

Entrepreneurship has been one of the main fields in business studies due to its significant role in driving positive transformation and strengthening economic resilience. Nevertheless, the realm of sustainable entrepreneurship is still relatively new and keeps changing, with the ongoing discussions regarding its definition, boundaries, and the determining factors. In this context, a model has been developed using various estimation approaches to examine how small and medium-sized enterprises (SMEs) and start-ups can integrate the long-term sustainability strategies through the implementation of

innovation and digitalization. [4] The research results indicate that most of the businessmen show a low level of interest in the growth-oriented agendas, thereby limiting the expansion of discourse that supports entrepreneurship and innovation. On the other hand, the company owners tend to focus on other aspects contributing to their businesses' sustainability, which are not solely related to the dynamics of innovation or the process of digitalization.

Data on the growing number of small and medium enterprises in Central Java, including Semarang, Salatiga, Surakarta, and Semarang Regency from 2020 to 2024, are as follows:

Table 1. Number of The Companies in Small Micro Industry in Four Regencies/Cities

Regencies and Cities	Head Number of Companies in Small Micro Industry by Regency/City in Central Java Province			
	2020	2021	2022	2023
Salatiga	2,552	3,052	3,153	1,611
Surakarta	6,416	7,137	8,050	15,514
Semarang	12,565	12,883	11,715	30,024
Semarang Regency	29,987	19,504	25,010	21,810

To date, there are still limitations in the empirical research that comprehensively examines the relationship among entrepreneurial experience, inherent value readiness, and the levels of acceptance and response to the implementation of QML as a tool to support the achievement of Sustainable Development Goals (SDGs). This gap indicates an important void in the literature requiring a further exploration. [5] Nevertheless, several studies have focused on a role of the non-financial reporting as a driver in efforts to achieve the SDGs. In addition, some researches also emphasize the importance of examining the AI adoption through both linear and non-linear relationship approaches, as well as identifying the effect of perceptions and attitude factors playing a role in the process. [6] Therefore, the QML aspects along with its sustainability issues in entrepreneurship need to get serious attention and cannot be ignored in scientific studies. [7] The symbiotic interaction between humans and QML gives rise to the new perspectives on self-identity and the role of individuals in the process of being an entrepreneur. [8] [9]

This synthesis examines the extent to which individuals begin to view AI as an extension of the self, a form of the advanced technology that fosters dependency while creating a synergy beyond human capabilities. Along with the development of AI-based tools and advances in biotechnology, the gene mapping, and the genetic engineering, the integration of physical and cognitive aspects in human beings with this technology demonstrates the emergence of a phenomenon that can be referred to as human-AI hybridization. [10], into QML.

Although its urgency has been recognized, the studies on cultural change and QML interventions offer an interesting research design to identify the factors driving the formation of sustainable entrepreneurial behavior. [11] [12] Understanding of the factors

that drive individuals to participate in a sustainable entrepreneurship is still relatively limited, particularly regarding the role of an intrinsic motivation affected by the QML.

Several studies indicate a gap in understanding how psychological needs interact and how the combined effects of these interactions affect the individual motivation. [13] On the other hand, the existence of QML has the potential to enhance operational efficiency and the decision-making effectiveness, while challenging the traditional paradigms regarding identity and creativity of the entrepreneurs. [14] Humans, as beings affected by hormones, emotions, and energy, naturally experience the fluctuating dynamics in their cognitive and emotional aspects. These changes in condition also affect how individuals perceive reality and make decisions. In a context of the temporal evolution of human behavior, along with the increasing complexity of AI capabilities, a reflective question arises regarding how the QML will shape entrepreneurial identity in the future. Based on the framework of Self-Determination Theory (SDT), this study develops an integrative model to examine how insights generated through QML can influence entrepreneurs' intrinsic motivation toward their entrepreneurial intention practices. Several previous studies indicated that several factors (e.g., role models, opportunity evaluation processes, and entrepreneurship education) are key components that play a role in the formation of entrepreneurial intentions. [15] Intrinsic factors are elements fulfilled through an individual's involvement in carrying out an activity. Several previous studies have focused on aspects of the intrinsic motivation to formulate theories that explain how these factors simultaneously influence sustainable entrepreneurial intentions through the utilization of Generative Artificial Intelligence (GenAI), such as ChatGPT application. [16] ChatGPT itself is a form of GenAI application in processing the data with an ability to generate new information by replicating other patterns obtained from the previously analyzed training data. [17] This study assumes that advancements in the field of quantum computing have the potential to affect the development of entrepreneurial intentions. The synergy between AI and quantum technology is believed to give rise to a new concept called Quantum-Driven Sustainable Entrepreneurial Readiness (QDSER), which constitutes the main novelty of this study.

2 Theoretical Background

2.1 Quantum Machine Learning and Intrinsic Motivation

Today, Machine Learning (ML), as one of the branches of AI, has been the focus of attention in various leading scientific researches [18]. According to [19] [20], the patterns generated by ML algorithms have the capability to automatically extract features, identify error patterns, and predict error trends from large volumes of the monitoring data. ML technology offers a number of significant advantages. First, ML algorithms can process a large amount of the historical operational data to perform error detection, diagnosis, and prediction. Second, the automated analysis and the real-time monitoring data processing enable the system to provide the early warnings of potential errors, ultimately improving accuracy and reliability of the monitoring process. Third, ML models have the adaptive capabilities through continuous data updates, allowing for the improved ability to recognize new error patterns. Nevertheless, the advancements in

the quantum computing and QML also require support for high computational costs, particularly during the training and deployment stages of the model to process the large-scale or complex datasets. [21]

QML is a cutting-edge innovation that combines the principles of ML techniques with the quantum computing, while having a great potential in solving various complex problems in the modern age. These recent developments indicate that several QML algorithms, namely Quantum Support Vector Machine (QSVM), Quantum Boltzmann Machine (QBM), and Quantum Neural Network (QNN), have demonstrated a superior performance, compared to the conventional approaches in various application fields. [18] Among these various developing quantum algorithms, the issue of anomaly detection holds an important position due to its wide relevance across various disciplines, ranging from cybersecurity and fraud detection to research in the field of particle physics. [22] Moreover, it is possible to cover the discipline of management.

The development of QML began with the building of a continuous variable neural network for quantum computers and anomaly detection [23]. Meanwhile, the next QML development is the existence of a full quantum neural perceptron model [24].

H1: QML having a constructive influence on an individual's level of intrinsic motivation.

2.2 Intrinsic Motivations and Quantitative Structure-Disrupting Energy Relationship (QDSER).

Prior researches based on the behavioral drivers that facilitate the achievement of goals and performance indicated this finding an orientation toward the sustainability can serve as a basis for explaining various forms and characteristics of the investor's motivation, while providing opportunities for learning a deeper knowledge and understanding related factors initiating the emergence related to such motivation. [25] The entrepreneurs' characteristics influenced by educational background as well as the predetermined features. [26] On the other hand, several researchers assert that the entrepreneurial archetype as well as the figure or role model of an entrepreneur have a significant influence on the formation of an individual's intention to engage in the entrepreneurship. [27]

Research shows that several components, namely a role model, the decision-making process related to assessing business opportunities or innovations, entrepreneurship education aimed at equipping participants with entrepreneurial knowledge, skills, and attitudes, as the main components of entrepreneurial intentions. [15] Determination derived from internal aspects refer to elements which falls into the category fulfilled through an individual's involvement in an activity. Several previous studies have emphasized the intrinsic motivation to build a theoretical foundation that explains how these factors simultaneously influence sustainable entrepreneurial the goals to be achieved through the use of Generative AI technology, particularly artificial intelligence-based language modeling platform for adaptive text interaction and production application. [16] A language-based generative model developed to produce automatic responses is a form of Generative AI technology application serving to process the data with an ability to generate the new data by reconstructing patterns from the previously

analyzed training samples. [17] Authors assume that advancements in a field of the quantum computing have the potential to significantly impact the development related to the drive for entrepreneurship. The element synergy between advancements in the field of artificial intelligence along with computing innovations based on quantum mechanics principles is believed aimed at generate a new concept called QDSER, which constitutes a key novelty aspect in this research.

H2: Intrinsic motivation has a positive impact on QDSER, indicating that an individual's internal drive contributes significantly to the improvement of that dimension's quality.

2.3 The Main Element That Characterizes a technology.

Nowadays, the use of ML has expanded across various fields. In this context, this study seeks to examine how the technology characteristics play a role in affecting the sustainable entrepreneurial intentions. [28] Several previous studies on the sustainable intentions have adopted theoretical models with an assumption that the motivational factors have an implicit effect on sustainability. [29] Authors argue that the presence of complex interactions allows QML users to experience a holistic experience, in which the configuration of various elements simultaneously fosters the formation of a strategic commitment to developing and carrying out entrepreneurial activities that are oriented towards long-term economic, social, and environmental sustainability, both at a significant intensity and at a relatively low level levels about aspects of sustainability. That thing perspective interpreted as based on the assumption what is meant QML patterns of behavior and tendencies of individuals in using a product, service, or technology is affected on the basis of multivalent mutual influence process between motivational driving factors along with technological fundamental dimension. [30]

Within this framework context, this research is oriented toward the goal of further critically analyzing related to reciprocal relationship between technology characteristics and intrinsic motivation as well as sustainable entrepreneurial intention. For instance, the individuals with a high level of motivation to acquire knowledge through the stimulating use of QML tend to participate in the instructive learning activities. Such engagement can be affected by the level of enthusiasm experienced, which ultimately contributes to an increase in their entrepreneurial capabilities intention.

H3: QML has a constructive influence on the improvement of QDSER.

H4: The characteristics of technology have a constructive influence on intrinsic motivation.

H5: The characteristics of technology have a positive influence on the quality of QDSER performance.

2.4 Research Framework.

Previous research on motivation indicated that a sustainability-oriented approach can be used as a basis to explore the characteristics and variations of investor motivation. This approach also provides a more comprehensive understanding of the factors driving

the formation of such motivation. [25] The characteristics of an entrepreneur are influenced by their educational background as well as the extent to which they adhere to or reflect the established entrepreneurial attributes. [26] Meanwhile, several researchers argue that the entrepreneurial archetype as well as the figure or role model of entrepreneurs have a significant influence on a person's intention to start a business. [27]

The research modeling framework is used to describe the conceptual relationships between variables and serve as the basis for empirical testing in a scientific study. research modeling framework is used to describe the conceptual relationships between variables and serve as the basis for empirical testing in a scientific study. integrates this research identifies three main components in sustainable development main a set of interconnected elements, namely inherent and originates from the individual's internal drive motivation, extrinsic motivation, and technology characteristics. In the dimension of intrinsic motivation, this study highlights three main aspects, namely Internal drive that comes from personal satisfaction to complete a task or achieve a certain accomplishment (InMaccomplish), Internal motivation to gain deep understanding and knowledge (InMknow), and An individual's internal drive to seek experiences that provide sensation, challenge, or emotional and cognitive stimulation (InMstimulation). Meanwhile, technology characteristics are represented by two variables, namely the perceived usefulness and the perceived novelty. In addition, the model includes the factor of sustainable entrepreneurial intention, which reflects five personality dimensions, namely openness, conscientiousness, extraversion, agreeableness, and neuroticism. This research model is described as follows:

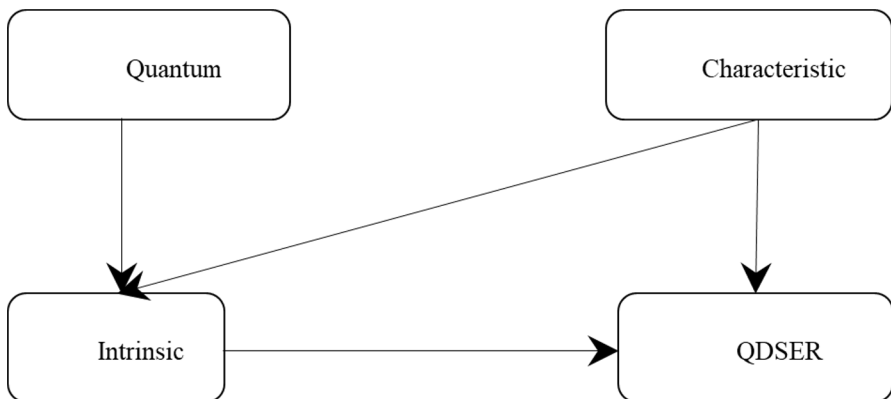


Fig. 1. Research Model

3 Methodology

3.1 Study subjects and research implementation mechanisms

The quantitative research method applies purposive sampling techniques, in which the undergraduate students from the Digital Business Department of Ngudi Waluyo University were the entity being studied, for obtain empirical evidence that supports the premises formulated based on a literature review.

Questionnaire-based study were compiled using an online data collection instrument through Google Forms., with a the totality of research participants analyzed of a total of 142 individuals who were research subjects, namely what is meant undergraduate the academic community from the Oriented towards computer systems Business Research Program of Ngudi Waluyo University.

3.2 Research Analysis Instruments

1. The data analysis method was applied using the PLS (Partial Least Square) approach by utilizing SmartPLS version 3.0 software as a tool for model processing and testing.
2. In the context of the outer model, an indicator is considered valid if it has met the established requirements the level of suitability and interconnection between indicators that measure similar constructs, as well as to indicates high reliability and validity when having when the outer loading value exceeds the threshold of 0.70, it indicates adequate indicator reliability and the Average Variance Extracted (AVE) value must exceed 0.50 as an indicator that the latent variable is able to explain more than half of the variance of its indicators.
3. Inner Model; the structural model was evaluated using R-square for the dependent variable.
4. Hypothesis test; it was carried out by considering the estimated level of the relationship coefficient generated through evaluation of the structural model (inner model).

4 Result and Discussion

4.1 Measurement Model Evaluation To Assess The Consistency And Validity Of Indicators

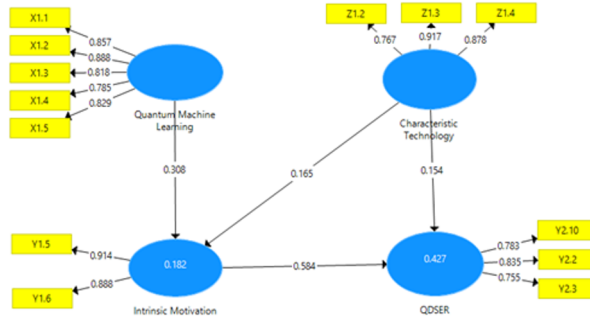


Table 2. Outer Loading Convergent Validity Test

Variable	AVE	R Square	Fornel Lacker
QML	.699	-	.836
IM	.812	19.504	.901
CT	.733	-	.856
QDSER	.627	.427	.792

Table 3. Outer Loading Convergent Validity Test

Variable	Construct	Outer Loading	VIF
QML	x1.1	.857	2.692
	x1.2	.888	2.862
	x.13	.818	2.013
	x1.4	.785	1.772
	x1.5	.829	2.286
IM	y1.5	.914	1.644
	y1.6	.888	1.644
QDSER	y2.2	.783	1.502
	y2.3	.835	1.318
	y2.10	.755	1.353
CT	z1.2	.767	1.531
	z1.3	.917	2.544
	z1.4	.878	2.169

4.2 Inner Model Test

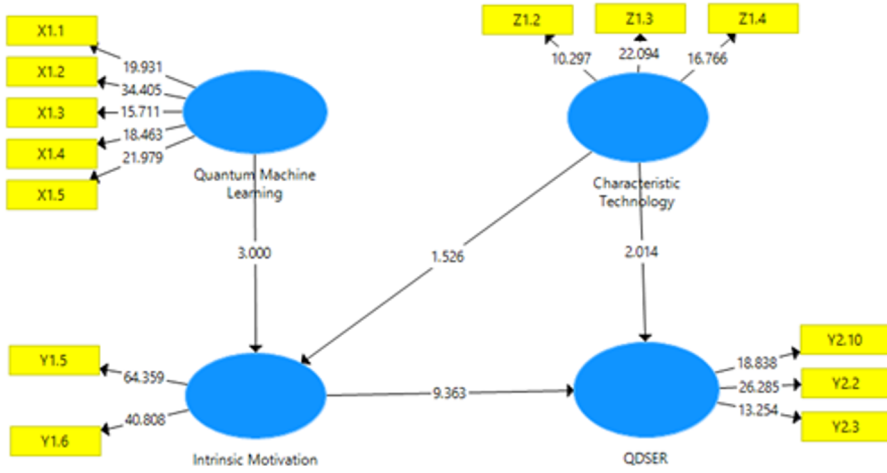


Table 4. Path Coefficient and Indirect Effect

Variable	Original Sample	t statistics	p-values
Quantum Machine Learning → Intrinsic Motivation	0.308	3.000	0.003
Intrinsic Motivation → QDSER	0.584	9.363	0.000
Quantum Machine Learning → QDSER	0.180	2.634	0.009
Characteristic Technology → Intrinsic Motivation	0.165	1.526	0.128
Characteristic Technology → QDSER	0.250	2.568	0.001

QML and Intrinsic Motivation (IM). From previous study [22], the integration of quantum computing and the adaptive computational model based on data learning, by optimizing the superposition approach along with entanglement through quantum mechanics-based bit format, collectively produced Quantum Machine Learning science-based engineering system to efficiently address the highly complex computational problems. This scientific review was recognized through [18], in which Quantum Machine Learning to provide an opportunity for extraordinary capabilities in processing high-dimensional data in real-time. These capabilities make QML highly relevant for application in various contexts of the developments and changes in the business environment, including the systematic efforts to maintain the balance of the environment, society, and economy to ensure the continuity of quality of life in the long term driven the process of managing opportunities to create economic value through innovation and business development. In the context of entrepreneurial engagement interact with QML, the current research is not only the tool, but also a strategic a potential avenue for improving operational efficiency to maintain a strategic position that provides a

competitive advantage, accompanied by and effectiveness through practices that ensure long-term viability way. With the help of examining the relationship in the relationship linking QML with IM, this research endeavor affirms that QML is present in a specifically defined form has the potential to create conditions that indirectly stimulate a deeper cognitive engagement among technology users, particularly the entrepreneurs, while encouraging the emergence of entrepreneurial intentions. Individuals who are able to identify the personal benefits and potential of the QML use will exhibit a higher level of intrinsic motivation. According to the SDT, the demand for feel adequately skilled and well-versed in relevant practices a personal the improvement process is marked by the main principle of this research focuses on the development of valid and reliable methodology aspect that determines the sustainability of a person's motivation in carrying out the entrepreneurial activities.

Individual Internal Drive As Well As Qualities, Discipline, Strategy Ethics, And Reflection (QDSER) As An Evaluative Framework. Research on foreign language proficiency [16] found the motivation that comes specifically from the individual himself motivation achieving certain accomplishments, Intellectual drive to understand, Motivation to experience new things, recreational interaction an important the impact on determining the intention to utilize a recent technological developments in a sustainable way, as stated below.

“Intrinsic motivation, particularly in the form of curiosity, accomplishment, and cognitive stimulation, is a key driver of continuance intention in innovative digital environments.”

Based on the above description, it can be concluded that this view aligns with the concept of QDSER. Within this framework, entrepreneurs do not merely adopt the quantum technology due to external factors, such as operational efficiency, but also the intrinsic drives, such as personal satisfaction, intellectual challenges, and the desire to develop themselves through utilization of the advanced technology. Thus, the intrinsic motivation plays a crucial role in shaping the mental and emotional readiness of entrepreneurs toward the sustainable entrepreneurial practices in the quantum-digital era.

Our argument is supported by [15]. In this context, intrinsic motivation serves as the main driver in the adaptation process toward technology in the realm of technology-driven advancements and novel developments entrepreneurial configuration, particularly aligned with market dynamics moves toward the era of digitalization and quantum computing. IM can gain knowledge contributing to shaping individuals' readiness to take on new challenges, entrepreneurial risks, and maintain resilience amid the dynamics of a business ecosystem orientation toward sustainability based on the quantum technology.

This study empirically shows that QDSER it's not enough just to go through profit as external influence. As a result, IM constitutes a key component of a within the framework of the a revolutionary quantum technology that is not yet fully stable terms of facilities and support systems. Nonetheless, the business developers driven by intrinsic motivation demonstrate a pronounced orientation toward long-term vision, thoughtful

analysis, and proactive initiative in designing and sustaining the business continuity compared to those whose actions are primarily affected driven by external factors.

Quantum Machine Learning and Quantum Deep Sequential Energy-based Reinforcement. In studies from [18] [21], it can be stated that QML, as an integral part of AI and ML, plays a role in accelerating adaptive learning processes, enhancing decision-making efficiency, and enabling the personalization data exchange through intelligent systems Intelligent educational methods supported by computing systems (ICAI). These capabilities have substantial implications for the business, particularly in efforts to maintain competitiveness amid an increasingly dynamic digital ecosystem. This study is supported by [29] and it is believed that technology, which functions to increase efficiency, monitor consumption patterns, and foster awareness of sustainability, has the potential to strengthen users' intentions and behaviors toward the sustainable action. Based on the findings from previous researches, authors argue that QML can drive the decision-making process through predictive and simulative mechanisms, which are central to the entrepreneurial readiness in the context of quantum-based sustainability. Thus, QML does not only serve as technological apparatus, nevertheless also a catalyst to enhancing the entrepreneurs' understanding of the environment and psychological conditions, in developing the businesses that are adaptive, innovative, and oriented toward the quantum concept and sustainable entrepreneurial readiness.

Technology Characteristics (CT) and Intrinsic Motivation (IM). Within the framework of this research, TC encompasses main factors, the level of perceived usefulness of a system for user performance, which describes the degree of technological influence, QML in that situation, it is considered as to provide benefits, in addition, the concept of Perceived Novelty (PN) can be represented as the level of novelty perceived by an individual relates to perceptions regarding the level of innovation, modern, and special in technological systems. Conceptually, referring to SDT as well as technology adoption models (TAM and UTAUT2), technology is generally considered to play a role in perceived to be advantageous and appealing can positively stimulate the intrinsic motivation, including curiosity (motivation to acquire knowledge), the sense of fulfillment derived from accomplishing goals (motivation to realize), as well as the engagement and positive experience derived from the learning process (motivation to undergo sensory or cognitive stimulation). This empirical evidence from the study shows that the influence of technique characteristics on intrinsic motivation has not been proven significant. These results are corroborated by a research [31]. Intrinsic motivation basically stems from an individual's internal drive, not merely influenced by perceptions of technology. Therefore, organizational values and technology characteristics do not demonstrate sufficient strength to foster such intrinsic motivation.

Although QML technology is considered advanced and new, the absence of personal value or the meaning attached means the insufficiency to trigger IM. An entrepreneur who feels that QML is not aligned with their personal identity or goals will not automatically be driven by intrinsic motivation [32]. Researchers stating that most of the typical dimensions of a technology, namely the ease of use, novelty, speed, and

efficiency, belong to the external attributes that tend to stimulate the extrinsic motivation, which is driven by external benefits, namely time efficiency, cost savings, or the increased prestige, rather than eliciting the intrinsic motivation from personal satisfaction and individual interest.

Characteristic Technology and QDSER. Conceptually, the results of this study are consistent with the literature asserting that the level of entrepreneurs' readiness to implement the sustainable business practices is greatly influenced by their perception toward technology's ability to enhance efficiency and drive operational innovation. In line with this, studies that adapt the UTAUT2 model to the context of sustainable technology indicate that performance expectations and innovative orientation are key determinants in shaping individuals' intentions and behavioral readiness to adopt technologies that support sustainability [33]. Thus, when a technology, QML for instance, is considered highly useful and revolutionary, entrepreneurs tend to experience the increased confidence, feel more relevant to the contemporary developments, and demonstrate a greater readiness to adopt modern business practices oriented toward sustainability.

Furthermore, in the article by [21], the artificial intelligence-based technology, QML in particular, is reported to enhance the adaptive capacity as well as the effectiveness of operational decision-making processes in the digital era ecosystems. QML is more than the competence to endure challenging conditions thrive in an increasingly complex and digitalized business environment that encompasses market dynamics. CT becomes an important foundation in building entrepreneurial readiness and in line with the principle of sustainability emphasizes a balance between the environment, economy, and society. Not in line with the relationship that emerges between CT as well as IM, as a result of which does not show significance in this study, the correlation between Technology Characteristics and QDSER confirms the preparedness to participate in the Sustainable entrepreneurship tends to be significantly influenced by rational considerations and strategic aspects that warrant greater attention compared to the internal drive. Entrepreneurs typically exhibit a propensity to adjust the level of their intention and readiness measured based on objective criteria evaluation concerning the technological tools and competencies applied. Within the scope of this study context, the use of methods and techniques to improve efficiency characteristics serve because the factors that trigger readiness, rather than that with the purpose of emotions alternatively intrinsic impulse, which explaining the reasons behind its influence on QDSER found to be relevant. Authors argue that higher QML is relevant with the technology they use based on the sustainable entrepreneurial practices.

5 Conclusion

Based on the results of the analysis and discussion, this study shows that intrinsic motivation and technology characteristics play an important role in shaping quantum-driven sustainable entrepreneurial readiness. Intrinsic motivation is the main factor that

encourages individuals to be ready to face changes in digital entrepreneurship, particularly in creating sustainable ventures. Meanwhile, technology characteristics function as a supporting factor that helps enhance adaptive capabilities, encourages innovation, and accelerates responses to the constantly changing and complex dynamics of the business environment.

Research findings also indicates that intrinsic motivation and technological characteristics interact synergistically in strengthening sustainable entrepreneurial readiness. Additionally, a quantum-driven approach suggests that small changes in aspects of motivation or technology can trigger significant impacts, thereby confirming that the relationships between variables are dynamic and nonlinear in the context of modern entrepreneurship.

Theoretically, this study expands the literature on entrepreneurial readiness by integrating sustainability perspectives and technology dynamics based on a quantum approach. Practically, the results of this study provide strategic implications for the development of entrepreneurship education, organization digital transformation, and the formulation of policies that support a sustainable entrepreneurial ecosystem. Thus, this study affirms that sustainable entrepreneurial readiness in the digital era depends not only on technical skills, but also on the strength of intrinsic motivation and adaptive technological capabilities that are integrated in shaping a resilient, innovative and sustainable business ecosystems.

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