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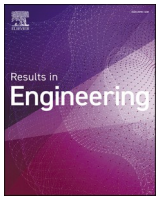

Cultural influences on lean manufacturing and productivity: Evidence from Malaysia

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ABSTRACT

This study investigates the impact of cultural values on the efficacy of lean manufacturing strategies within an emerging economy. Partial Least Squares Structural Equation Modeling (PLS-SEM) was used to look at data from a survey of 259 respondents from Malaysian manufacturing companies. Most research focuses on lean techniques and processes, but this study brings attention to the often-ignored significance of national culture. Within Hofstede's five dimensions, only uncertainty avoidance demonstrated a slightly significant positive correlation ($p < 0.10$) with lean implementation success, suggesting that organized, risk-averse environments may facilitate lean adoption. There were no significant effects from power distance, individualism, masculinity, or long-term orientation. Human resource practices were recognized as the most significant predictor of production, emphasizing the necessity of employee involvement and skill enhancement. The findings enhance lean theory by situating implementation within cultural frameworks and provide pragmatic assistance for managers and policymakers aiming to harmonize lean strategies with local cultural characteristics in emerging nations.

1. Introduction

Lean manufacturing has long been regarded as an effective strategy for boosting productivity, minimizing waste, and improving operational efficiency [1,2]. Rooted in the Toyota Production System, lean principles have gained widespread traction across numerous industries, especially within developed nations. Nevertheless, applying lean in developing countries presents distinct challenges shaped by cultural norms, economic limitations, and infrastructural constraints [3]. Although lean manufacturing tools and principles are often treated as universally applicable, contextual differences, particularly in developing countries, can affect how these practices are understood, adopted, and sustained. While a substantial body of literature has explored the technical and operational aspects of lean, the role of cultural influences in its implementation remains underexplored. Culture plays a pivotal role in shaping organizational behavior, employee motivation, leadership styles, and decision-making processes, all of which directly impact the effectiveness of lean initiatives [4]. Research indicates that cultural dimensions such as power distance, uncertainty avoidance, and collectivism can strongly shape how employees interact with lean processes. For example, in high power distance societies, employees might be reluctant to actively participate in continuous improvement initiatives [5]. In contrast, collectivist cultures may more quickly adopt techniques that depend on collaboration. Notwithstanding these insights, most lean frameworks have been formulated within Western or Japanese cultural contexts, resulting in a deficiency in comprehending how indigenous cultural values influence lean practices in emerging nations. Developing nations present a distinctive environment for lean methodologies owing to their particular socio-cultural frameworks, constrained resources, and frequently informal labor structures [6]. Although some studies have touched on the barriers to lean adoption in these environments, few have systematically examined how local cultural values can be incorporated into lean methodologies to enhance their effectiveness [7]. Much of the existing literature focuses on adjusting the technical aspects of lean tools rather than aligning them with cultural norms and workforce behavior. This oversight can lead to resistance, disengagement,

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and ultimately, subpar results in lean initiatives [8].

Several critical fundamental organizational enablers are essential for lean implementation, in addition to cultural influences. Continuous improvement systems, employee involvement, leadership commitment, training and development, and performance measures are frequently identified as critical factors in the success of lean initiatives. However, there is still a fundamental absence of research related to incorporating cultural value preferences into lean frameworks for developing countries, despite the steady increase in interest in lean manufacturing. Most models assume that lean is a universal system and fail to consider the impact of cultural diversity on the diffusion of lean [9]. Given this context, the primary goal of this study is to examine the impact of cultural values and fundamental lean enablers on the efficacy of lean manufacturing in enhancing productivity within the Malaysian manufacturing sector. The Malaysian manufacturing industry constrains the scope of this research, as it serves as a representative example of a developing economy with unique cultural attributes. In resource-constrained environments, the research underscores the influence of contextual and cultural factors on lean practices by situating the study within Malaysia. This investigation is expected to make two significant contributions: (i) to expand cross-cultural lean theory by offering empirical evidence from a developing economy, and (ii) to provide managers with practical insights on how to incorporate cultural considerations with lean enablers to increase productivity. The remaining portion of this paper is organized as follows: Section 2 provides a comprehensive review of the literature on cultural influences and lean manufacturing. Section 3 delineates the research methodology. Section 4 presents the results. Section 5 discusses the findings in the context of theory and practice. Section 6 concludes with contributions, limitations, and strategies for future research. The focus of the research is illustrated in Fig. 1.

2. Lean manufacturing practices and productivity improvement

Prior research shows that lean manufacturing techniques are associated with numerous components that contribute directly to productivity improvement. Lean manufacturing practices are described as an element of production planning and control that specifically emphasizes higher productivity, lower waste, and greater overall productivity [10,11]. Previous research has identified various components of lean manufacturing techniques contributing to productivity improvement, including human resources, labor management, production planning and control, supplier relationships, customer relationships, and environmental performance.

Planning and control processes relate to scheduling strategies that coordinate output and market demand. Good schedules produce inventory reduction, work-in-process reduction, resource efficiency, and customer satisfaction [12]. Making small batches also helps eliminate line imbalances, enabling a more flexible production flow. Using methods like Kanban and lot size reduction helps lower inventory and storage costs by limiting the amount of waste created by overproduction.

Human resource policies also aim to facilitate the implementation of lean objectives by addressing human capital and establishing a suitable work environment [13]. In lean manufacturing, the term "human resource" denotes the process of establishing an appropriate work environment to generate human capital to achieve lean objectives [14]. Workforce management is an additional critical factor, as lean methodologies can increase productivity by improving flexibility and agility [15]. When lean concepts are implemented in the workforce, the alignment of labor with demand has the potential to reduce lead times and costs [16].

Supplier relationships are also indispensable. The capacity to resolve quality concerns and guarantee just-in-time delivery is contingent upon a positive relationship with a supplier, which encompasses the quantity of suppliers, the duration of the relationships, the extent of supplier participation in product development activities, and the response the supplier receives regarding its performance [4]. In the same vein, customer relationship management improves responsiveness, satisfaction, and loyalty by means of feedback and communication [14]. The development of innovative production systems is contingent upon customer feedback. Environmental benefits are inherent in the development of a seamless and rapid flow of products through the manufacturing process, as it minimizes errors, inventory, downtime, and wasteful movement. Finally, lean practices enhance environmental performance by decreasing waste, pollution, and resource consumption, thereby enhancing efficiency and sustainability [17]. The factors that are considered to be significant for the enhancement of organizational productivity are detailed in Table 1.

The research trends for lean manufacturing for productivity enhancement are receiving increased attention. A Scopus database search covering 2014–2024 revealed ten nations that are most active in this field. Fig. 2 and Table 2 illustrate the global distribution of research, highlighting India, Brazil, the United Kingdom, the United States, and Malaysia among the leading contributors.

As presented in Fig. 2 and Table 2, India leads with 189 articles, reflecting significant academic and industry engagement. Brazil, the United States, and the United Kingdom also show strong contributions,

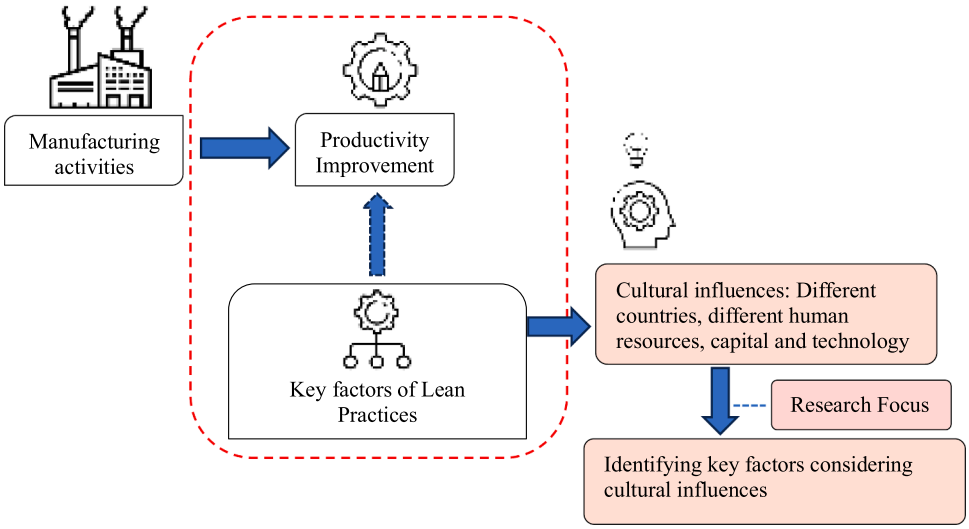

Fig. 1. Research focus: Identifying key factors of lean manufacturing considering cultural influences.

Table 1
Considered factors of productivity improvement.

Factor	Description
Production Planning and Control	Aligning output with demand through scheduling, small batches, Kanban, and inventory reduction.
Human Resources	Focusing on developing human capital through participation, empowerment, and training.
Workforce Management	Improving labor flexibility, motivation, and alignment with production needs.
Supplier Relationship	Building strong, long-term partnerships to ensure quality, timely delivery, and collaboration.
Customer Relationship	Enhancing loyalty, satisfaction, and responsiveness through communication and feedback.
Environmental Performance	Reducing waste, pollution, and resource usage, improving sustainability, and operational efficiency.

while Malaysia's 73 articles demonstrate a growing dedication to lean research aligned with national competitiveness goals. Countries such as China, Italy, Portugal, Australia, and Norway also emphasize lean productivity improvements, underscoring its global relevance. However, most studies remain technically oriented, with limited attention to cultural or contextual contingencies. This creates a gap for localized investigations, especially in developing economies such as Malaysia.

Prior literature confirms that lean practices—particularly production planning, human resource involvement, and supplier/customer integration—drive productivity. Yet, their effectiveness is not uniform across contexts. Practices that rely heavily on human behavior, such as employee involvement, empowerment, and continuous improvement (CI) routines, are likely to be the most sensitive to cultural values [18]. For instance, participation-based lean practices may thrive in collectivist settings but face resistance in high power-distance environments. In contrast, technical tools such as Kanban may be less dependent on cultural alignment. To position this study, three guiding propositions emerge from the literature review 1). Lean practices improve productivity, but their effectiveness varies across different national and organizational contexts. 2). Human-centered lean elements (e.g., HR practices, CI routines, teamwork) are more dependent on cultural alignment than technical or process-oriented practices. 3). Understanding the interaction between lean enablers and cultural values is necessary to explain differences in productivity outcomes across developing and developed economies. These propositions set the stage for the next section, which examines the role of culture in lean implementation and its implications for productivity in Malaysia.

3. Cultural values and lean implementation

Culture is the collective programming of the mind that differentiates the members of one group or category of people from others [19]. Hofstede identifies five cultural dimensions that influence workplace values and practices: collectivism-individualism, masculinity-femininity, power distance, uncertainty avoidance, and long-term orientation. The first dimension is Individualism-Collectivism, which distinguishes between societies that emphasize personal autonomy versus group cohesion [20]. Individualistic cultures stress independence, while collectivist cultures emphasize harmony and shared responsibility. Lean thrives on teamwork and collective responsibility, so collectivist settings may support group-oriented improvement routines, whereas highly individualist cultures may face challenges in sustaining collaborative kaizen efforts. Masculinity-Femininity is the second

Table 2
Trend Scopus data based on the country.

Country/Territory	Number of Articles
India	189
Brazil	94
United Kingdom	88
United States	83
Malaysia	73
China	61
Italy	60
Portugal	38
Australia	34
Norway	30

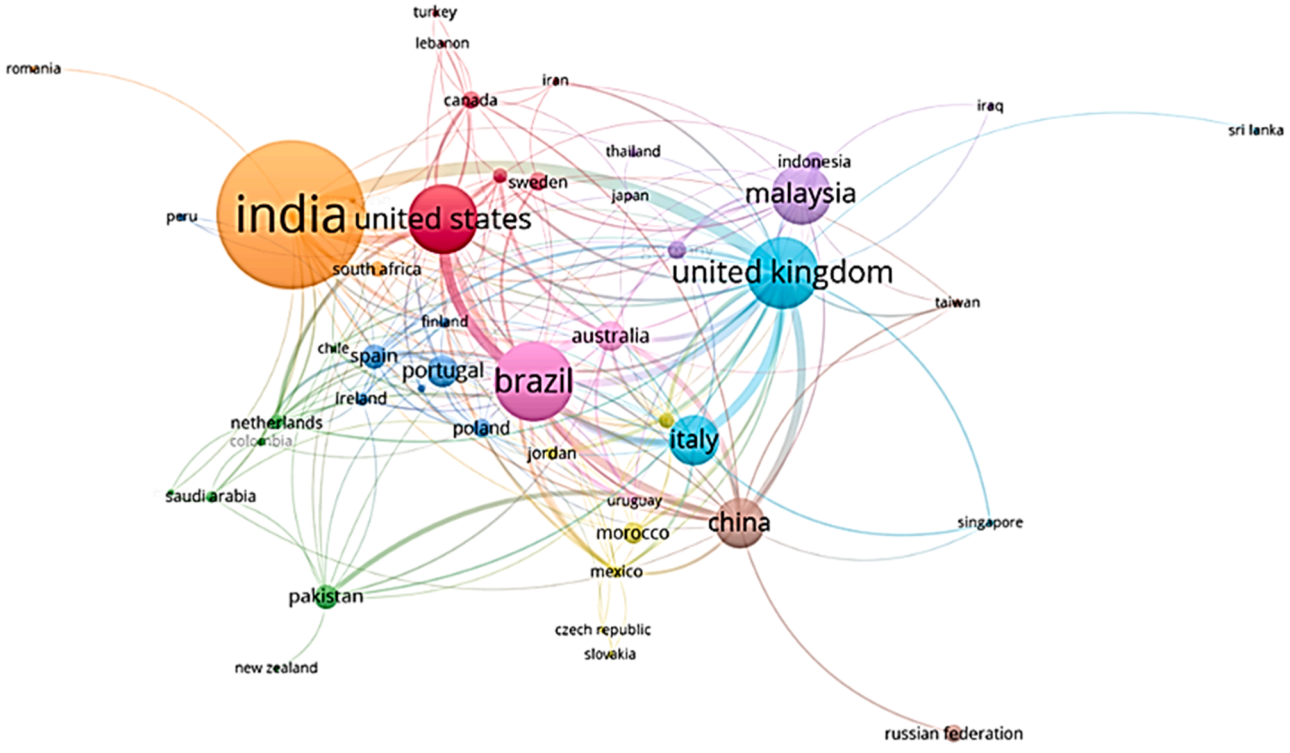

Fig. 2. Data visualization on lean manufacturing practices for productivity improvement based on the trend of countries.

dimension, which reflects whether a culture prioritizes competition and achievement (masculine) or cooperation and quality of life (feminine) [21]. Masculine cultures may reinforce performance pressure and measurable productivity gains, but can conflict with Lean's emphasis on collaboration and error sharing. In contrast, feminine cultures may better support cooperation but risk a less emphasis on efficiency.

The third concept is Power Distance, which describes how people in society accept and expect unequal distributions of power and authority. A high power distance indicates a hierarchical atmosphere with little opportunity for subordinate opposition, whereas individuals with low power distance prefer equality and shared decision-making. High power distance might restrict empowerment and bottom-up problem-solving in lean approaches like kaizen and team-based continuous improvement. The fourth factor, Uncertainty Avoidance, assesses tolerance for ambiguity and a propensity for structure [22]. High scores show adherence to rules and reluctance to change, whereas low levels suggest adaptability and risk tolerance. Because lean frequently includes experimentation, trial-and-error, and incremental progress, high uncertainty avoidance cultures may struggle to embrace new routines, whereas low uncertainty avoidance cultures may adapt more easily. The final factor is Long- vs. Short-Term Orientation, which describes whether civilizations emphasize perseverance and future-oriented investments over tradition and instant benefits [23]. Long-term-oriented cultures are more consistent with Lean's philosophy of continuous improvement, whereas short-term-oriented cultures may emphasize immediate outcomes over systemic change.

Since Malaysia is not a developed nation, its cultural index differs significantly from that of the United States and the United Kingdom. About Power Distance, Malaysia scores the highest at 100 out of 100, indicating the highest acceptance of hierarchical structure and unequal power distribution. On the other hand, people of the United Kingdom and the United States score much lower, at 35 and 40, respectively, indicating that both countries have less hierarchical cultures that tend to be more egalitarian. With Individualism, the US (91) and UK (89) are very individualistic, espousing an ethos of personal independence and self-sufficiency. At the same time, Malaysia, with a score of 26, is a more collectivist culture, prioritizing group cohesiveness and loyalty. The Masculinity dimension results show that the UK (66) and the US (62) have higher scores, indicating that they are more competitive and achievement-oriented compared to Malaysia (50), whose intermediate score suggests a moderate level of competitiveness between groups, balancing competition and cooperation among individuals. For the Uncertainty Avoidance factor, scores are on the low side for all three countries (Malaysia 36, United Kingdom 35, United States 46), showing a stronger acceptance of unclear situations and a higher reactivity to stress. The United Kingdom has the highest rank among the countries with a Long-Term Orientation score of 51, followed by Malaysia at a score of 41, and the United States at the third rank with a score of 29. The UK and Malaysia appear to be more long-term in their meticulous and persevering approach, whereas the USA seems to be more short-term in its focus. Fig. 3 shows five index of cultural dimensions for these countries.

4. Hypotheses development

Collectivism refers to individuals' tendency to prioritize group harmony, shared responsibilities, and loyalty toward group goals over personal interests. In contrast, individualism emphasizes personal autonomy and self-interest, even in social or organizational contexts [25]. Pakdil and Leonard [26] A study was conducted on implementing and sustaining lean processes that relate to cultural influences. This study noted that individuals in environments with low in-group collectivism exhibit greater independence and may leave the organization if their goals are unmet. They found that collectivism has a significant effect on lean implementation by enhancing employee involvement and sustaining continuous improvement efforts. Similarly, Hora et al. [27] found that lower levels of in-group collectivism are associated with high employee turnover, which disrupts lean initiatives and affects long-term productivity gains. This sense of collectivism makes the employees feel more involved in the Lean projects as they will desire to contribute

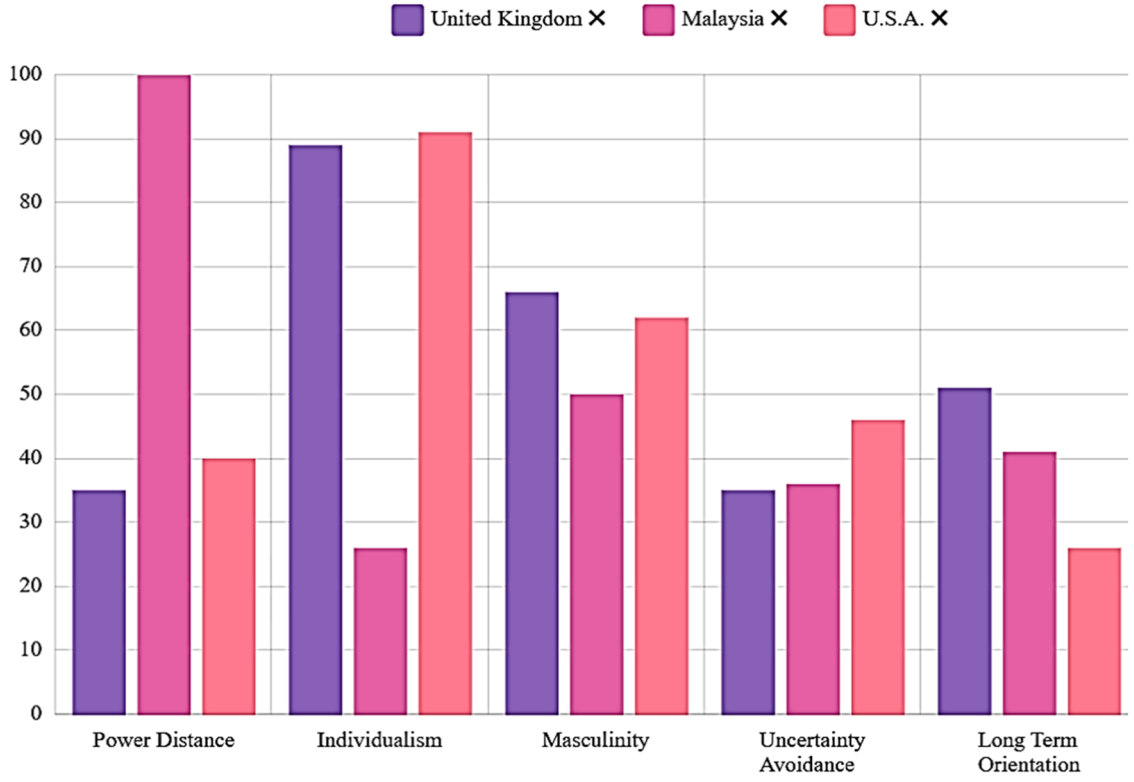

Fig. 3. Five cultural dimensions index [24].

towards Lean projects, knowing their effort could yield positive results. Thus, collectivism is expected to positively reinforce teamwork, loyalty, and participation in kaizen activities, supporting lean-driven productivity.

H1: Collectivism positively influences the productivity improvement factor of lean manufacturing practices.

Masculinity and femininity denote the illustrations of gender role distinctions. Masculine character prioritizes aggressiveness, the accumulation of riches, and widespread accomplishments. In contrast, feminine culture emphasizes assisting others, savoring a fulfilling life, and enhancing the overall quality of life [21]. This cultural orientation encourages goal-driven behavior, structured implementation of lean tools, and a results-oriented mindset that supports waste reduction and process optimization, which are key drivers of productivity. On the other hand, feminine cultures may promote teamwork, inclusiveness, and creativity. Although these values can support lean initiatives, the focus on harmony and consensus may reduce the urgency or intensity in pursuing operational targets. Masculinity is therefore more closely associated with the structured and efficiency-focused aspects of lean, making it a significant cultural factor influencing the degree to which lean practices lead to productivity improvements. Recognizing and aligning lean strategies with cultural orientation can help managers maximize productivity gains across different societal contexts. Accordingly, higher masculinity is expected to strengthen the structured, performance-driven aspects of lean implementation, thereby boosting productivity.

H2: Masculinity positively influences the productivity improvement factor of lean manufacturing practices.

In the context of individuals or organizations, uncertainty avoidance refers to the degree to which they see threats originating from ambiguous or unclear circumstances, which in turn motivates them to limit such hazards by establishing rules, structures, and strict information [23]. When compared to engaged cultures, high-low-acceptable companies are thought to have lower behavioral requirements. These companies also place considerable emphasis on control and the exploitation of factual data, which is consistent with the principles of lean management. Based on the findings of Hennessy et al. [28], it is vital for the implementation of lean to have conditions that are conducive to the adoption of systematic procedures. To add insult to injury, recent studies (for example, Tehrani et al. [29]) have highlighted the importance of standardization and process control to sustain productivity increases in lean systems. Businesses that have a low level of uncertainty avoidance, on the other hand, may be more open to making judgments that are flexible, intuitive, or opinion-driven. This can result in the introduction of unpredictability and a reduction in the reliability of lean outcomes. Since this is the case, it is anticipated that increased levels of uncertainty avoidance will have a favorable impact on the productivity enhancement factor in lean manufacturing principles.

H3: Uncertainty avoidance positively influences the productivity improvement factor of lean manufacturing practices.

Power distance is defined as the degree to which lower-ranking members of organizations and institutions accept and expect that power is distributed unequally [22]. In high power distance cultures, the hierarchical structure often results in low inter-level communication, making employees hesitant to challenge their bosses' opinions, which in turn hinders collaboration and creativity. These environments may result in inefficiency and slowness in resolving operational issues caused by central decision-making [30]. Empowering workers to identify problems and suggest improvements is essential to reducing waste and enhancing productivity in lean systems. Organizations with lower power distance are more likely to support this empowerment and collaborative culture, leading to more effective lean implementation and better productivity outcomes [31]. Therefore, the degree of power distance within an organization positively influences how successfully lean manufacturing practices improve productivity.

H4: Power distance positively influences the productivity improvement factor of lean manufacturing practices.

Long-term orientation, according to Hofstede [23], is described as the extent to which a culture values long-term aspects of behavior, which are those that demand effort and perseverance, such as thrift, in addition to those that have to do with persevering, preserving, and maintaining that which is already there. Plans and proformas become traditions at organizations that think long term, and budgets and performance appraisals can be used to create a continuity of effort that supports a constant focus on incremental innovations. Lean is inherently long-term, requiring incremental improvements and sustained commitment, as exemplified by Toyota's approach to kaizen—research by Hora et al. [27]. This is supported by the fact that outcome-focused firms are more likely to implement systems such as Total Quality Management (TQM) and lean practices, which depend on continuous employee engagement and a shared vision of operational excellence. In lean organizations, performance orientation is reinforced through incentive systems and cultural alignment, which help direct employee behavior toward achieving lean objectives. Therefore, long-term orientation is expected to play a significant role in supporting lean implementation and driving productivity improvement.

H5: Long-term orientation positively influences the productivity improvement factor of lean manufacturing practices.

Five hypotheses have been developed to determine the cultural implications related to the productivity enhancement elements of lean manufacturing processes. Through these five hypotheses, one research question, RQ1, may be addressed: Which lean practice areas generate productivity increase the most? The hypotheses are presented in Fig. 4.

5. Goodness of measurement

This study gathered data by using a questionnaire. A pre-test was conducted to ensure that this study's subjects would not find it difficult to answer the questions [32]. To find out if they had any problems with completing the survey, it was given directly to the respondents. After the initial test, the questionnaire was sent out for a pilot phase study. We checked the validity and reliability of the data collection to ensure it was accurate. Malaysia was chosen as the place to collect the data. Malaysia was chosen as the sample location due to its diverse population, rapid economic growth, and relevance to the research topic, enabling the collection of data that is both representative and pertinent to the study's objectives. A preliminary screening method was established to ensure that respondents were knowledgeable about the topics covered in the questionnaire. It was given directly to the people who answered to see if they had any trouble finishing the survey. After the preliminary test was finished, the questionnaire was made available for a pilot phase trial. To ensure the data collection was accurate, tests of validity and reliability were conducted. It was decided that Malaysia would be the place where the data would be collected. A preliminary screening process was conducted to confirm that the recruited respondents were exclusively individuals well-versed in the issues addressed by the questionnaire. This was done to guarantee data accuracy. The goodness of the measurement adopted in this study is described in Fig. 5.

The number of arrowheads pointing to the model's structure was used to calculate the minimum sample size (Hair et al., 2020). The minimum sample size was 205, and the required minimum R^2 was 0.10 with 80% statistical power and a significance level of 1%. This was

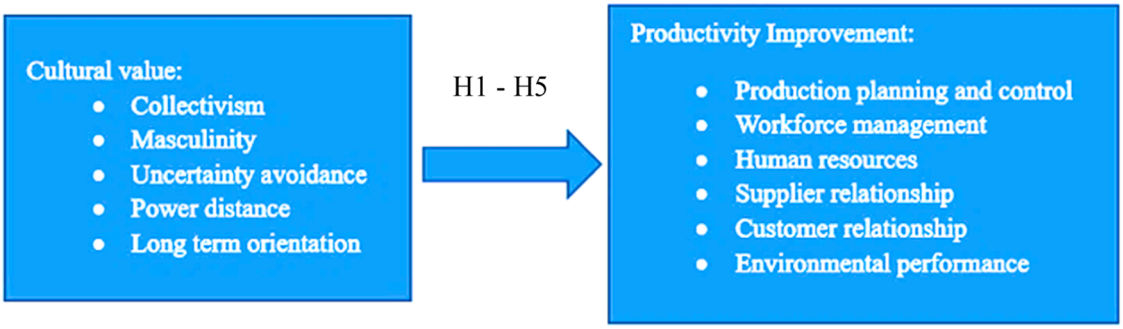

Fig. 4. Hypotheses evaluation.

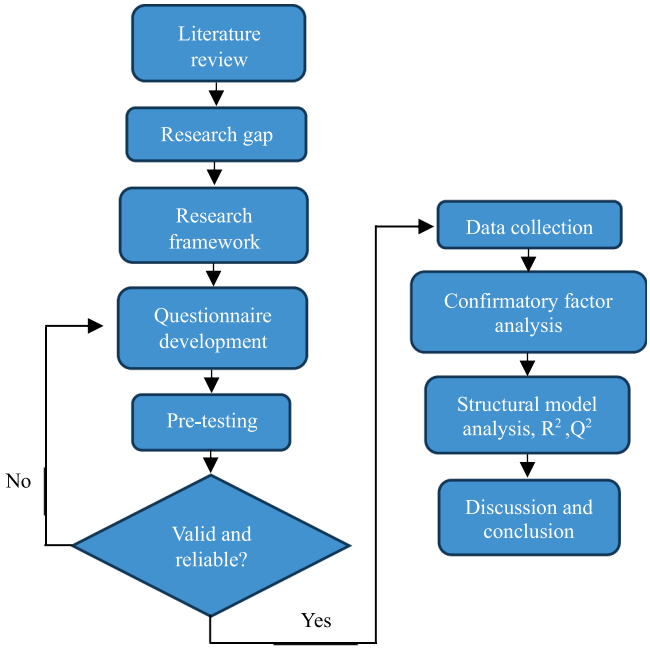

Fig. 5. Goodness of measurement.

related to the five cultural dimensions arrowheads that led to the productivity improvement construct. Eight items in total were invalidated due to inadequate responses, out of the 259 responses from companies in Malaysia that were gathered to complete the questionnaire. As a result, there were enough replies overall to collect data. Table 3 shows the profile of the respondents.

Table 3
Profile of respondents.

Demographic		Responses	
		Freq	%
Gender	Male	128	49
	Female	131	51
Age	18 – 25	57	22
	26 – 35	83	32
	36 – 45	70	27
	46 – 55	30	12
	56 and above	19	7
Position in the company	Production Manager & Executives	74	29
	QC/QA Manager & Executives	72	28
	Others	113	44
Years of employment	< 5 years	83	32
	5 – 9 years	130	50
	> 10 years	46	18

Due to this study is more exploratory concern, Partial least square structural equation modeling (PLS-SEM) was utilized to evaluate the hypotheses. To develop hypotheses, it was determined that Smart-PLS (version 4) is the most appropriate instrument for evaluating the validation of the items that are included in the Confirmatory Factor Analysis (CFA), the Heterotrait-Monotrait Ratio (HTMT), and the Hierarchical Component Models (HCM). A direct effects model was employed to illustrate the primary relationships, devoid of the complexities of moderation or mediation, consistent with the exploratory character of this study. This facilitates a more comprehensive analysis of the impact of culture on productivity and lean methodologies. The emphasis was on identifying overarching cultural similarities among various Malaysian companies; hence, factors such as firm size and industry were excluded. The evaluation of convergent validity was carried out utilizing Confirmatory Factor Analysis (CFA), while the assessment of discriminant validity was carried out utilizing the Heterotrait-Monotrait Ratio (HTMT). When considering the context of CFA, the composite reliability (CR) must be greater than 0.7, and the average variance extracted (AVE) must be greater than 0.5. The HTMT should have a value that is lower than 0.85 to be considered discriminantly valid [33]. Tables 4 and 5 present the results of each computation clearly and in an organized manner.

As shown in Tables 4 and 5, the calculations of AVE and CR for convergent validity, and the HTMT analysis for discriminant validity,

Table 4
Compilation of factor loading, AVE, and CR values.

Cultural dimensions	Items	AVE	CR
Collectivism	Coll1	0.538	0.850
	Coll2		
	Coll3		
	Coll4		
Masculinity	Mas1	0.702	0.876
	Mas2		
	Mas3		
	Mas4		
Uncertainty avoidance	Uai1	0.632	0.895
	Uai2		
	Uai3		
	Uai4		
	Uai5		
High power distance	Pdi1	0.666	0.907
	Pdi2		
	Pdi3		
	Pdi4		
	Pdi5		
Long-term orientation	Lto1	0.635	0.896
	Lto2		
	Lto3		
	Lto4		
	Lto5		

AVE is the average variance extracted (should be > 0.5)
CR is composite reliability (should be > 0.7; 0.60 to 0.70 is acceptable for exploratory study)

Table 5
Heterotrait-Monotrait Ratio (HTMT) for discriminant validity.

	Collectivism	Power distance	Long-term Orientation	Masculinity	Uncertainty Avoidance
Collectivism					
High Power Distance	0.162				
Long-term Orientation	0.184	0.657			
Masculinity	0.407	0.454	0.235		
Uncertainty Avoidance	0.241	0.213	0.569	0.235	

HTMT value should be < 0.85 to establish discriminant validity

satisfy the requirements for the critical threshold. In addition, to ensure the model fit in this study, a standardized Root Mean Square Residual (SRMR) and Common Method Bias (CMB) evaluation should be performed. SRMR refers to the difference between the observed correlation and the correlation matrix implied by the model. SRMR is essential to avoid model mis-specification. The value of SRMR should be less than 0.08 to indicate the model fit [34]. In this study, the value of SRMR was 0.043, which was less than 0.08. Therefore, there was no issue with model fit for this study. CMB refers to the bias or variation that occurs when data for both independent and dependent variables are gathered using identical methods (e.g., the same survey, the same respondents, and the same time period). This can distort relationships between constructs, resulting in collinearity issues. It can be indicated through the collinearity test by investigating the value of the Variance Inflation Factor (VIF), which should < 3.3 [35]. We indicated that the value of VIF in this study was less than 3.3. It means that CMB was not an issue for further analysis.

Once all the quality criteria have been tested, the next step is to continue the hypothesis analysis. The t-value is the standard criterion by which the significance of a coefficient is decided. It was recommended that bootstrapping should be performed with 5,000 sub-samples to evaluate the t-values.

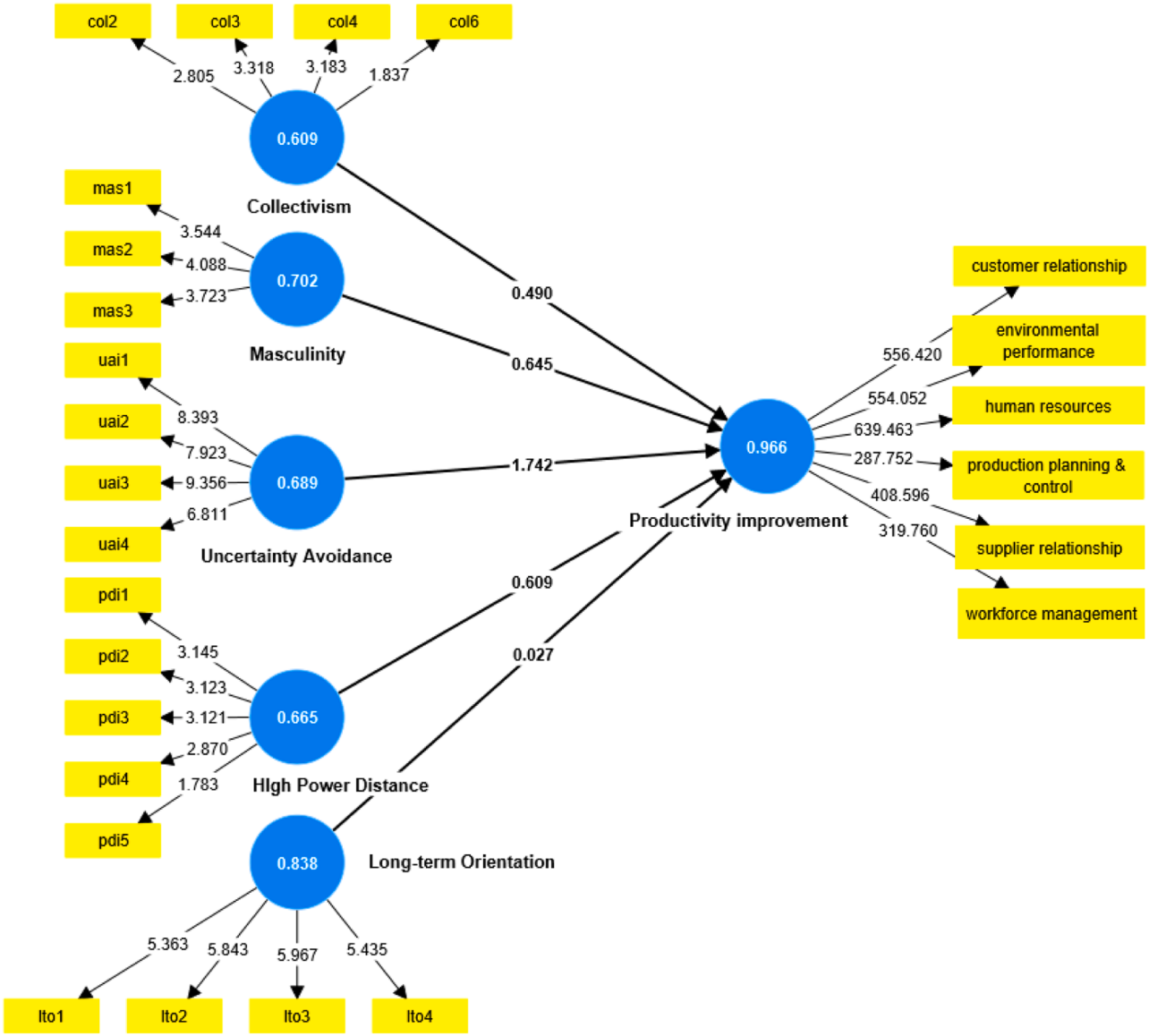

Fig. 6. Computation result.

As shown in Fig. 6, several items from the outer loadings were removed to obtain significant results. Col1 and Col5 of collectivism, mas4 of masculinity, uai5 of uncertainty avoidance, and lto5 of long-term orientation were deleted because their outer loadings were below 0.7, to ensure that convergent validity met the critical threshold.

The critical t-values for the significant levels of 1%, 5%, and 10% were 2.57, 1.96, and 1.65, respectively. The analysis of Table 6 demonstrated that the variables of uncertainty avoidance ($\beta = 0.072$, $p < 0.1$) significantly influence productivity improvement in the context of lean manufacturing practices. In contrast, the constructs of masculinity, collectivism, high power distance, and long-term orientation have an insignificant impact as they fall short of a critical threshold of $p < 0.01$. It was also important to determine the magnitude of the effect of the five-dimensional construct. The effect size (f^2) measures how much a predictor component affects an endogenous construct. The important effect size thresholds were 0.02, 0.15, and 0.35, which were small, medium, and large, respectively [36]. Table 6 shows that the calculated impact size (f2) for uncertainty avoidance was 0.124, which means that it was a small effect size. Even so, these results confirmed that the calculation of significant connections in the route analysis is still useful for further study, even though the impact sizes were small.

The next stage was to determine the level of the coefficient of determination (R^2 value) and predictive relevance (Q^2 value) after identifying significant relationships in the structural model. R^2 is a metric that quantifies the extent to which the predictor constructs account for the variance of an endogenous construct. To mitigate the bias towards sophisticated models, Hair et al.[36] recommended employing the adjusted R^2. Hair et al. [36] A value of 0.20 was regarded as high in the field of character and behavior prediction. The adjusted R^2 value in this investigation was 0.496. Consequently, the coefficient of determination assessment was deemed adequate based on the value of R^2. Predictive relevance (Q^2), also referred to as predictive power, is a metric that is used to forecast the accuracy of a model. The Q^2 values should be greater than 0, and a value of less than 0 suggests that the model that was developed was not predictively relevant [36]. The value of Q^2 in this investigation was 0.232. It suggests that predictive relevance met the critical threshold.

6. Discussion

The purpose of this research is to identify the key aspects of lean manufacturing methods that enhance productivity, considering the influence of cultural factors. According to the findings of our empirical research, the cultural dimension of uncertainty avoidance plays a significant role in influencing the productivity improvement of lean manufacturing practices in the Malaysian context. On the other hand, the dimensions of collectivism and individualism, masculinity and femininity, power distance, and long-term orientation do not have a significant influence. The calculated beta coefficient ($\beta = 0.072$) suggests a positive relationship between uncertainty avoidance and the enhancement of lean manufacturing processes. The critical t-value of 1.65 at the 10% significance level further supports the robustness of this finding. This implies that the relationship between uncertainty avoidance and productivity improvement in lean manufacturing practices is statistically significant [37]. This finding aligns with a study that found uncertainty avoidance significantly influences lean manufacturing practices, particularly in terms of people's development, operational results, and continuous improvement [38]. In addition, the assessment revealed a low concern index for uncertainty avoidance in lean manufacturing practices. The results showed that low uncertainty avoidance was rejected as the influencing national culture, indicating that the effect of high uncertainty avoidance has a significant influence. The degree to which people of society feel intimidated by unknown events and choose structured conditions, rules, and stability over ambiguity and danger is referred to as uncertainty avoidance [39]. This cultural component characterizes the degree to which individuals in society feel scared by unfamiliar situations. Lean manufacturing can provide enormous challenges in high uncertainty-avoiding cultures [40]. Leaning jobs involving experimentation, iterative problem-solving, and departure from conventional, accepted thinking could be a challenge for workers to engage [7]. This cultural resistance manifests as employee aversion to change, strong loyalty to current methods, and a slower pace of lean initiative implementation, driven by a fear of deviating from the norm. Thus, these challenges can lower the effectiveness of lean techniques, as management and employees may find the less predictable and more flexible character of lean operations problematic. From a productivity improvement perspective, the effectiveness of lean initiatives can be directly influenced by the cultural challenges linked with significant uncertainty avoidance.

Lean manufacturing aims to boost output by reducing waste, improving process efficiency, and promoting an always-growing culture [41]. However, in environments with significant uncertainty avoidance, the desire for stability and the resistance to deviate from recognized procedures might produce less-than-perfect lean adoption. Missed opportunities for productivity gains could result from this opposition to changes involving new methods or techniques judged to be hazardous or unknown [42]. Moreover, lean manufacturing's emphasis on quick adjustments, problem-solving, and incremental improvements calls for a degree of adaptation and flexibility that can contradict the approach adopted in high uncertainty-avoiding societies. For lean techniques like value stream mapping or the 5S approach, employee willingness to actively find inefficiencies and offer changes defines their success. In high uncertainty avoidance situations, this participative approach could be seen as disruptive or unsettling, hindering efforts to improve productivity. Therefore, removing these cultural barriers is necessary if lean manufacturing in high uncertainty avoidance cultures is to raise productivity [43]. Strategies including thorough training, faith in lean techniques, and small-scale execution of improvements help to reduce the perceived hazards related to lean initiatives. By combining lean practices with the cultural demands for structure and predictability, organizations can gradually boost confidence in lean approaches and create a more suitable atmosphere for productivity improvement. Overcoming resistance and releasing lean manufacturing's full potential for improving productivity ultimately depends on recognizing the capacity to manage cultural issues, including uncertainty avoidance.

Collectivism did not demonstrate a significant influence, most likely because individualism serves as a counterbalance to it in Malaysian workplaces. Lean techniques are dependent on individual responsibility

Table 6
Hypotheses testing result.

Hyp	Description	Path coefficient	Std. error	*t*-value	Effect size (f^2)	Result
H1	Collectivism →Productivity improvement of lean manufacturing practices	0.032	0.066	0.490	0.003	Not supported
H2	Masculinity → Productivity improvement of lean manufacturing practices	0.035	0.054	0.645	0.002	Not supported
H3	Uncertainty avoidance → Productivity improvement of lean manufacturing practices	0.072	0.041	1.742***	0.124*	Supported
H4	High power distance → Productivity improvement of lean manufacturing practices	-0.045	0.073	0.609	0.000	Not supported
H5	Long-term orientation → Productivity improvement of lean manufacturing practices	-0.002	0.067	0.027	0.001	Not supported

*p< 0.01, **p< 0.05, ***p< 0.1
0.02*, 0.15**, 0.35***; small, medium, and large effect sizes, respectively.

and performance, which diminishes the influence of collectivism alone [44]. Teamwork is crucial, but lean practices also depend on individual responsibility. In the same vein, masculinity was not significant since its emphasis on rivalry and achievement is counterbalanced by femininity, which places equal weight on harmony and cooperation [45]. Furthermore, power distance was found to have less impact because lean performance is dependent more on well-defined procedures and routines than it is on rigid hierarchy, which is more strongly linked to the avoidance of uncertainty [39]. It was less important to have a long-term orientation because many businesses adopted lean to address urgent operational problems rather than as a component of their long-term cultural planning. These findings, taken as a whole, indicate that the influence of these four cultural dimensions is diminished by the values that are opposed to one another. As a result, uncertainty avoidance emerges as the primary cultural facilitator of lean manufacturing and productivity in Malaysia.

By reflecting on the outer weight output, this study also indicated the importance rating of each factor used to construct lean manufacturing practice for productivity improvement. It is served in Table 7 as follows:

As described in Table 7, the human resources factor was identified as the most important for productivity improvement for lean manufacturing practices considering cultural influences. It emphasizes employee empowerment, involvement, and training, playing the most vital role [1]. Driving lean projects depends on a well-trained and involved staff since employee involvement in activities related to problem-solving and ongoing improvement directly affects production increases [5]. Customer relationships are closely tied to success, as they enable companies to tailor their operations to deliver outstanding value and understand consumer needs. Maintaining contact with consumers helps products and services satisfy consumer expectations, improving production and market competitiveness. Environmental Performance is ranked third and is strongly associated with lean approaches, including waste reduction and efficiency improvements. Lean manufacturing frequently leads to decreased resource utilization and diminished environmental impact, promoting sustainability objectives and facilitating cost reductions and increased efficiency [46]. Supplier relationships are paramount since they are crucial in guaranteeing the quality and punctual delivery of supplies, which are essential for just-in-time production. An efficiently controlled supply chain minimizes fluctuations and interruptions, facilitating the seamless progression of production and enhancing overall productivity.

Ranked sixth, workforce management focuses on reducing costs, improving flexibility, and optimizing labor to meet manufacturing demand. Organizations can improve output and change market responsiveness by controlling workforce variability and matching labor resources with demand. Finally, lean manufacturing depends on production planning and control, which entails matching production schedules with market demand [47]. Good planning helps lower inventory levels, minimize work-in-process, and match manufacturing activities to consumer needs, raising productivity. These elements interacting in high uncertainty avoidance cultures can present other difficulties [48]. Notably, in sectors that scored highly, such as human resources and customer relationships, lean manufacturing's dependence on adaptability and continuous improvement may counter-cultural tastes for stability and predictability [49]. Overcoming these cultural barriers requires customized plans that include thorough training, open communication, and a gradual implementation of lean techniques to foster confidence in lean systems. Through lean manufacturing, companies can create a supportive atmosphere that reduces resistance and maximizes productivity improvements by aligning lean activities with cultural preferences for structure and predictability.

Table 7
Key factors of lean manufacturing practices.

Rank	Key factors of lean manufacturing practices	Outer Weight
1	Human Resources	0.621
2	Customer Relationship	0.482
3	Environmental Performance	0.382
4	Supplier Relationship	0.341
5	Workforce Management	0.336
6	Production Planning & Control	0.215

7. Conclusion

The research undertaken examines how cultural predispositions influence the effectiveness of lean manufacturing practices in driving productivity gains. Notably, the analysis reveals that among Hofstede's cultural dimensions, only the trait of uncertainty avoidance demonstrates a statistically meaningful association (marginal $p < 0.10$) with lean performance outcomes in the Malaysian setting. Specifically, environments characterized by a low tolerance for ambiguity tend to benefit from more structured, carefully managed lean implementation efforts. This observation suggests that lean strategies are more successful when they are introduced gradually and supported by clear frameworks, particularly in cultures that favor predictability and risk aversion. Consequently, the study advocates for practical interventions—such as extensive employee training, phased adoption processes, and support systems tailored to mitigate apprehension toward change—as essential mechanisms to bolster lean uptake. Furthermore, the findings emphasize the significance of several enabling factors, including the role of human capital, customer participation, and environmental considerations, with human resources identified as the most pivotal contributor to productivity improvement. These enablers underscore the importance of aligning lean initiatives with internal capacity-building and broader organizational objectives. However, the study is inherently limited by its exclusive focus on a single national context, which poses constraints on the wider applicability of its insights. Additionally, the lack of significant results across several hypotheses suggests that future inquiries might benefit from integrating more diverse cultural indicators or contextual variables. For practitioners, the evidence highlights the importance of tailoring lean frameworks to the cultural context of the workforce, particularly in settings characterized by high uncertainty avoidance. Further research is recommended to test the robustness of this model across other developing economies and to refine the theoretical framework by incorporating additional cultural dimensions.

Data availability

Data is provided within the manuscript or supplementary information files.

Ethics approval and consent to participate

Participants were informed about the study's purpose and data confidentiality before beginning the survey. Consent was implied by completing the survey, with the option to withdraw at any time. Data were collected anonymously and handled confidentially. The study did not involve clinical data or constitute a clinical trial. Ethical approval was obtained from the Universiti Teknikal Malaysia Melaka (UTeM) Ethics Committee.

Informed consent

We are confirming that informed consents (Consent to Participate and Consent to Publish) were obtained from all participants. This questionnaire is requested to be filled in by social personnel mainly focusing on the impact of environmental protection, economic development, social responsibility, and governance on the sustainable development of enterprises (for example, green products, environmental protection, social responsibility, economic development, sustainable development, etc.).

CRediT authorship contribution statement

Ihwan Ghazali: Writing – original draft, Validation, Supervision, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Tia Tanjung:** Writing – review & editing, Resources, Project administration, Methodology. **Eias Al Humdan:** Project administration, Methodology, Funding acquisition. **Wan Hasrulnizzam Wan Mahmood:** Writing – review & editing, Supervision, Resources, Project administration, Funding acquisition. **Safarudin Gazali Herawan:** Resources, Funding acquisition, Conceptualization. **Wangi Pandan Sari:** Writing – review & editing, Project administration, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

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