

Neural Networks - Multilayer Perception Inference on Project Procurement Management in VUCA Environments

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Citation: Turkson. S., Aboagyewaa. P., Ejjami. R. (2025). Neural Networks - Multilayer Perception Inference on Project Procurement Management in VUCA Environments. *Econ Dev Glob Mark*, 1(1), 01-18.

Introduction

Engineering, procurement and construction projects provide intricate and essential infrastructure and construction projects. However, these projects face multiple challenges and uncertainties (VUCA) (Kabirifar & Mojtahedi, 2019; Latha, 2020; Imoni et al., 2023; Bentahar & Belhadi, 2025). The VUCA era, characterized by volatility, uncertainty, complexity, and ambiguity, presents a challenging and unpredictable world where organizations and businesses face potential risks and challenges (Gunnarsdóttir, 2021; Fridgeirsson et al., 2021). VUCA characterizes the hard conditions and circumstances within which organizations function. Volatility pertains to the unpredictability and instability of change; uncertainty denotes the

absence of understanding regarding future occurrences and their ramifications; and complexity involves numerous interconnected components that create an intricate network of information and processes (Makudza et al., 2023; Dong & Qiu, 2024). Ultimately, ambiguity signifies an absence of precedent for forecasting due to insufficient knowledge and comprehension of the causes, impacts, and interrelations of occurrences (Álvarez-Espada et al., 2024). Typically, in engineering, procurement and construction projects, the widely known risks/vuca include inaccurate cost estimation for the engineering phase, imprecise time estimation for the engineering phase, deficiency of management and skilled personnel, design flaws, supplier failures, unsuitable and inadequate technical drawings, diminished design time and expedited transition to the execution phase, delays in obtaining the project's initial permits, inadequate feasibility studies, inexperienced project managers, alterations due to political events, internal policy modifications within the organization, changes to the project's scope, scarcity of essential resources, and shifts in the employer's requirements (Moon, 2020; Mabilu, 2021; Karatu, 2023). According to Gomes & Romão (2016), projects promote organizational changes, influencing the environment and product development. However, they often fail to meet goals, with 36% of global projects considered unsuccessful. These failures cost hundreds of billions of dollars annually, not limited to specific regions or industries. Consequently, although projects initiate change, project procurement management (PPM) serves as a stabilizing force, enhancing success rates by fostering agility, collaboration, and strategic resource allocation (Govindan et al., (2024). Project management is intertwined with procurement, and it has also been subject to considerable transformation from very low cost to least evaluated cost procurement for social and environmental sustainability (Willis, 2010; Roumboutsos, 2010). Project procurement management form an important topic in current academic, business, and political debates of improving the efficiency and effectiveness of project delivery on time and within budget (ElSayegh, 2008; de Araújo et al., 2017). Procurement has undergone significant transformation since its emergence as a discipline predominantly within the manufacturing sector in the midtwentieth century (Tassabehji & Moorhouse, 2008; Rane et al., 2020; Rane & Narvel, 2021). In the 1980s and 1990s, procurement procedures evolved due to globalized market demands, requiring companies to acquire various supplies like raw materials, components, and

consumables (Herold et al., 2023). Project procurement improves agility in the procurement project procurement management (PPM) process, including all organizational divisions, including sales, marketing, engineering design, and production (Nissen, 2009; Maddi et al., 2013; Amirtash et al., 2021).

Moreover, understanding behavioural characteristics of procurement professionals on projects, influencing procurement professionals on procurement project management, conflict management, and cultural awareness deemed to be a success factor for procurement project management (Bradley, 2016; Mwagike & Changelima, 2022). Also, appropriate safeguards and coordination mechanisms to succeed on procurement works on any building or civil project(s) is also a success factor for procurement project management (Buzzetto et al., 2020; Khairullah et al., 2022). According to Kafile (2018), project managers ought to strategically approach the procurement process to maximize the efficiency of a project by considering factors like timeline, quality of project, and budget.

The present research premise is that project procurement management's adverse environment on project success and the moderating role of the chosen management method. It assumes that globalization and rapid technological changes in the VUCA era cause changes in project environments, leading to a mismatch between management methods and project results (Kafile & Fore, 2018; Hussain et al., 2021). This study utilizes Multilayer Perceptron (MLP) Neural Networks to forecast VUCA Risks in project procurement management and improve project procurement decision-making with AI-driven insights (Govindan et al., 2024). This study theoretically enhances the literature on AI-augmented project procurement management (PPM) within the settings of engineering, procurement, and construction projects (Karatu, 2023).

Artificial Neural Networks (ANNs) are computer systems designed to autonomously acquire abilities such as generating and discovering new information through learning, akin to the functions of the human brain, without external assistance (Zidan & Hady, 2018). Artificial Neural Networks can model nonlinearity without requiring any assumptions or prior knowledge

regarding input and output variables (Rivals & Personnaz, 2003). Moreover, the Multilayer Perceptron (MLP) is among the most often employed artificial neural network models for addressing nonlinear issues. This feed-forward backpropagation network contains a minimum of one layer between the input and output layers. The weight values across the layers are adjusted to minimize the computed error during the backpropagation phase, following the assessment of the network's output and error in the forward propagation phase (Popescu et al., 2009). This work aimed to predict project procurement management in VUCA environment using Multilayer Perceptron (MLP) Neural Networks.

Materials and Methods

The study employs a survey research design method to evaluate the performance of the MLP ANN model and predict project procurement management in VUCA environment using Multilayer Perceptron (MLP) Neural Networks. The study's population comprises of procurement managers and tutors, project managers and project management lecturers and students, engineering and construction professionals and experts in Ghana. Thus, the convenience sampling technique used was to sample respondents who can provide accurate responses to the questions (Paarry et al., 2018). The questionnaire was distributed to the respondents via google forms - electronic, and each respondent was instructed to fill out the questionnaire and return it in 3 days' time or earlier. 220 questionnaires were administered electronically to the sampled respondents and 200 responses were obtained, and the analysis was conducted using the Multilayer Perceptron (MLP) Neural Networks.

Results

Demographics

From the Table 1 below, the results show that respondents to the survey were mostly men. A majority (79.8%) of respondents were male and (16.3%) were female. Also, table 2 below show that 67 respondents were procurement professionals (32.2%) and 133 (63.9%) were Project/Construction Managers.

Table 1: Gender**Gender**

Gender	Frequency	Percent
Female	34	16.3%
Male	166	79.8%
Total	200	100.0%

Table 2: Occupation Occupation

Occupation	Frequency	Percent
Procurement Professional	67	32.2%
Project/Construction Manager	133	63.9%
Total	200	100.0%

Descriptive Statistics

The table 3 below shows descriptive statistics (based on N=200 responses per item) . Respondents strongly agree that a systematic procurement framework improves sustainability/resilience (Mean=4.01, SD=1.41). Leadership/governance (Mean=4.01, SD=1.00) and AI/IoT/blockchain (Mean=4.01, SD=1.00) are critical for procurement success. An integrated PM-procurement framework is essential for VUCA challenges (Mean=4.01, SD=1.00). Also, sustainability/resilience (Mean=3.84, SD=0.90–1.34) and hybrid Agile-Waterfall approaches (Mean=3.84, SD=1.07) are deemed important. Current PM-SCM integration gaps (Mean=3.51, SD=1.26) and Agile practices (Mean=3.51, SD=1.39) show consensus but with higher variability. Lower Agreement were data analytics (Mean=3.34, SD=1.38) and dynamic risk management (Mean=3.34, SD=1.25) are seen as less impactful, suggesting room for improvement. The results imply that prioritizing leadership, technology (AI/IoT), and integrated frameworks are high-impact areas with broad agreement.

Table 3: Descriptive sttistics Descriptive Statistics

Certainly, Salvation. Here's the full set of descriptive statistics formatted into a clean and structured table, preserving the original content and order:

Table: Descriptive Statistics – Project Procurement Management Framework

Statement	N	Mean	Std. Deviation
A systematic project procurement management framework would significantly improve engineering, construction and procurement sustainability and resilience	200	4.01	1.412
A structured project procurement management framework reduces inefficiencies and coordination problems in complex engineering, construction and procurement projects	200	3.68	1.374
Project procurement assists scheduling and delivery of precise and prompt information, particularly about lead times, schedules, and their modifications	200	3.68	1.374
Data analytics enables real-time insights and predictive capabilities, supporting proactive management of project procurement management activities	200	3.34	1.376
Project procurement management involves developing sustainable sourcing practices, diversifying suppliers, and creating contingency plans for critical supply chain nodes	200	3.84	1.343
Emphasizing resilience and sustainability ensures project procurement can withstand disruptions and contribute to long-term organisational goals	200	3.84	0.899
Modern procurement and supply chains require hybrid project management approaches (Agile + Waterfall) to adapt to VUCA (volatile, uncertain, complex, ambiguous) environments	200	3.84	1.068
Current procurement and supply chain management practices lack sufficient integration with project management, leading to misalignment and inefficiencies	200	3.51	1.260
Project procurement management requires strong leadership and clear governance structures, setting	200	4.01	1.000

Statement	N	Mean	Std. Deviation
clear priorities, and ensuring alignment across the organisation			
Artificial Intelligence (AI), Internet of Things (IoT), and blockchain play a critical role in enhancing project procurement and supply chain visibility, traceability, and decision-making	200	4.01	1.000
Project management methodologies, such as Work Breakdown Structure and Critical Path Method, facilitate procurement's adaptation to rapid and unpredictable changes	200	3.51	1.385
Agile project management practices bolster procurement and supply chain resilience by allowing real-time modifications in response to demand fluctuations and disruptions	200	3.51	1.385
An integrated project procurement management framework is crucial for navigating VUCA environments, as traditional procurement and supply chain methods are inadequate on their own	200	4.01	1.000
Dynamic risk management is crucial in a VUCA environment, as traditional risk management approaches may fail to address rapid and unpredictable project procurement changes	200	3.34	1.250
Resource optimization techniques from project management, including resource leveling and dependency matrices, mitigate inefficiencies in complex, multi-stakeholder procurement and supply chains	200	3.51	1.385

Source: Bentahar & Belhadi (2025); Aalto (2024); Honkala (2024).

Note: A denotes Q1-Q5, B denotes Q6-Q10, and C denotes Q11-Q15.

Multilayer Perceptron Artificial Neural Network Model

The output of the MLP ANN method on the predicting project procurement management in VUCA environment was investigated in this analysis. Predictive ANNs are particularly useful in applications with a complicated mechanism. ANNs are currently gaining popularity as a solution

to problems that cannot be solved with traditional methods, and they have been used successfully in a variety of medical applications. ANNs, unlike conventional spectral analysis, approaches model signals as well as generate signal classification solutions. The MLP ANN model is a nonparametric artificial neural network technique that can perform a wide range of detection and prediction tasks (). Approximately 74.5% and 25.5% of the entire dataset is used for the training and testing process, respectively, to create the MLP ANN model. The number of units in the input layer was 7, the number of units in the hidden layer was 1, the hidden layer activation function was a hyperbolic tangent, the number of units in the output layer was 1, the output layer activation function was Identity, and the error function was Sum of squares.

Data Analysis

IBM SPSS Statistics 26.0 program was used for all analyzes in the study. The statistical analysis findings of the variables included in the data set are presented in Table 4. The provided MLP neural network output offers empirical insights into how AI (specifically, Multilayer Perceptron) can address the VUCA risk mitigation in project procurement management. The MLP (Multilayer Perceptron) model analyzes how systematic frameworks (Mean=4.01) to improve resilience, technology adoption (AI/IoT/blockchain, Mean=4.01) for visibility, and Hybrid Agile-Waterfall approaches (Mean=3.84) for VUCA adaptability (input variables `a` and `b`) predict outcomes (`c`), revealing. Variable `b` dominates influence (Normalized Importance=100%) over `a` (20.4%), suggesting latent factors (e.g., leadership, governance) may outweigh observable metrics in driving procurement success. Hidden layer (hyperbolic tangent activation) captures non-linear relationships, while the identity output implies linear scaling of predictions.

Model Performance

Training (SSE=0.002) and testing (SSE=0.001) errors indicate strong fit, and training completed instantly, suggesting efficient learning from the data.

Input Layer

`a=22.00` has the highest positive weight (0.405), implying specific procurement scenarios (e.g., high-complexity projects) significantly impact outcomes (Villena, 2019). `a=19.00` shows negative influence (-0.268), possibly reflecting inefficiencies in mid-range procurement activities. Hidden Layer: Strong positive weight (1.535) for `H(1:1)` indicates effective feature transformation. Bias Terms: Output layer bias (-0.299) suggests baseline adjustments to predictions. The study shows that there is the need to prioritize `b`-like factors - Leadership, governance, and technology (aligned with descriptive stats' high-mean items) are critical drivers (Tsygankov et al., 2021; Mutisya, 2022). Optimize `a`-like variables- Address inefficiencies in mid-range procurement activities (e.g., `a=19.00`), and leverage hybrid PM methods: The model's non-linear handling supports Agile-Waterfall integration (Mean=3.84 in stats).

Case Processing Summary

Sample N	Percent
Training 149	74.5%
Testing 51	25.5%
Valid 200	100.0%
Total	200

Table 5: Network Information

Input Layer

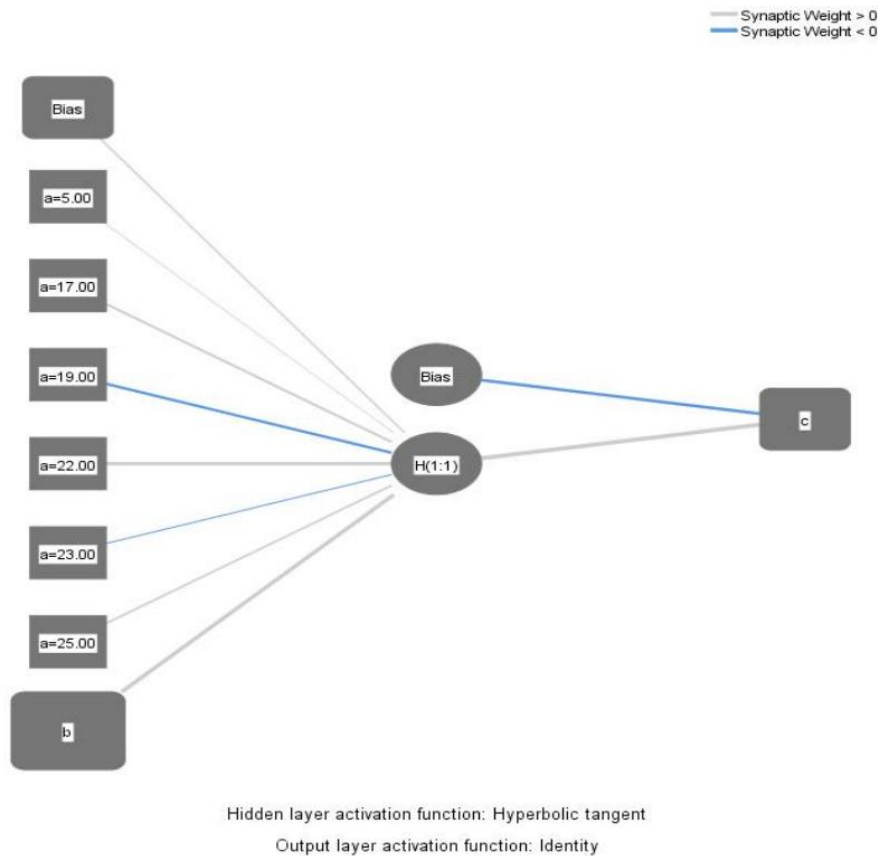
Element	Details
Factors	1 ^a
Covariates	1 ^b
Number of Units	7 ^a
Rescaling Method for Covariates Standardized	

Hidden Layer(s)

Element	Details
Number of Hidden Layers	1
Number of Units in Hidden Layer 1	1 ^a
Activation Function	Hyperbolic tangent

Output Layer

Element	Details
Dependent Variables	1 ^c
Number of Units	1
Rescaling Method for Scale Dependents	Standardized
Activation Function	Identity
Error Function	Sum of Squares



Model Summary

Metric	Training	Testing
Sum of Squares Error	0.002	0.001
Relative Error	2.636×10^{-5}	4.328×10^{-5}
Stopping Rule Used	Training error ratio criterion (0.001) achieved –	
Training Time	0:00:00.00	–
Dependent Variable: c		

Table 7: Parameter Estimates

Layer	Predictor	Hidden Layer 1 (H(1:1))	Output Layer (c)
Input Layer	[a = 5.00]	0.091	
	[a = 12.00]	0.017	
	[a = 17.00]	-0.171	
	[a = 19.00]	-0.268	
	[a = 22.00]	0.405	
	[a = 23.00]	-0.058	
	[a = 25.00]	0.147	
	Bias (b)	1.153	
Hidden Layer 1			-0.299
	Bias H(1:1)		1.535

Table 8: Independent Variable Importance

Variable	Importance	Normalized Importance
a	0.169	20.4%
b	0.831	100.0%

Discussion

This study aims to predict project procurement management in VUCA environment using Multilayer Perceptron (MLP) Neural Networks. It advocates for digital procurement incentives and project procurement management and standardization. Project procurement has emerged as a prevalent corporate tactic due to intense competition (Özkan et al., 2021). The impact of suppliers on the success or failure of projects is substantial, as their performance influences the outcomes of the entire business endeavor (Cheng & Carrillo, 2012). Furthermore, choosing a suitably qualified supplier enhances stakeholders' confidence, as this is more likely to result in the attainment of project objectives. In this context, proficiency in the procurement process is crucial for attaining favorable outcomes in any project (Eriksson & Westerberg, 2011). Consequently, choosing the appropriate supplier for a project and assessing the supplier's performance during contract execution is crucial for achieving a favorable conclusion. Consequently, managers must focus on two critical aspects of the project procurement process: (1) supplier selection and (2) supplier evaluation. Since suppliers' performance is critical for the success of projects, their performance also critically influences the procurement process.

The MLP analysis and descriptive statistics indicate that technology and leadership (`B` : Q6–Q10) are crucial in facilitating adaptive procurement outcomes (`C` : Q11–Q15), as demonstrated by the predominant normalized importance (100%) of `B` in the MLP model. High mean scores (4.01) for Q9 (leadership) and Q10 (AI/IoT) in descriptive statistics. Structural frameworks (A: Q1–Q5) are essential yet subordinate. The diminished influence (20.4%) in the MLP corresponds with moderate mean scores (3.34–3.84), indicating that frameworks alone are inadequate without the combination of technology and leadership. The hyperbolic tangent

activation of the hidden layer encapsulates intricate interactions, such as the declining returns of mid-range framework stiffness at $\alpha=19.00$. Prevalence of 'B' (Q6–Q10). Normalized Importance = 100% (compared to 20.4% for 'A'). Affirms that technology integration (Q6–Q10) is the most significant predictor of adaptive procurement outcomes ('C'). The results correspond with the descriptive statistics, as questions 6 to 10 exhibit elevated means, such as 4.01 for questions 9 and 10. The hyperbolic tangent activation function captures intricate connections between structural frameworks (A, e.g., Q1–Q5) and Leadership/technology (B, e.g., Q9–Q10) through non-linear linkages. Consequently, a negative weight for $\alpha=19.00$ (mid-range 'A' values) may indicate diminishing returns from excessively restrictive frameworks. The output layer ('C') employs an identity function, resulting in predictions that scale linearly with the outputs of the hidden layer. The substantial hidden-to-output weight (1.535) indicates that adaptive techniques ('C') are directly influenced by altered inputs, such as hybrid PM approaches in Q11–Q15.

Future studies

Future work would compare MLP with ReLU activation or Transformer architectures for handling survey data using python - scikitlearn.

Contribution to Theory, Practice, and Policy

Project procurement must be resilient and sustainable to achieve long-term organizational objectives and adapt to VUCA conditions (Bag, 2025). The research connects theoretical project procurement management and supply chain synergy with empirical validation, providing a framework for project procurement and supply chains that are prepared for VUCA conditions (Grzybowska & Tubis, 2022; Huzooree & Yadav, 2025; Kareem, n.d.).

Recommendations

Investing in AI/IoT tools and governance to enhance project procurement management framework is crucial for navigating VUCA environments (Akhtar, 2025; Ejjami & Boussalham, 2024). Also, it bolster project procurement and supply chain resilience by allowing real-time

modifications in response to demand fluctuations and disruptions (Ivanov & Dolgui, 2021). Moreover, the study recommends academics to develop a unified project procurement management framework combining (systematic project procurement management framework enhances sustainability and resilience in engineering, construction, and procurement by reducing inefficiencies, providing precise information, and utilizing data analytics for proactive management, sustainable sourcing practices, and contingency plans) and (Resilient and sustainable project procurement to meet long-term organizational goals and adapt to VUCA environments. Strong leadership, clear governance structures, and the use of AI, IoT, and blockchain are crucial for improved visibility and decision-making).

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