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AI Vendor Performance Assessment in the Mining Industry: A Monte Carlo and LLM Approach

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ABSTRACT

This paper examines the methodologies for assessing AI vendor capabilities in the context of Roy Hill, a prominent iron ore mining company in Western Australia. Through the use of Monte Carlo simulations and Large Language Models (LLMs), including innovative techniques like the Multi-Persona LLM (MP-LLM), we evaluate potential AI vendors to identify those that align with Roy Hill's strategic and operational goals. A robust vendor evaluation framework was developed, integrating survey data with independent assessments of LLMs and their products. The MP-LLM framework was specifically tested for its problem-solving ability and demonstrated enhanced performance when combined with tailored prompt engineering and curated personas. To mitigate challenges such as information asymmetry and confirmation bias, vendor feedback was incorporated, and evaluation metrics were refined using both LLMs and Monte Carlo simulations. The study contributes to AI vendor selection methodologies in the mining sector, emphasizing the importance of adaptive strategies in a rapidly changing technological landscape. Future work will explore advanced techniques such as knowledge graphs and expanded persona libraries to improve AI capability assessments and support operational excellence across industries.

1. Introduction

This chapter discusses the methodologies used in evaluating AI vendor capabilities, especially within the context of Roy Hill, a leading iron ore mining company in Western Australia. The heart of the study's research question poses the question of whether Monte Carlo simulations and Large Language Models (LLMs) with more refined techniques, such as Multi-Persona LLM (MP-LLM), could be employed to screen AI vendors that align with the strategic objectives and operational efficiency goals of the company. Five sub-research questions are developed: the efficiency of Monte Carlo simulations in vendor evaluation, the impact of LLMs in evaluating vendor capabilities, the role of MP-LLM in improving problem-solving abilities, the incorporation of vendor feedback to reduce information asymmetry, and the design of holistic evaluation metrics. The study uses a quantitative approach and focuses on independent variables such as simulation and LLM techniques and dependent variables related to vendor alignment and efficiency outcomes. The paper progresses from a literature review to methodology, findings, and a conclusion, which emphasizes the importance of adaptive strategies in vendor selection**.**

2. Literature Review

The section surveys literature into AI vendor assessment methodologies, directed at the five sub-research questions-Effectiveness of Monte Carlo simulation, the impact of LLM on the

assessment of capability at the vendor's end, MP-LLM's role in problem solving, integration of vendor feedback, and comprehensive evaluation metrics. The review determines areas of weaknesses in the existing methodologies, such as minimally adaptable and manually biased methodologies, and suggests that this study has bridged those gaps by incorporating new techniques. Five hypotheses are formulated based on the relationships between the variables.

2.1 Effectiveness of Monte Carlo Simulations in Vendor Evaluation

Initial studies on Monte Carlo simulations in vendor assessment highlighted their predictive accuracy but often lacked integration with real-world constraints. Subsequent research introduced constraints to enhance realism but still faced challenges in scalability. Recent advancements have improved scalability and adaptability, yet the application in mining vendor selection remains underexplored. Hypothesis 1: Monte Carlo simulations significantly enhance the accuracy and reliability of AI vendor evaluations by incorporating realistic constraints and scalability factors.

2.2 Effects of LLMs on Vendor Capabilities Assessment

Early LLM researches mainly concentrated on language processing capabilities and did not contribute much to the vendor assessment. More recent studies expand their use in the assessment of technical documentation but often leave out the detailed analysis of the vendor's capabilities. Advanced LLM applications started filling these gaps, though consistency problems still exist. Hypothesis 2: LLMs represent a strong basis for the evaluation of AI vendors' capabilities. It increases the depth and consistency of assessments across the technical domains.

2.3 MP-LLM Role in Improving Problem Solving Ability

Early work on MP-LLM focused on the multi-persona adaptability; however, experiments were not reported in a specific testbed scenario about vendor assessments. Subsequent efforts demonstrated an advanced logic reasoning skill but only under a partial extension of integrating different techniques. Efforts within more recent periods prove its aptness in complicated problems but remains poorly utilised within mining. Hypothesis 3: MP-LLM contributes improved problem-solving strength in the vendor assessments for AI, multi-persona adaptability, and a logic reasoning perspective for nuanced understanding.

2.4 Integration of Vendor Feedback to Reduce Information Asymmetry

Vendor feedback integration studies underscore the need to reduce information asymmetry, yet there were often missing structured approaches. Follow-up studies further established more systematic approaches for structured feedback mechanisms with enhanced accuracy in comparison with ad-hoc methods. However, such methods continue to lack comprehensiveness in applying such approaches for overall AI vendor selection. Hypothesis 4: Systematic integration of vendor feedback reduces information asymmetry and biases in AI vendor evaluations, thereby enhancing the accuracy of decision making.

2.5 Development of Holistic Assessment Metrics

Initial work on metrics for evaluation was quantitative but inherently lacked qualitative understanding. Recent research efforts have included qualitatives, increasing the depth but not necessarily standardization. Existing research emphasizes the need for holistic development of metrics but has done little to apply that in assessments of AI vendors. Hypothesis 5: Holistic assessment metrics, which integrate both quantitative and qualitative understanding, offer a more comprehensive view of AI vendor strengths and weaknesses, thereby enabling strategic alignment.

3. Methodology

This section describes the quantitative research methodology that will be used to test the hypotheses. It details the methods of data collection, which include surveys and LLM assessments,

as well as the variables used in the study. This will ensure a multi-dimensional analysis of AI vendor capabilities that is in line with Roy Hill's strategic and operational objectives.

3.1 Data

The data will be collected by means of surveys in conjunction with independent assessments of LLMs, considering AI vendors pertinent to the mining industry. Data collection takes place between 2020 and 2023, covering feedback from vendors as well as their performance metrics. Stratified sampling ensures adequate diversity representation in vendor types and sizes. Screening criteria have emphasized relevance to mining operations and technological innovation, ensuring a strong dataset for effectiveness testing in Monte Carlo simulations, LLM techniques, and MP-LLM adaptability**.**

3.2 Variables

Independent variables include Monte Carlo simulation parameters, LLM configurations, and MP-LLM personas. Dependent variables are concerned with the alignment of the vendors with strategic goals, operational efficiency, and problem-solving capabilities. Control variables account for industry trends and market dynamics, thus allowing the effect of the methodologies to be isolated. Control variables such as market volatility and technological advancements have been established and used in this study. The reliability of the measurement methods has been validated by literature from industry reports and academic sources. The applied regression analysis explores relationships among variables while serving to test the hypotheses.

4. Discussion of Results

The findings section captures results derived from analysis of data between 2020 and 2023. Descriptive statistics offer the basis of establishing a foundation upon which hypotheses will be tested. Regression analyses confirm all five hypotheses, which show the efficacy of Monte Carlo simulations, LLMs, MP-LLM, vendor feedback integration, and comprehensive evaluation metrics in AI vendor assessments. These results show the promise of advanced methodologies in improving vendor selection processes, filling gaps in the existing literature, and providing strategic insights for the mining industry.

4.1 Accuracy and Reliability of Monte Carlo Simulations

This result validates Hypothesis 1 and supports the view that Monte Carlo simulations are strongly used to increase AI vendor evaluation accuracy and dependability. In this analysis, results indicate that using more realistic constraints yields better prediction accuracy than those produced by classical approaches. Main independent variables involved are simulation parameters. The dependent variables, meanwhile, concentrate on accuracy metrics from evaluations. From an empirical standpoint, Monte Carlo simulations appear to produce reliable predictions; thus, this research follows probabilistic modelling theories and decision support theories. By addressing previous methodological gaps, this finding underscores the importance of simulation techniques in strategic vendor assessments.

4.2 LLMs' Robust Framework for Evaluation

This finding supports Hypothesis 2, indicating that LLMs provide a robust framework for assessing AI vendor capabilities. Analysis of LLM assessment data shows enhanced consistency and depth in evaluating technical documentation, with key independent variables including LLM configurations and dependent variables focusing on evaluation metrics. The empirical significance reinforces

theories of language processing and knowledge representation, which underlines the ability of LLMs to provide comprehensive vendor insights. This finding underlines the value of LLMs in strategic decision-making by filling gaps in the application of LLMs in vendor assessments.

4.3 MP-LLM's Problem-Solving Enhancement

This result supports Hypothesis 3 by providing evidence that MP-LLM is enhancing AI vendor evaluation skills in terms of problem solving. Data analysis proves to increase the logic reasoning of the agent along with the flexibility, and major independent variables have MP-LLM personas and the dependent variable in the case focused on the metric of problem-solving. Empirical relevance resonates with multi-agent system and cognitive modeling theories since MP-LLM demonstrates delivering rich results by filling up these gaps within strategic vendor assessment capabilities.

4.4 Vendor feedback does help reduce asymmetric information.

This finding supports Hypothesis 4, focusing on the impact of vendor feedback to reduce information asymmetry and bias in AI vendor evaluations. Data analysis depicts better accuracy of decisions made while key independent variables are feedback mechanisms and dependent variables focus on the metrics of bias reduction. The empirical significance reinforces the theories of information theory and the feedback system, making systematic integration into feedback more important. This finding addresses gaps within the utilization of feedback and emphasizes how it is very important in the strategic assessment of vendors.

4.5 Comprehensive Metrics' Holistic Assessment

This result supports Hypothesis 5, that integrated evaluation measures are a comprehensive indicator of AI vendors' capabilities. Evaluation data analysis indicates significant strategic alignment from the use of integrated metrics: the independent variable consists of its components, whereas the dependent variables consist of performance measures. It is in consonance with both theories of performance measurement and strategic alignment that highlight the significance of having integrated metrics for vendor selection strategy. By filling such gaps in integrated metric development, the finding underscores the significant role of integration in strategic assessments of vendors.

5. Conclusion

This paper compiles findings on methodologies used to analyse AI vendor abilities, their implications in creating strategic alignment and operational efficiency for the mining industry. Key takeaways therefore centre around the importance of Monte Carlo simulations, LLMs, MP-LLM, vendor feedback, and complete metrics during the assessment of vendors, but limitations identified include using historic data and possible vendor biases. Future research should look into various financial instruments and regulatory conditions to expand the scope and applicability of the methodologies. This approach aims to refine strategies for AI capability assessments, enhancing operational excellence and strategic alignment in the mining industry. By addressing these areas, future studies can provide a more comprehensive understanding of advanced methodologies' roles in AI vendor evaluation.

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