Human-Machine Teaming in AI Driven Supply Chains

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Topic Areas: Artificial Intelligence, Digital Transformation, Strategy

Summary: Artificial Intelligence ("AI") increasingly performs cognitive tasks and has evolvedintothe role of a human's teammate. However, algorithms arenot designed to facilitate a teaming process.This Capstone project explores effective human-machine teaming ("HMT") capabilities thatenable successfulAI implementations. The developed and empirically validated HMT framework (based on 22 case studies) provides guidelinesto supply chain professionalsfor AI project implementations and assessments.

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KEY INSIGHTS

1.Seven foundational HMT capabilityindicator concepts are required for successful Supply Chain AI Implementation.

2.As AI projects evolve from a low-risk, closed design to a high-risk, open design context, a higher level of Observability, Common Ground, Shared Decision Making, and a synchronized Feedback Loop are required.

3.HMT capability configurations are more strongly driven by difference in decision context than by difference in application type.

4. As AI projects evolve, they change their position within the decision-context framework and as a result, require different capabilities as learning takes place.

Introduction

AI in recent years hasdeveloped from a novel concept to practical applications throughout the global economy.Supply chain is considered one of the areas in which AI is uniquely capable to assist humans with prescriptive and predictive analytics to identify patterns and generate actionable insights from the large amount of data it generates. 50% of multinational corporations are expected to have implemented AI in supply chain operations by 2023, according to Gartner.However, many AI implementations are not meeting performance expectations.

The causes of failure are often rooted in many firms not adequately investigating the right balance of the strengths of machines (computing power and memory storage) and humans (e.g. intuition and expertise) and the dynamics of these interactions. Facilitating effective human-machine teaming, therefore, becomes critical to AI projects' success. To tackle the challenge of designing effective AI systems,Saenz, Revilla, and Simon (2020)[1]draw connectionsbetween HMT capability configurations and the decision context, which is measured by decision risks and the openness of the AI decision-making process (Figure 1).

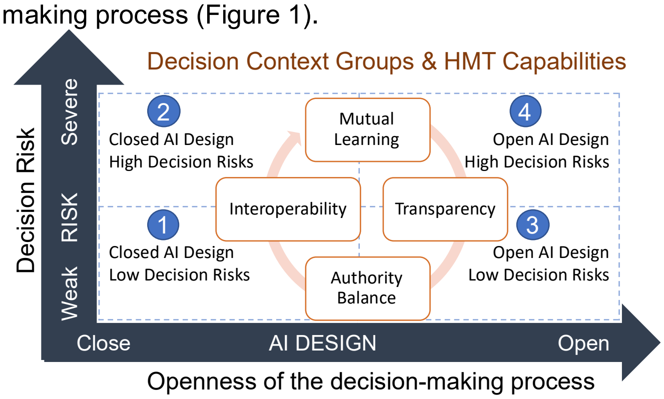

Figure 1: Established HMT Framework

[1]Saenz, M. J., Revilla, E., & Simón, C. (2020). Designing AI Systems With Human-Machine Teams. *MIT SLOAN MANAGEMENT REVIEW*, 7.

Building on Saenz's efforts, the present paper provides three core results:

1) expansion and validation of the conceptual HMT capability framework and empirical assessment of AI projects

2) recommendation of a quantitative assessment instrument for future research

3) provision of recommendations to organizations and supply chain leadership for successful handling of AI implementations

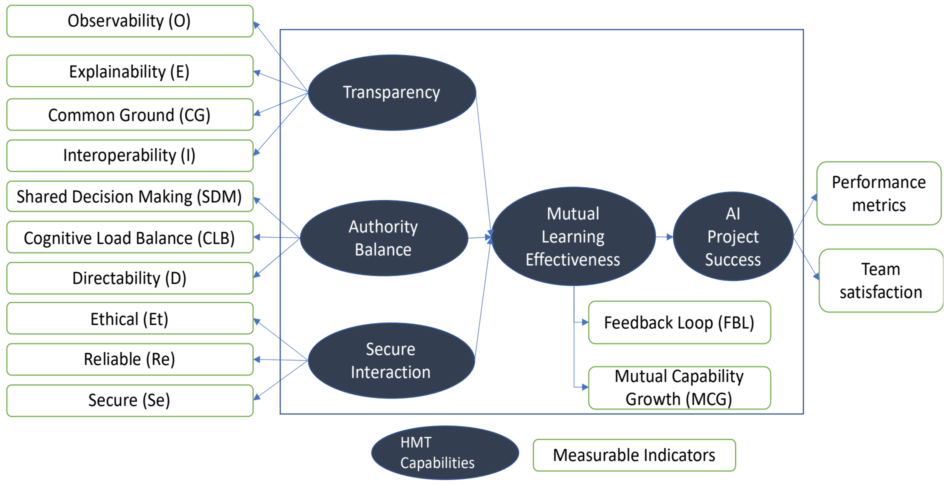

Figure 2: HMT Conceptual Framework

Methodology

This capstone developed an expanded HMT capability conceptual framework (Figure 2),which proposes that the AI project's success is explained by the effectiveness of human-machine **Mutual Learning**. The effective outcome of mutual learning is enabled by HMT capabilities in **Transparency, Authority Balance** and **Secure Interaction**. A subset of indicators for each HMT capabilityis also identified to measure the performance of the HMT capabilities. The authors empirically tested the HMT capability conceptual framework via multiple case study research methodologyin three stages. In the **first stage**, 20 supply chain AI application case studies from various industries were selected based on a set of defined criteria. A developed assessment tool based on the HMT conceptual framework was utilized to **assess the level of presence**of the HMT capability indicators. A 5-point Likert scale was appliedto assess each of the indicators. 1 meantthe indicator'slevel of presence is weak, while 5 indicatedthat the level of presence is strong in the AI project. In the **second stage**, two companies were selected for a series of in-depth semi-structured interviews to further **test the HMT framework** and **evaluate different human roles** played in the facilitation of human-machine mutual learning during the AI project development and deployment process. In the **third stage**, in-depth webinars were conducted with the two participating companies in an effortto review research findings, obtain feedback and **further refine the research outputs**.

Results and Propositions

According to the consolidated rating results, all four HMT capabilities have shown strong presence, which confirmed their fundamental importancefor a successful AI implementation. This confirmedthe validity of the conceptual framework.

Among the different concepts that HMT capabilities are based on, some are more pronounced than others in successful AI project implementations.Therefore, the authors considered these strongly consistent pronounced HMT capability indicator conceptsto bethe fundamental HMT capability indicator concepts that exist in all AI-driven supply chain applications.

Within the capability of **Transparency,** User Interface Simplicity and Understandability of Information Presented (E1) and the Ability of Making Coherent Connections for Inputs from Various Sources (I2) were the most strongly developed concepts.

Concerning **Authority Balance**, Ability to Assist Human to Eliminate Oversight Slips and Errors (SDM2), Ability to Control and Override Decisions (D1) and the Ability to Assure a Manageable Human Workload by Balancing Workload Distribution Between Human and Machine (CLB)showed the highest level of presence.

Regarding **Secure Interaction**, all three concepts proved to be developed with Accordance to Acceptable Social Conduct Principles (Et) and Validated Method to Protect Interaction Processes and Prevent Unintended Access (Se) being especially strong. From the overall assessment, no evidence of the need for human and machine team members to Anticipate Mutual Changes (O3), and for the AI to be Capable to Redirect and Re-allocate Tasks (D3) can be derived.Therefore, the authors derived thefirst proposition (P):

P1: Seven HMT capability indicator concepts are considered fundamental HMT concepts for AI-driven supply chain applications.

The decision context group (see Figure 1) analysis revealed that the higher risks and more open decision-makingprocess, the higher Visibilityin System State(O1) and Intentions (O2), Mutual Awareness (CG1) and High-level Information Sharing (CG2), teaming level in Joint Solution Development (SDM3), level of synchronized Feedback Loop (FBL)and Mutual Capability Growth (MCG1, MCG2) are required. Hence,the authors propose:

P2: Higher sophistication in HMT capability configurations is required as an AI project evolves to higher risk more open decision-making process.

Based on the analysis on application types, the HMT capability configurations are more similar than different across three types of AI supply chain applications. It is common that a high level of Explainability (E), Interoperability (I), Shared Decision Making (SDM) are present.However, it shows that Quality Assurance applications require a higher level of shared decision making and mutual learning interactions, which are correlated with the characteristics of the decision context group these applications fall in. The authors propose the following:

P3: The HMT capability configurations are dependent on the decision contexts.

In the case study analyses as well as the interviews conducted, the authors observed that human-machine teaming efforts in AI-driven supply chains over the course of their lifetime change their position within the decision-context matrix. Consequently, the authors propose:

P4: AI projects dynamically shift their position within the decision-context framework, requiring different capabilitiesas learning takes place.

Besides these clear capability-based propositions which are summarized in Figure 3, the authors also observed the important role played by select managerial best practices from the fields of project management and finance.A viable business case, executive sponsorship and agile project management are preconditions to successful AI project design and implementation.

Managerial Recommendations

The findings also informed managerial recommendationswhich cover best practices in employee engagement, AI project scoping, design and project management. Companies' leadership and supply chain professionals can leverage these insights to develop an AI project design and implementation plan.

The derived managerial recommendations:

1. Maintaining secure interaction is of fundamental importance
2. Ensure employee buy-in by addressing their concerns
3. Employees do not need the technical ability to understand algorithms, but they have to be able to follow the intuition behind them
4. Focus on providing richer human feedback to the AI
5. Focus on actively engaging employees across the organization in AI project development process (e.g. using cross-functional teams, user-centric design, and agile methods)
6. Determine a clear definition of the project's decision context, comprised of decision risk and AI process design, to be able to prioritize HMT capabilities
7. In project management, commit to a clear vision

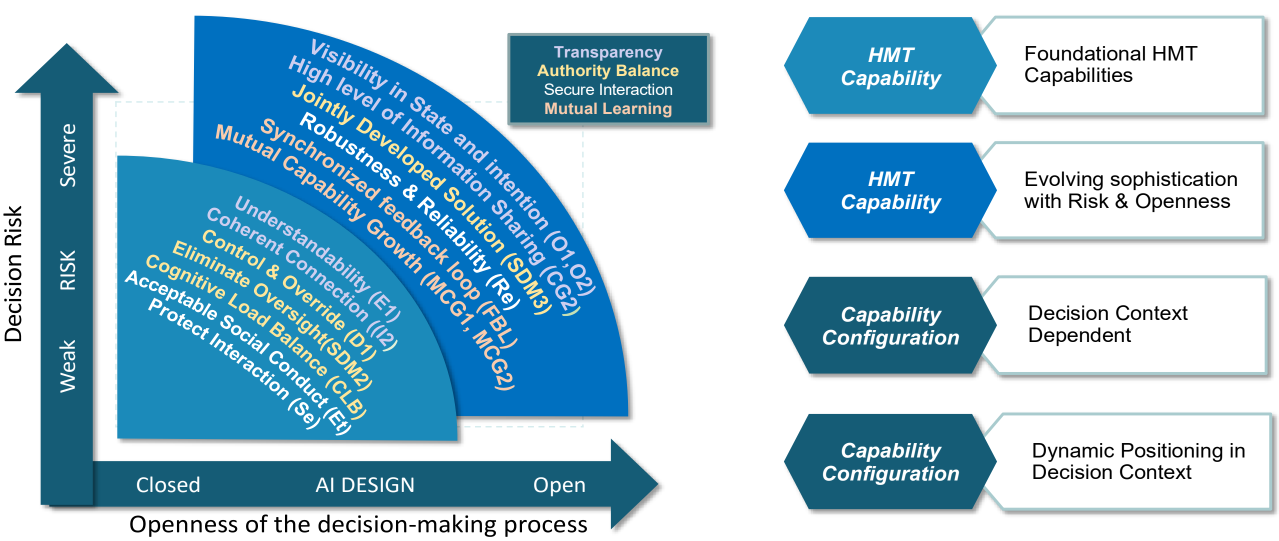

Figure 3: HMT Capability Framework Key Findings

while also iteratively improve a minimum viable product.
8. Invest in data governance to leverage the power of AI and enable interoperability

Conclusion

This paper advances research in the field of human-machine teaming in AI-driven supply chains by providing both academic and practical insights. The detailed literature review and expansion of the HMT framework developed by Saenz, Revilla, and Simon (2020) enables a better understanding of how different capabilities are defined and how they can be measured. Applications of these concepts to 22 case studies further advanced the understanding of how these capabilities function under changing circumstances and how practitioners can leverage such insights. Even when taking into account the limitations of this capstone, predominantly driven by the low number of observations, the authors believe that the present research advances the field and providesa basis for future opportunities.

The collected data leveraging the proposed assessment instrument can be used for further validation of the structural relationships of the HMT capabilities, which would improve the practical utility of the framework.As the field of artificial intelligence is ever expanding, it would be an interesting aspect to further research whether individual AI applications require specific capability configurations potentially not captured by the framework. Future research can also contribute to better understanding how corporate and organizational culture interacts with the successful establishment of different capability configurations.