Chapter 6
Agentic Control Towers: Multi Agent LLM RL Orchestration for Autonomous and Resilient Supply Chains

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ABSTRACT

Supply chains exist today under chronic volatility, uncertainty, complexity, and ambiguity. Batch based planning and decision rights fragmentation render companies sluggish to detect disruption and costly to rebound. This paper develops an integrated concept—Agentic Control Towers (ACTs)which combines large language model (LLM) agents, multi agent reinforcement learning (MARL), and digital supply chain twins to provide closed loop, explainable autonomy for plan, source, make, move, and serve. We integrate findings across inventory and logistics reinforcement learning, LLM tooling and multiagent coordination, digital twin orchestration, and resilient operations. We position ACTs as a decision fabric that continuously senses, simulates, negotiates, and performs while placing guardrails for safety, sustainability, cost, and service. The paper provides an integrated architecture, end to end decision flows, stability and governance design decisions, and evidence informed pathways of impact. We also establish evaluation criteria.

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1. INTRODUCTION

Global supply chains are increasingly b complex, dynamic, and vulnerable to disruption. Traditional control towers enhance visibility but remain limited in their capacity to learn, explain, and adapt autonomously. This chapter introduces Agentic Control Towers (ACTs) an integrated framework that unites Large Language Model (LLM) agents, Multi-Agent Reinforcement Learning (MARL), and Digital Supply Chain Twins to achieve explainable, adaptive, and continuously improving decision-making. Drawing on recent advances in artificial intelligence, operations management, and digital-twin technology, ACTs form a decision fabric that enables supply chains to anticipate, resist, adapt to, and recover from disruptions. Within this architecture, LLMs provide interpretability and collaborative reasoning; MARL agents provide decentralized, real-time adaptability; and digital twins simulate and validate recovery options in secure environments. Together, these elements operationalize resilience as a closed-loop data capability, making disruption response a learning and strategic development moment. The chapter places ACTs within emerging theories of socio-technical resilience and dynamic capabilities, offering both research agendas and managerial implications for creating truly autonomous and resilient supply chains

Over the past two decades, global supply chains have become more complex, more costly interconnected and interdependent, linking supply chain activities across continents, including linking suppliers, manufacturers, distributors, and customers. While supply chain management has delivered efficiency at large scales, it has also exposed it to vulnerability. The COVID-19 pandemic shock, geopolitical tensions, natural disasters, and the surge in consumer demand have time and again revealed how easily the interconnected network system can be disturbed (Ivanov, 2020; Queiroz et al., 2022; Qadeer & Awad, 2025).

Resilience has been the supply chain management strategic priority ever since. Essentially, resilience is a supply chain's ability to anticipate, resist, adapt to, and recover from disruptions (Ivanov, 2023). Companies lean and cost-optimized supply chain inventories that were faced with bottlenecks, shortages, and unexpected risks. Classical approaches to resilience rely on buffers—safety stocks, dual sourcing, redundant logistics capacity, and contractual hedges. While helpful, these strategies are costly, relatively static, and insufficient for systemic or prolonged crises (Dolgui & Ivanov, 2023).

As a reaction, supply chain management practitioners and scholars have invested extensively in visibility solutions, the most visible of which is the supply chain "control tower.". They integrate information from multiple sources into dashboards to give managers a unified single view of supply chain operations which is designed to give a "single version of the truth" about supply chain operations. The past de-