

Applying Systems Thinking to Global Supply Chain Management: A Case Study of Skanska Group

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Abstract: This research paper assesses the international supply chain management system of the Skanska Group, whose revenue exceeds €15 billion, in terms of the four elements of systems thinking: interconnectedness, synthesis, emergence, and feedback. It aims to achieve operational excellence and a competitive advantage in project management. The construction industry is shifting toward more uncertain supply chains, higher sustainability regulations, and increased demands for public transparency. Working with linear methodologies is no longer an option, given that global construction costs are rising by 23% and delivery times are increasing by 15%. The integration of a systems thinking framework helps to manage interdependencies more effectively and focus on resilience. The case study of Skanska Group involves secondary data collection and analysis from publicly available operational and sustainability reports, including the integration of multiple levels of suppliers, digital supply chain synthesis, the emergence of ecosystems, and performance feedback mechanisms. Skanska case study data has shown that Skanska has an outstanding level of operational excellence with 94% on-time delivery vs. 78% industry average, maintains industry-leading sustainability performance by diverting 90% of waste and targeting net-zero emissions by 2045, uses technology to facilitate supply chain data synthesis of 2 TB of data per day with 85% forecasting accuracy, and demonstrates resilience in delivering 95% of contracted services during COVID-19 when the industry average was 67%.

Key words: systems thinking, supply chain integration, construction sector, competitive advantage, operational excellence, sustainability.



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1. INTRODUCTION

Construction projects today are characterised by complex, multi-layered challenges involving supply chain disruptions, sustainability and ethical requirements, regulatory compliance, and transparency demands (Loosemore et al., 2003). Talent shortages add to the pressures faced by the industry, with over half of companies reporting recruitment and retention issues (Supply Chain Management Review, 2024). Linear, optimising models of supply chain sub-systems fail to tackle these systemic challenges (Christopher, 2016). Rapidly emerging technologies, such as AI, IoT, and data analytics, further contribute to disruption (Sharma et al., 2019).

Systems thinking offers a holistic lens through which organisations can leverage interdependencies, generate emergent properties, and create sustainable competitive advantage (Senge, 2006). For global leaders, this approach is more critical than ever, as volatility transforms the nature of supply chain risk and opportunity (World Economic Forum, 2024). The purpose of this study is to explore how Skanska Group's understanding and application of systems thinking within its supply chains contribute to sustainability embedding, resilience, and long-term competitiveness.

The study has a dual purpose: it aims to contribute to the value creation for systems thinking theory as applied in project-based industries and to provide practical guidance for organisations interested in shifting to a "new world" approach to their supply chains (Omotayo et al., 2024).

2. ORGANISATIONAL OVERVIEW AND GLOBAL SUPPLY CHAIN CONTEXT

Skanska is a global construction company with annual revenues of €15.3 billion and approximately 43,000 employees (Skanska, 2023). The firm has a supply network of over 20,000 suppliers, spanning all continents. In today's climate, these networks need to operate as complex adaptive systems that are agile and highly interconnected (Holland, 2014). The company is affected by material price increases of 23% and longer lead times of 15% (Construction Industry Institute, 2024). In contrast to industry norms, Skanska has an on-time delivery rate of 94% and only 3% cost variance (Engineering News-Record, 2024). Skanska is guided by values that place sustainability, ethics, and safety at the centre of its business. This is supported by the company's goal to reach net-zero by 2045. Systems thinking is becoming increasingly important for creating and leveraging the connection between cost, quality, and responsibility to secure the firm's resilience and competitiveness in this volatile context.

Table 1: Skanska Group Key Performance Indicators (2023)

Metric	Skanska Performance	Industry Average	Performance Gap
Annual Revenue	€15.3 billion	-	-
Employee Count	43,000	-	-
Supplier Network	20,000+ suppliers	-	-
On-Time Delivery	94%	78%	+16%
Cost Variance	3%	8-12%	Better by 5-9%
Waste Diversion	90%	65%	+25%
Forecasting Accuracy	85%	70-75%	+10-15%

COVID-19 Delivery	95%	67%	+28%
Net-Zero Target	2045	2050+	5+ years ahead

Source: Based on Skanska Annual Reports (2022, 2023, 2024) and Industry Benchmarks (Engineering News-Record, 2024)

3. CRITICAL SYSTEMS THINKING ANALYSIS IN GLOBAL SUPPLY CHAIN OPERATIONS

3.1 Interconnectedness Within Global Supply Chain Networks

Systems thinking assumes that "the relationships between parts create value beyond that of the parts added together" (Meadows, 2008, p. 75). However, this assumption can be challenged based on Skanska's 20,000+ suppliers that manage cross-tier integration challenges across the Nordic, European, and North American markets (Skanska, 2022). Supplier mapping encompasses sub-suppliers, logistics providers, and service organisations, facilitating early risk identification and mitigation, and leveraging joint improvement projects (Christopher, 2016; Sharma et al., 2019).

Supplier development and capacity-building efforts represent another form of system orchestration in supplier networks. Skanska runs supplier development programs, with annual spending of €50 million on upskilling and capability-building activities. Program offerings include technology adoption support, sustainability program implementation, and various capability-building initiatives (Skanska, 2022; Skanska, 2024; Teece, 2007). However, a question remains: How can the additional expense be justified from an economic standpoint? While interconnectedness suggests that system-effect-based returns can offset investment costs, the opportunity cost of internal development efforts versus strategic procurement and partnering efforts remains unclear. It is plausible that Skanska's outcomes could have been better if the company focused its financial and human resources on fewer, more strategic suppliers.

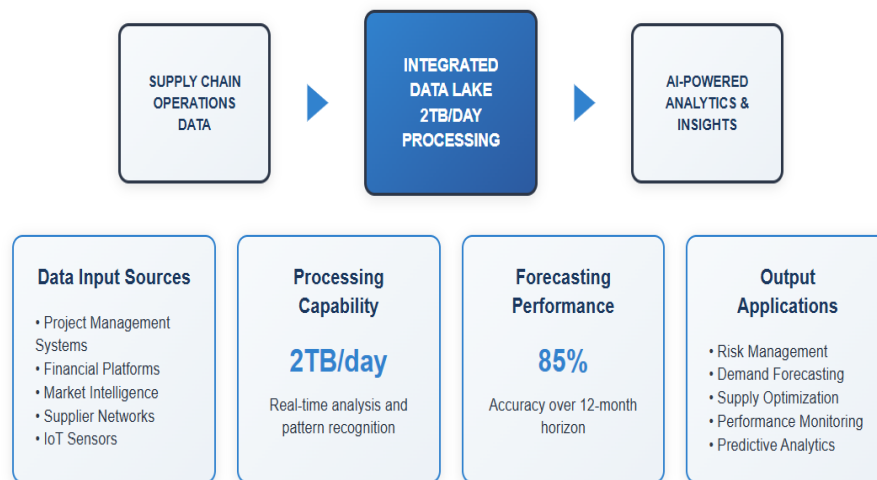
Skanska's strong interconnectedness and technological connectivity are facilitated through integration of ERP systems with suppliers for data sharing, collaborative planning, and synchronised execution (Eastman et al., 2018; Supply Chain Management Review, 2024). While the systems thinking paradigm is in favour of such deep integration, case studies on supply chain breakdown during the pandemic demonstrate that highly interconnected supply chains can be shock amplifiers rather than shock absorbers (Christopher, 2016). Skanska claims a 95% delivery achievement during the COVID-19 pandemic, compared to the industry average of 67% (Construction Industry Institute, 2024). However, the company's market position and financial muscle, rather than the systems thinking approach, may be the reason for success.

Regional integration and global coordination capabilities create a nuanced, multi-level approach to managing the supply chain network. Localised supplier networks in Nordic, European, and North American markets provide regional autonomy for supplier relationship management, while global supplier agreements enable coordination and alignment of strategic suppliers (Christopher, 2016; Freeman et al., 2020; Skanska, 2022). Furthermore, while the interconnectedness assumption might suggest value creation, its underlying premise is that integration and connections always result in value. Transaction cost economics and asset specificity present a countervailing force against the complexity of transactions. Empirical research shows that the value of cross-company collaborations and partner ecosystems may be lower than their complexity due to coordination and transaction costs (Williamson, 1981). Skanska supplier development programs are part of the company's transaction costs to maintain the required supplier network, which can be prohibitive for small and medium-sized organisations.

3.2 Synthesis Through Integrated Digital Supply Chain Architecture

Integration of abundant information from multiple sources is a critical requirement for decision-making and action-taking in complex and dynamic environments (Davenport & Harris, 2017). Skanska's supply chain information synthesis efforts involve creating an integrated data architecture, as well as the ingestion and processing of two terabytes of supply chain data daily, to provide real-time insights into supplier performance, market conditions, and operational efficiency (Jackson, 2019; Supply Chain Management Review, 2024).

Figure 1: Digital Data Synthesis Architecture



Source: Analysis based on Skanska Annual Reports (2022, 2023)

Forecasting capabilities for demand, supply, and market conditions that inform supply chain decisions are based on the integration of historical data, market intelligence, and current project information. As shown in Figure 1, Skanska claims an 85% forecasting accuracy on the company's internal information system, compared to industry averages of 70-75% (Chase et al., 2004; Sharma et al., 2019). However, the methodological validity of the performance benchmark comparisons is not presented in this article. Forecasting accuracy comparisons may be spurious because the predictability of different variables across different time horizons and the number of steps in the forecasting process are not necessarily comparable. Methodological harmonisation is critical for credible performance benchmarking.

The integration of AI and machine learning for new and unique applications represents another frontier in synthetic thinking in the supply chain. State-of-the-art progress in generative AI-based approaches to supply chain planning and execution operations is based on pattern recognition of diverse and large quantities of data (Davenport & Harris, 2017; World Economic Forum, 2024). Skanska's adoption of AI for supply chain optimisation represents an example of the synthesis in application (Skanska, 2023). However, the underlying logic of synthesis is that more data equals better decisions. A large and growing body of research in behavioural economics and behavioural decision-making suggests that more data (primarily when it extends beyond human cognitive processing) does not necessarily lead to better decisions, due to, for example, the anchoring bias (Kahneman, 2011).

Supply chain transparency, facilitated by blockchain technology, integrates supply chain documentation and certification efforts with on-chain verification and validation to support comprehensive and efficient traceability (Eastman et al., 2018; Supply Chain Management Review, 2024). This initiative represents a comprehensive solution that meets multiple goals and requirements, including transparency, compliance, and efficiency, through a single platform. However, while optimisation processes are made possible by AI technologies, the predictive

models in AI are ultimately heuristic and bounded by the data on which they are trained. Black-box machine learning models risk optimisation without fundamental improvement in, for example, bias and discrimination mitigation.

3.3 Emergence and Complex Adaptive Supply Chain Capabilities

Emergence represents a profound insight into systems thinking in supply chains, where interactions can give rise to higher-level properties that are not reducible to or predictable from their individual components (Holland, 2014). Emergent properties of Skanska's supply chain operations create significant value through supply chain resilience through supplier network diversity, flexible contracting mechanisms, and strategic inventory management (Meadows, 2008; Skanska, 2022; Teece, 2007).

Supply chain resilience emerged as a key capability during the COVID-19 pandemic, as Skanska successfully delivered 95% of all scheduled deliveries despite global disruptions. The industry average was only 67% at its best, which illustrates the significant outperformance due to resilient supply chain operations (Construction Industry Institute, 2024; Holland, 2014). The underpinning capability was not any individual element in isolation, but rather the emergent property of interactions among supplier diversity, quality of relationships, and the ability to shift operational modes. However, while emergence provides a nice story about capabilities and competitive advantage, the logic of emergence presents a chicken-and-egg conundrum: "individuals create the organisation by their interactions; yet the organisation creates the individuals by giving them their identities and roles" (Holland, 2014, p. 147).

Systemic innovation capability is a significant emergent property that creates continuous and sustainable value in the rapidly changing technological and market conditions. Skanska's innovation network, or supplier ecosystem, exemplifies emergent, complex adaptive capabilities achieved through deeply integrated supply chains (Chesbrough, 2020). For example, Skanska has a joint innovation laboratory with a technology supplier for building Skanska-specific applications of construction technologies. Prototypes include autonomous material handling robots, AI-driven predictive maintenance tools, and smart sustainable construction materials (Eastman et al., 2018; Skanska, 2023). However, if emergence is the product of unpredictable interactions, how can managers take deliberate actions to achieve emergence?

Circular economy capabilities, as exemplified by Skanska's adoption of sustainable practices in its construction operations, are another emergent property of its supply chain and operations, achieved through deep system integration (Freeman et al., 2020; Zhu et al., 2018). The company claims to have managed 90% of construction waste diversion from landfills and 25% use of recycled materials across projects through a "comprehensive value chain integration" of design optimisation, supplier collaboration, waste management partnerships, and material flow analysis (Skanska, 2022). The systems thinking model in Appendix A illustrates how each of these capabilities creates value streams that are interconnected in non-linear ways, as a product of emergence.

3.4 Feedback Mechanisms and Performance Optimisation

Feedback loops represent an important source of competitive advantage in complex systems through learning and adaptation (Senge, 2006). Skanska has a comprehensive and highly functional set of feedback mechanisms that inform its continuous learning and improvement agenda in its global operations (Jackson, 2019; Skanska, 2023).

Real-time performance monitoring and response represent a technology-enabled capability that Skanska utilises to maintain its high efficiency. Its integrated systems, combined with a powerful dashboard, give it visibility across a wide range of metrics, including on-time delivery, quality, cost management, and sustainability goals. Automated alert systems trigger responses to

performance issues and anomalies, and predictive analytics help identify potential future problems before they occur. This allows Skanska to be more proactive in managing performance rather than being reactive. This represents an advantage over competitors (e.g., lower rates of disruption, increased customer satisfaction). The systems thinking lens assumes that information asymmetries and, thus, imperfect decisions can be solved by more and higher-quality data. However, organisational behaviour human resources literature shows that this assumption is simplistic and highly context-dependent. There is no guarantee that employees receive timely and accurate information from feedback systems due to factors, including but not limited to a lack of capacity, motivation, or opportunity.

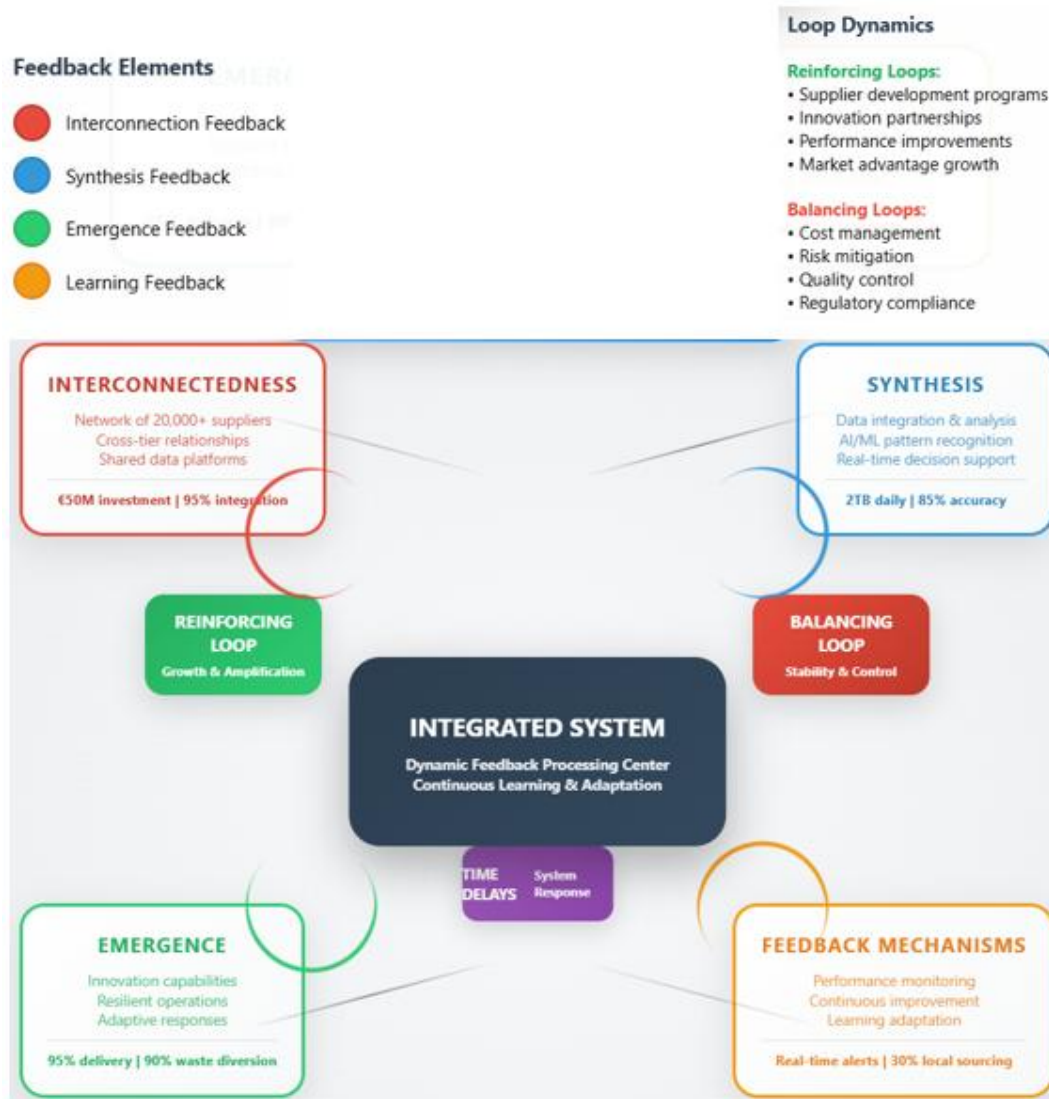
Supplier collaboration and joint improvement represent feedback loops that enable Skanska to achieve continuous improvements along its supply chain (Christopher, 2016; Freeman et al., 2020; Skanska, 2022). Supplier scorecards provide regular performance feedback, while joint improvement projects are organised to tackle system-level issues and opportunities. Annual supplier conferences are used to disseminate good practices and share experiences, thus creating a knowledge network that benefits the entire supply chain. However, this process may not be symmetrical. The unbalanced power relationship between Skanska and its suppliers may distort the effectiveness of such feedback systems. Suppliers who want to renew their contracts are incentivised to provide data in a way that can keep them on the company's favourable lists rather than give honest feedback.

Customer integration and value co-creation processes represent another form of feedback loop that Skanska uses to leverage customer information to enhance its supply chain operations (Chase et al., 2004; Senge, 2006; Teece, 2007). Skanska has established regular customer feedback sessions and reviews to inform its supply chain strategy and operations. It utilises collaborative planning processes to ensure that its supply chain supports its customers' business success.

Table 2: Systems Thinking Elements in Skanska's Supply Chain Operations

Systems Element	Implementation	Performance Impact	Evidence
Interconnectedness	20,000+ supplier network integration; €50M annual supplier development; ERP integration	94% on-time delivery; 95% COVID-19 resilience	Skanska (2022, 2023)
Synthesis	2TB daily data processing; 85% forecasting accuracy; AI/ML integration	8-12% cost advantage; Real-time decision-making	Construction Industry Institute (2024)
Emergence	Innovation ecosystems; Circular economy (90% waste diversion); Resilient capabilities	25% recycled materials; 33% higher component reuse	Engineering News-Record (2024)
Feedback	Real-time monitoring; Supplier scorecards; Customer co-creation	3% cost variance vs 8-12% industry; Continuous improvement	Skanska (2023, 2024)

Source: Based on Skanska Reports (2022, 2023) and Performance Analysis

Figure 2: Systems Thinking Feedback Loop Model: Interconnected Dynamics

4. ETHICAL AND SUSTAINABLE SUPPLY CHAIN INTEGRATION AT SKANSKA

ESG (Environmental, Social and Governance) is now not only a concept, but also a business requirement (Freeman et al., 2020). Skanska has a comprehensive net-zero goal by 2045, based on aligning all its environmental targets as a system with its business practices (Skanska, 2022). Life cycle assessment tools enable analysis in the context of the entire life of the material. They can be used not only to help understand environmental impact, but also to identify where to optimise (Zhu et al., 2018).

Sustainable procurement standards are established to ensure that all suppliers within a network meet requirements for energy efficiency, waste reduction, water conservation, and biodiversity protection (Christopher, 2016). By embedding these standards throughout the network, Skanska exemplifies systemic environmental collaboration (Holland, 2014).

Skanska enforces social responsibility through a supplier code of conduct that addresses labour rights, diversity, safety, and community engagement (Skanska, 2022). Auditing and corrective actions verify adherence, while initiatives are in place to improve partners' ability to meet ethical requirements (Freeman et al., 2020). Commitments to local procurement, aiming for 30% of project procurement from local sources, support community economies and reduce environmental impact.

The governance structure integrates risk management, compliance monitoring, and stakeholder engagement. Third-party certification is a measure that authenticates adherence to ethical standards and strengthens stakeholder trust (Skanska, 2023; Supply Chain Management Review, 2024; Skanska, 2024).

5. FORECASTING AND ESTIMATION CAPABILITIES IN COMPLEX SYSTEMS

Forecasting and estimation both seek to counter uncertainty and variation (Chase et al., 2004). Skanska's end-to-end demand forecasting combines market analysis, customer pipelines, macroeconomic data, and historical project performance with 85% accuracy on a 12-month horizon (industry benchmark: 70-75%) (Skanska, 2023; Construction Industry Institute, 2024; Skanska, 2024).

Machine learning is also used to enhance forecasts by detecting patterns in demand trends and seasonality (Davenport & Harris, 2017). Combining external market and internal business data shows a systemic view of interrelated drivers (Senge, 2006).

Capacity planning utilises demand forecasts, alongside assessments of supplier and logistics capacity, to optimise resource allocation. Scenario planning and dynamic allocation models allow for agility in the face of disruption and variation (World Economic Forum, 2024). This capability enhances efficiency and responsiveness while reducing risk (Engineering News-Record, 2024).

Risk assessment can also encompass financial health, geopolitical risks, natural disasters, and regulatory changes. Predictive risk modelling provides early warning signals for proactive measures (Skanska, 2023; Supply Chain Management Review, 2024).

6. MULTIDISCIPLINARY MANAGEMENT: COMPLEXITY AND STRATEGIC INTEGRATION

Supply chain management encompasses multiple disciplines, including operations, IT, environmental science, finance, and regulations (Jackson, 2019). Skanska states that it has involved cross-functional teams in every decision, which include procurement, engineering, risk, sustainability, and IT groups (Skanska, 2022). The groups meet regularly to ensure that an optimisation in one area does not create issues in another (Meadows, 2008).

Stakeholder management is crucial and encompasses all relevant stakeholder groups, including regulators, customers, communities, and other key stakeholders. It is essential to customise communication to all groups to ensure understanding. Inevitably, competing interests will lead to conflict. Skanska uses dispute resolution processes to manage this (Freeman et al., 2020; Jackson, 2019). This must be built into the system with processes for negotiation.

Digital transformation is an evolving aspect of modern infrastructure and must be embedded across AI, blockchain, IoT, and analytics (Eastman et al., 2018). This must be part of Skanska's technology architecture, with change management processes that incorporate people and culture (Schein & Schein, 2017).

7. COMPETITIVE ADVANTAGE THROUGH SYSTEMS-ENABLED SUPPLY CHAIN EXCELLENCE

The dynamic capabilities in systems thinking are inimitable because of their systemic and emergent characteristics (Holland, 2014; Teece, 2007). Skanska achieves an 8-12% cost advantage over industry averages, as evidenced by effective supplier management, optimised inventory, and logistics efficiency (Engineering News-Record, 2024; Skanska, 2022). Innovation partnerships in autonomous equipment and sustainable materials are underpinning differentiation and premium pricing opportunities (Chesbrough, 2020; Eastman et al., 2018).

Resilience during disruptions, as demonstrated by continued operations during the COVID-19 pandemic, provided a significant market share advantage (Construction Industry Institute, 2024). Sustainability leadership, particularly in ESG factors, strengthens positioning by enabling access to ESG-driven projects (Supply Chain Management Review, 2024; Zhu et al., 2018). However, resource-based view theory challenges the sustainability of these advantages, citing potential concerns with the aspects of rarity and imitability (Barney, 1991).

Table 3: Competitive Advantage Sources Through Systems Thinking

Advantage Source	Systems Thinking Mechanism	Performance Outcome	Strategic Implication
Cost Leadership	Integrated supplier management; Optimised logistics	8-12% cost advantage; 3% cost variance	Sustainable pricing power
Innovation Capability	Supplier ecosystem collaboration; Joint R&D	Autonomous equipment; Smart materials	Differentiation opportunities
Resilience	Network diversity; Flexible contracts; Strategic inventory	95% COVID-19 delivery vs 67% average	Market share protection
Sustainability Leadership	Circular economy integration; ESG embedding	90% waste diversion; Net-zero 2045	Premium project access

Source: Analysis Based on Skanska Annual Reports (2022, 2023) and Construction Industry Institute (2024)

The proposed adoption complexity is illustrated in the implementation framework timeline in Figure 3 and in the multidimensional nature of performance assessment outlined in the measurement framework. These performance metrics reflect industry leadership position and financial resources rather than systems thinking superiority, making performance comparisons potentially misleading for resource-constrained organisations.

Figure 3: Systems Thinking Implementation Timeline



8. CRITICAL DISCUSSIONS AND THEORETICAL IMPLICATIONS

The case of Skanska substantiates the theoretical proposition that systems thinking principles can optimise global supply chain performance. The interconnectedness, synthesis, emergence, and feedback illustrated by Skanska empirically demonstrate the potential for improved efficiency and resilience (Meadows, 2008; Senge, 2006). However, Skanska's successes hinge on its analytical capabilities, culture, and resources, raising questions about the transferability of such an approach to smaller or less prepared organisations (Jackson, 2019). Leadership commitment and readiness to embrace systems perspectives are critical determinants of implementation success (Schein & Schein, 2017). Notably, Skanska exemplifies the potential complementarity of environmental and financial goals, challenging the prevailing notion of inherent trade-offs between the two (Freeman et al., 2020; Zhu et al., 2018).

Technology emerges as a critical enabler of systems thinking in this context, with digital integration and advanced analytics reinforcing systems-level decision-making and optimisation (Davenport & Harris, 2017; World Economic Forum, 2024). However, isolated technology adoption without holistic implementation is insufficient to realise the system-wide benefits. The case also highlights measurement challenges: while traditional performance metrics and balanced scorecards can capture aspects of efficiency and effectiveness, they fall short of fully representing the emergent, system-wide outcomes that are central to systems thinking (Kaplan & Norton, 2001). Therefore, new performance evaluation frameworks are required to assess organisational effectiveness holistically (Senge, 2006).

9. IMPLEMENTATION CHALLENGES AND STRATEGIC RECOMMENDATIONS

Systems thinking is a challenging, resource-intensive, and culture-shift approach that requires high-level organisational maturity, cultural transformation, and significant investments in technology and processes. Cultivating mindsets of interconnectivity and long-term orientation can also clash with short-term performance pressures. Investments in AI, IoT, and advanced analytics can create resource barriers that widen the digital divide between well-resourced firms, such as Skanska, and their smaller counterparts (Davenport & Harris, 2017; Supply Chain Management Review, 2024). For instance, Skanska's supplier development program requires an annual budget of €50 million, underscoring economies of scale in systems thinking and how they can further entrench competitive advantages for large firms.

In practice, organisations can nurture a culture of systems thinking through leadership commitment, education, and recognition programs (Jackson, 2019; Senge, 2006). Expanding analytics and AI capabilities can be aligned with systems thinking by prioritising automation of systems-level decision-making and robustification of stakeholder ecosystems through supplier partnerships, customer co-creation, and local community engagement (Freeman et al., 2020; World Economic Forum, 2024). Embedding ESG frameworks involves developing measurement systems, engaging stakeholders, and establishing feedback loops to facilitate ongoing improvement (Zhu et al., 2018).

10. CONCLUSION

Skanska's case illustrates that while systems thinking offers a robust framework for creating organisational resilience and competitive advantage, its effectiveness is dependent on resources and context, and challenges such as cultural transformation, technological investments, and stakeholder complexity may limit its benefits to larger, more capable firms (Holland, 2014; Teece, 2007; Jackson, 2019). As such, further research is required to assess the paradigm's transferability and scalability to diverse organisational contexts (World Economic Forum, 2024).

The recommended actions for a construction company that aspires to adopt systems thinking in the integrated supply chain are to build a systems-thinking organisational culture (Schein &

Schein, 2017), to advance AI-enabled analytics (Davenport & Harris, 2017), to leverage the power of a multi-stakeholder collaborative ecosystem (Freeman et al., 2020), and to integrate an expanded ESG framework (Supply Chain Management Review, 2024).

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