http://jhmi.sums.ac.ir
Health Man & Info Sci 2025, 12(4), 267–273

HMIS
Health Management and Information Science

Original Article

A Model for Process Control in Agile Supply Chain Networks Using Artificial Neural Networks

Alireza Aliasgharzadeh[1], Mahmood Mohammadi*[1], Hassan Mehrmanesh[1]
[1]Department of Industrial Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran

Abstract

Introduction: This study proposes an Artificial Neural Network (1)-based process control model to enhance agility in supply chain networks, focusing on optimizing decision-making under demand fluctuations and cost constraints.

Methods: A quantitative descriptive design was employed, utilizing cluster sampling (n=384) from a manufacturing company's customer base. The ANN model integrated key variables (e.g., raw material flow, production volume, storage capacity) and was tested via sensitivity analysis to evaluate the impacts of production cost, service level, and factory capacity changes on objective function values.

Results: The model significantly improved supply chain agility, enabling a dynamic response to demand shifts. A 111% production cost variation altered costs by ±15.7%, while a 91% capacity reduction rendered the model infeasible. A 411% demand surge disrupted service levels (91%), highlighting capacity constraints. Flexibility indicators (e.g., production adaptability) emerged as critical agility drivers.

Conclusion: The ANN-based model optimizes supply chain performance, particularly in healthcare contexts where responsiveness and cost efficiency are paramount. Practical recommendations include workforce skill development, just-in-time production systems, and enhanced supplier IT integration.

Keywords: Process Control, Agile Supply Chain, Artificial Neural Network

Article History:
Received: 8 July 2025
Accepted: 16 September 2025

Please cite this paper as:
Aliasgharzadez AR, Mohammadi M, Mehrmanesh H. A Model for Process Control in Agile Supply Chain Networks Using Artificial Neural Networks. Health Man & Info Sci. 2025;12(4): 267-273. doi: 10.30476/jhmi.2025.108149.1306.

***Correspondence to:**
Mahmood Mohammadi,
Department of Industrial Management, Islamic Azad University, Tehran Central Branch, Tehran, Iran
Email:
mah.mohammadi@iau.ac.ir

Introduction

Companies face increasing pressure to improve responsiveness and reduce costs in today's competitive market. Recent advancements in artificial intelligence, particularly Artificial Neural Networks (ANNs), have emerged as transformative tools for achieving supply chain agility. For instance, it has been demonstrated that AI-driven dynamic capabilities can enhance real-time decision-making in volatile environments, reducing operational costs by up to 20% (1).

Similarly, the efficacy of LSTM-based neural networks in forecasting demand fluctuations was highlighted with 92% accuracy, enabling firms to adjust production plans dynamically. These studies underscore the critical role of ANN in modern supply chain optimization (2).

As a result, SCM has become a critical necessity to enhance operations, increase profits, improve customer satisfaction, ensure product quality, and address competitive pressures resulting from globalization, the rise of e-commerce, and increasing supply chain complexity (2). SCM is recognized as an integrated approach for managing the flow of materials, information, and capital, capable of rapidly responding to environmental conditions (3). In other words, it involves managing all supply and production processes—from raw material procurement to product delivery to the end customer—to create value for customers and stakeholders (4).

However, supply chains have grown increasingly complex, involving decisions regarding the location of facilities, capacities, production and inventory planning, supplier selection, demand forecasting, and transportation and information flows (1, 5). This complexity is inevitable in effectively meeting customer expectations, such as lower costs, higher quality, and shorter lead times (6).

To cope with such complexity, researchers have proposed various solutions, including mathematical modeling, linear programming, metaheuristic algorithms, and multi-objective optimization approaches (7, 8). Artificial neural networks (ANNs) represent a specialized and promising technique. Specifically, ANNs are computational models designed to mimic human pattern recognition and have shown effective performance in artificial intelligence, engineering, and supplier selection tasks (8). Their integration can significantly enhance the performance of agile supply chains.

An agile supply chain network refers to systems capable of responding swiftly to market changes and customer demands. Agility is an organizational response to challenges in dynamic environments, incorporating adaptive strategies and innovative performance metrics. Agile supply chains consist of legally independent but operationally interdependent entities that emphasize flexibility and responsiveness to volatile conditions. Consequently, they enrich customer and employee satisfaction while enabling organizations to establish a unique and competitive market position (9, 10).

Building on these foundations, this research explores the supply chain and its components, highlighting the importance of supply chain management and the role of artificial neural networks in enhancing agility. Specifically, it provides a literature-based overview of ANN-based methods applied in the SCM domain. The study first introduces foundational concepts related to supply chains and neural networks in the literature review section. Then, through a systematic review methodology, the applications of neural networks in supply chain management will be identified and classified. This study aims to propose a model for process control within an agile supply chain network using artificial neural networks.

Methods

Research Design

This study employed a quantitative and descriptive research design to examine the current state and underlying characteristics of the phenomenon under investigation. The goal was to provide a structured and systematic description of existing conditions and, where applicable, to explore relationships between relevant variables.

Study Population

The statistical population consisted of customers and end-users of a manufacturing company, representing the target group to which the study findings are intended to be generalized.

Sampling Method

A cluster sampling method combined with convenience access was used to select participants. Clusters were defined based on relevant operational units, and participants were selected from accessible clusters. This approach was chosen due to the lack of a complete list of the population.

Sample Size

The sample size was determined using Cochran's formula for an unlimited population, assuming a 95% confidence level and a 5% margin of error. Based on this, the required sample size was 384 respondents. Following clustering, data were collected from within the selected clusters.

Inclusion and Exclusion Criteria

Participants included in this study were customers and end-users of the selected manufacturing company who had direct or indirect interaction with the supply chain processes. Inclusion criteria required that respondents be at least 18 years old and have a minimum of six months of experience interacting with the company's production or distribution system. Respondents must also be literate and willing to participate in the study voluntarily.

Exclusion criteria included individuals without prior experience with the company's supply chain or who failed to complete the questionnaire thoroughly. Incomplete or inconsistent responses were excluded from the final analysis.

Data Collection Tools and Process

The primary data collection instrument was a structured questionnaire based on a comprehensive review of the relevant literature on supply chain agility and artificial neural networks. The questionnaire consisted of closed-ended and Likert-scale items and was validated by a panel of academic and industry experts to ensure content validity.

Data were collected using a cluster random sampling approach. Questionnaires were distributed in person and electronically across different branches of the company's supply and distribution departments. Before distribution, participants were informed about the research objectives, and their informed consent was obtained. Anonymity and confidentiality of the data were strictly maintained throughout the research process.

Statistical Analysis

Data were analyzed using SPSS version 23. Descriptive statistics were calculated to summarise the demographic characteristics of participants and the main study variables. Inferential statistical methods were used to examine relationships between supply chain agility factors and performance indicators, including correlation analysis, regression analysis, and structural equation modeling (11) where applicable.

Reliability of the instrument was assessed using Cronbach's alpha, with a threshold of 0.70 indicating acceptable internal consistency. All analyses were conducted with a significance level of α=0.05.

Ethical Considerations

This study adhered to all ethical guidelines for research involving human participants. Before data collection, participants were fully informed about the study's purpose and procedures and provided informed consent to participate voluntarily. Participation was optional, and respondents had the right to withdraw at any stage without any consequences.

Confidentiality and anonymity of all participants were strictly maintained, and no identifiable personal data were collected. The data were used solely for research purposes and stored securely to prevent unauthorized access.

The study protocol was reviewed and approved by the institutional ethics committee of Azad University, ensuring compliance with national and international ethical standards for social science research (Code: 16236051).

Results

This study investigated the role of supply chain agility and developed a process control model using Artificial Neural Networks (ANNs) to optimize supply chain performance. The findings highlight the critical importance of information integration and process control in enhancing responsiveness and efficiency.

Enhancement of Supply Chain Agility

The proposed model demonstrated significant improvements in supply chain agility by enabling dynamic storage capabilities at distribution and production centers. This allows suppliers and manufacturers to respond swiftly to demand fluctuations, improving overall performance.

Optimization of Decision Variables

The model incorporated critical decision-making variables, including: Quantity of raw materials transferred from suppliers to manufacturers, Volume of products manufactured and distributed, Storage capacity at each stage of the supply chain, and Capacities of suppliers, manufacturers, and distributors. By accurately integrating these variables, the model supports data-driven supply chain operations optimization.

Sensitivity Analysis Results

Effect of Production Cost on Objective Function

A 111% decrease in production cost reduced the objective function value to 1,248,194,831. Conversely, a 111% increase raised it to 1,444,324,761 (Figure 1).

Effect of Customer Service Level on Objective Function

Higher service levels (e.g., 1.95) correlated with increased costs (1,444,324,231). Lower service levels (e.g., 1.6) reduced costs significantly (943,644,397) (Figure 2).

Effect of Factory Capacity on Objective Function

A 91% reduction in capacity rendered the model infeasible. A 51% increase in capacity optimized costs (1,147,444,431) (Figure 3).

Demand Fluctuation Analysis

A 411% surge in demand led to an inability to maintain a 91% service level due to capacity constraints. A 25% to 111% demand reduction resulted in gradual cost declines, as fixed costs remained constant.

The ANN-based process control model enhances supply chain agility by optimizing decision variables and adapting to demand fluctuations. These insights are particularly valuable for healthcare supply chains, where responsiveness and cost efficiency are critical.

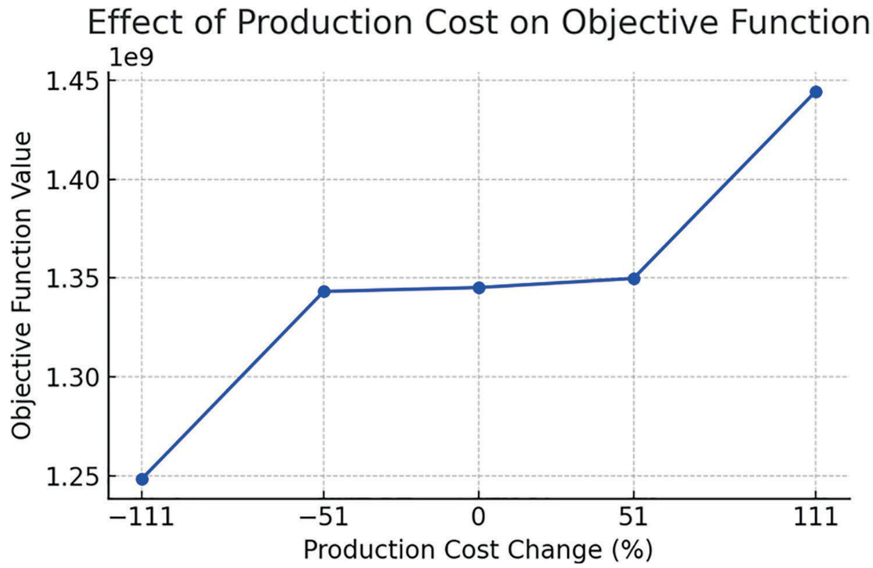

Figure 1: Effect of Production Cost on Objective Function

Figure 2: Effect of Customer Service Level on Objective Function

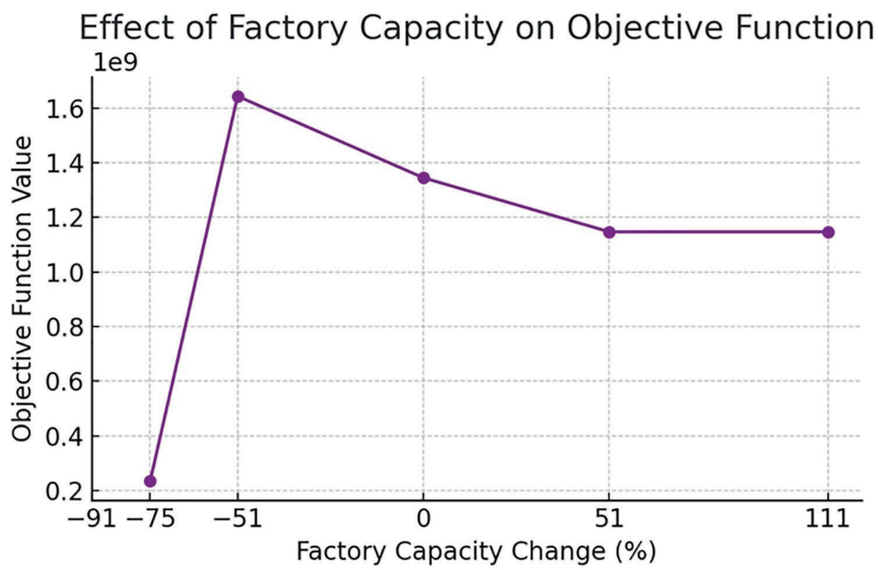

Figure 3: Effect of Factory Capacity on Objective Function

Discussion

This study aimed to propose a model for process control within an agile supply chain network using artificial neural networks. The research focused on various dimensions such as cost reduction, customer responsiveness, and flexibility to develop a comprehensive process control model tailored for agile supply chain networks.

The present study's findings indicated that customer responsiveness is a key factor in supply chain agility. Moreover, this result aligns with the study by Gilaninia et al. (2013), who demonstrated the positive impact of supply chain strategies on customer responsiveness and production efficiency. This consistency highlights the critical role of timely and reliable service delivery in maintaining a competitive supply chain (12). This study found that cost reduction is a critical factor influencing the performance of agile supply chains. This aligns with Christopher and Towill (2001), who highlighted that while speed and responsiveness are vital, controlling and reducing costs remains a fundamental challenge for supply chain competitiveness. Effective cost management is essential for balancing agility with profitability, enhancing overall supply chain resilience. (13). The present study also confirmed the significant role of flexibility-related indicators in supply chain performance, ranking among the top factors. This finding supports the work of Yusuf, Gunasekaran, and Adeleye (2014), who emphasized various dimensions of supply chain flexibility—such as volume, product, and delivery flexibility—as key enablers of lean and agile supply chain paradigms. Their research underlines the importance of adaptability and responsiveness in managing dynamic market demands. (14) Furthermore, our study reveals that different types of flexibility—production, mix, and change flexibility—exert distinct effects on supply chain agility. This echoes the findings of Swafford, Ghosh, and Murthy (2006), who identified flexibility as a primary driver of supply chain performance and profitability, while speed was considered important but less influential in comparison (15). These insights collectively highlight flexibility as a central element influencing operational efficiency and financial outcomes in agile supply chains.

Based on the findings of this study, several practical recommendations can help improve supply chain agility and overall company performance. First, boosting production efficiency is key by focusing on increasing workforce flexibility through skill development, implementing just-in-time production systems, adjusting production plans to meet market demands, minimizing downtime and changeover times, automating processes to reduce risks, and ensuring defect-free production by involving workers in design and quality control. Next, improving new product introduction involves identifying new market opportunities, conducting thorough market research to understand customer preferences, analyzing competitors' strengths and weaknesses, and encouraging continuous innovation in product development and launches.

Strengthening integration mechanisms is also important, which includes setting up electronic links for direct data exchange, implementing enterprise-wide systems for unified data access, and enhancing IT collaboration with suppliers and customers. Lastly, increasing responsiveness to market changes by constantly monitoring shifts in the market, competitor activities, customer needs, technological advances, and economic and social factors will enable faster adaptation of supply chain strategies. By adopting these approaches, companies can build an agile supply chain that delivers faster, reduces costs, and improves customer satisfaction.

Limitations

This study has some limitations. Using cluster sampling with convenience access may restrict the generalizability of the findings across various industrial sectors. Moreover, focusing on a single manufacturing company limits the applicability of the results to broader contexts. Future research should include more diverse samples from multiple industries and consider integrating additional advanced computational techniques to improve supply chain agility modeling further. Nevertheless, despite these limitations, the present study makes valuable contributions by quantitatively prioritizing key factors within a specific industrial context, thereby providing actionable insights for supply chain managers seeking to optimize process control.

Conclusion

Overall, the findings highlight the critical importance of integrating advanced computational techniques into supply chain management to better navigate uncertainty and evolving customer demands. This study introduces an ANN-based model that accurately identifies and prioritizes the key factors driving supply chain agility. By providing practical insights and recommendations, it equips practitioners with effective tools to enhance process control, improve responsiveness, and sustain a competitive edge in today's complex and rapidly changing market environments.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' Contribution

A.A.: Conceptualization, Methodology, Data curation, Writing – original draft. M.M.: Supervision, Validation, Writing, review & editing. H.M.: Formal analysis, Investigation, Resources. All authors read and approved the final manuscript

Acknowledgement

The authors would like to thank the manufacturing company and its customers who participated in this study. We also appreciate the valuable feedback from the editors and reviewers.

Conflict of Interest

There are no conflicts of interest.

References

1. Nurjanni KP, Carvalho MS, Costa L. Green supply chain design: A mathematical modeling approachbased ona multi-objective optimization model. *International journal of production economics*. 2017;183:421-32. doi: 10.1016/j.ijpe.2016.08.028.
2. Mohanty R, Sahoo G, Dasgupta J. Identification of risk factors in globally outsourced software projects using logistic regression and ANN. *International Journal of Sup Chain Mgt*. 2012;1:2-11.
3. Seyed Hosseini M, Asadi Nia S. Production and Service Management for Executive Managers. Vol. 1. Tehran: Islamic Azad University, Science and Research Branch; 2015. Persian.
4. Naslund D, Williamson S. What is management in supply chain management?-a critical review of definitions, frameworks and terminology. *Journal of Management Policy and Practice*. 2010;11(4):11-28.
5. Azadeh A, Sheikhalishahi M, Neghab AP, Asadzadeh SM, editors. Modeling and Optimization of a Supply Chain Loop's Performance by an Integrated Neural Network-Fuzzy Regression-Ridge Regression Approach. 2010 Fourth UKSim European Symposium on Computer Modeling and Simulation; 2010: IEEE. doi: 10.1109/EMS.2010.45.
6. Gumus AT, Guneri AF, Keles S. Supply chain network design using an integrated neuro-fuzzy and MILP approach: A comparative design study. *Expert Systems with Applications*. 2009;36(10):12570-7. doi: 10.1016/j.eswa.2009.05.034.
7. Altiparmak F, Gen M, Lin L, Karaoglan I. A steady-state genetic algorithm for multi-product supply chain network design. *Computers & industrial engineering*. 2009;56(2):521-37. doi: 10.1016/j.cie.2007.05.012.
8. Wang F, Lai X, Shi N. A multi-objective optimization for green supply chain network design. *Decision support systems*. 2011;51(2):262-9. doi: 10.1016/j.dss.2010.11.020.
9. Zandhesami H, Rajabzadeh A, Toloei A. Factors Affecting Supply Chain Agility. *Iranian Journal of Trade Studies*. 2009;13(51):121-61.
10. Swafford PM, Ghosh S, Murthy N. Achieving supply chain agility through IT integration and flexibility. *International journal of production economics*. 2008;116(2):288-97. doi: 10.1016/j.ijpe.2008.09.002.
11. Speckemeier C, Pahmeier K, Trocchi P, Schuldt K, Lax H, Nonnemacher M, et al. One-year follow-up healthcare costs of patients diagnosed with skin cancer in

Germany: a claims data analysis. *BMC Health Serv Res*. 2022;22(1):771. doi: 10.1186/s12913-022-08141-9.

12. Gilaninia S, Taleghani M, Mousavian SJ, Tajani TK, Ghoreishi SM, Shahidi SF, et al. Comparative study of lean and agile supply chain management along with the optimal model presentation of agile supply chain management. *Arabian Journal of Business and Management Review (Kuwait Chapter)*. 2011;1(4):46-56.
13. Christopher M, Towill D. An integrated model for the design of agile supply chains. *International Journal of Physical Distribution & Logistics Management*. 2001;31(4):235-46. doi: 10.1108/09600030110394914.
14. Yusuf YY, Gunasekaran A, Adeleye EO, Sivayoganathan K. Agile supply chain capabilities: Determinants of competitive objectives. *European Journal of Operational Research*. 2004;159(2):379-92.
15. Swafford PM, Ghosh S, Murthy N. The antecedents of supply chain agility of a firm: scale development and model testing. *Journal of Operations management*. 2006;24(2):170-88. doi: 10.1016/j.jom.2005.05.002.