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Analysis of The Influence of Supplier and Government Partnerships on Hospital Supply Chain Performance

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Abstract

Indonesia's healthcare industry has expanded rapidly alongside population growth to 278 million by 2023, driving a notable increase in healthcare expenditure. Hospitals form the backbone of healthcare provision, Within the complex landscape of the healthcare industry, the hospital supply chain (HSC) is crucial for ensuring the timely delivery of medical resources. Partnerships may play a crucial role in improving an HSC's overall performance. This study employs System Dynamics modeling to analyze the impact of supplier and government partnerships on HSC performance. The study extends the existing literature by incorporating both CLD and SFD methodologies to provide a more comprehensive analysis of the factors and intricacies within hospital supply chain partnerships. The findings indicate that high trust, IT integration, and hospital dynamic capabilities improve hospital supply chain performance through better information sharing and integration. Hospital demand significantly influences government regulations and control, further affecting performance. Theoretically, this study advances how dynamic interactions and feedback loops between multiple stakeholders within the HSC can be effectively modeled to gain insight and enhance healthcare supply chains.

Keywords: Hospital Supply Chain, Supply Chain Partnerships, System Dynamics Modeling, Hospital Supply Chain Performance.

1. Introduction

The healthcare industry in Indonesia has been experiencing rapid growth alongside a significant increase in population, reaching 278 million people in 2023. According to the World Bank, healthcare expenditure per capita in Indonesia increased by 12.21% from 2001 to 2020 ($17 to $133). As the Ministry of Health (2023) reported, Indonesia's healthcare budget rose by 43.87% from 2020 to 2023 (from Rp 119.9 trillion to Rp 172.5 trillion). The healthcare industry encompasses sectors providing healthcare services, including healthcare provider networks, hospitals, and medical facilities

In this industry, hospitals stand at the forefront and are responsible for receiving various supplies to support care delivery. They are also where consumers or patients directly interact to access healthcare products or services. Figure 1.1 illustrates a 7.06% increase from 2020 to 2024 (2959 units to 3168 units of hospitals) (Jaya, 2023; Sadya & Bayu, 2023). According to data from the Indonesian Ministry of Health (2024), out of the 3168 hospital units in Indonesia, general hospitals constitute the largest type with 2647 units (84%), and private organizations own the majority of hospitals, with 868 units (27%) being privately owned (*RS Online*, n.d.)

In this highly complex industry, hospital supply chains play a key role in ensuring the smooth provision of essential medical resources. The Hospital Supply Chain (HSC) is a complex network that facilitates the timely delivery of goods and medical services to healthcare facilities (Setiawati et al., 2023). Generally, the HSC is not much different from supply chains in other industries. The HSC is the heart that pumps the continuity of healthcare services. The supply chain plays a crucial role in ensuring that hospitals have supplies such as medical equipment and medications of the optimum quality and standard and delivered timely to provide optimal patient care.

The HSC encompasses three main flows: information, product, and cash. Three main entities interact to provide the right products and services at the right time: backward entities, forward entities, and focal entities (Kitsiou et al., 2007; Setiawati et al., 2023; Singh & Parida, 2022). Forward entities are entities generally responsible for the flow of funds. These entities include private or public payers such as government agencies or insurance companies (Kitsiou et al., 2007). Focal entities typically refer to healthcare providers responsible for the purchasing and ordering process in the supply chain (Singh & Parida, 2022). Backward entities are institutions responsible for fulfilling large-volume orders and the flow of medical products for patient care (Kitsiou et al., 2007).

According to Singh & Parida, Focal, forward, and backward entities can be defined as hospitals, public and private funders, and manufacturers (Singh & Parida, 2022). Several studies have shown that partnerships between entities in the supply chain can influence the HSC. (Mandal, 2017; Matopoulos & Michailidou, 2013; Setiawati et al., 2023). Partnerships in a supply chain offer the potential for more efficient resource utilization, and the design process can result in increased productivity (Schliephake et al., 2009).

To visualize the interaction between the three entities in the hospital supply chain, the system dynamics approach can be employed, which is a modeling approach to uncover the inherent complexity in complex systems and is aimed at enhancing understanding and providing information for decision-making (Malbon & Parkhurst, 2023). Approaches in system dynamics that can be used to model complex systems include Causal Loop Diagrams (CLD) which is a system modeling method that depicts complex relationships and feedback loops within a system and Stock Flow Diagrams (SFD) a graphical representation used in system dynamics modeling to illustrate the dynamic relationships between various variables in a system (Sterman et al., 2000).

CLDs have the advantage of helping to visualize a complex system and the interactions between components within that system, which are typically non-linear. CLD assists in identifying and understanding feedback loops within a system, which are feedback cycles formed by causal relationships between variables. Understanding feedback loops is key to predicting system behavior that can result in dynamic and unstable behavior. CLD has several limitations. Firstly, CLD cannot differentiate between stocks and flows, which are the most important components in system dynamics. Additionally, some loops in CLD can be further detailed to enhance understanding. SFD can be used to address these limitations (Sterman et al., 2000).

Not much research has been done to simulate the effects of partnerships on a hospital's overall performance. This research is a continuation of a previous research done by Setiawati et al. which solely focuses on identifying key factors within a supply chain partnership using a causal loop diagram. This study aims to complement the results of the previous research done by incorporating both CLD and, in addition, SFDs which will add the concept of stocks and flows, to simulate and visualize the factors and intricacies within a partnership in an HSC and to analyze the impact of supplier and government partnerships on hospital supply chain performance.

2. Literature Review

2.1. Partnerships in Hospital Supply Chain

A supply chain typically comprises various entities collaborating to promptly deliver goods, information, finances, and other resources to the final destination. Hence, collaboration or partnership within a supply chain is inevitable. As defined by the Indonesian Dictionary (KBBI), partnership entails cooperative relations or collaborative efforts among partners. Partnerships alleviate traditional barriers occurring among supply chain members due to competition. They foster mutually beneficial relationships, increasing information flow, reducing uncertainty, and more profitable supply chains (Maloni & Benton, 1997). A more integrated approach among supply chain partners enhances the potential for more efficient resource utilization, ultimately leading to increased business process productivity (Schliephake et al., 2009).

In the context of the HSC, structured partnerships within the HSC can enhance supply chain effectiveness and potentially aid in cost savings, improved service levels, risk mitigation, and quick responses to external changes and market demands (Abdallah et al., 2017; Mishra et al., 2018). Partnerships and collaboration between hospitals and suppliers are significant factors that can enhance the performance of a hospital supply chain (Abdallah et al., 2017; Alshahrani et al., 2018; Kitsiou et al., 2007; Matopoulos & Michailidou, 2013; Setiawati et al., 2023; Setyawan et al., 2022). Government entities also play a vital role in partnerships within the HSC, being responsible for regulating and overseeing healthcare service networks and providing financial assistance to hospitals in the form of government healthcare expenditure (Dobrzykowski, 2019; Pan et al., 2013).

2.2. Actors in Hospital Supply Chain

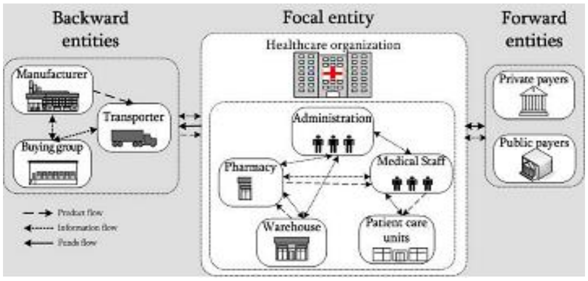

Figure 1. A schematic diagram of the healthcare supply chain according to Kitsiou et al, 2007

HSC differs from standard supply chains due to its complexity, the presence of valuable medical materials, and, most importantly, the fact that they deal with human life (Singh & Parida, 2022). An HSC consists of focal, backward, and forward entities (Kitsiou et al., 2007). Focal entities are healthcare service providers, including administration, overseeing ordering, and procurement. Large-scale procurement is handled by backward entities, including manufacturers, distributors, and purchasing organizations. Insurance organizations and governments are examples of forward entities. The three main streams in HSC are products, information, and funds (Kitsiou et al., 2007). Figure 1 depicts a schematic diagram of the healthcare supply Chain.

2.3. Role of Suppliers in Hospital Supply Chain Partnerships

Numerous studies have examined the impact of suppliers on hospitals, particularly factors influencing integration, collaboration, and partnerships. Key factors include trust and information exchange. Trust enhances hospital-supplier integration and supply chain performance, reducing uncertainty and fostering collaboration (Abdallah et al., 2017; Sodhi & Son, 2009). It also mitigates risks associated with information sharing, promoting openness and accelerating information exchange (Alshahrani et al., 2018).

Effective information exchange is crucial for competitive success and strategic resource acquisition (Alshahrani et al., 2018). It facilitates smooth business planning, improves supplier quality control, and enhances adaptability to external changes (Ariesty, 2016; Setyawan et al., 2022). Finally, IT integration between hospitals and suppliers is essential, reducing transaction costs and risks and improving logistics integration, business performance, supply chain efficiency, and patient safety (Alshahrani et al., 2018; Sodhi & Son, 2009).

2.4. Role of Governments in Hospital Supply Chain Partnerships

The government plays a crucial role in regulating and overseeing healthcare service provision networks, referring to the interconnected system of healthcare providers, facilities, and organizations collaborating to deliver healthcare services to patients. Governments establish policies and payment systems to ensure safe, effective, efficient, and timely healthcare outcomes. Government regulations and payment systems vary between countries but generally focus on cost control, hospital utilization management, emphasis on primary care physician services, ensuring quality care, and information management (Dobrzykowski, 2019; Pan et al., 2013).

An increase in healthcare demand can push government entities to partner with hospitals. Increased demand for healthcare services prompts governments to increase efforts to accommodate this demand through regulatory and operational controls and even government healthcare expenditures (Pan et al., 2013).

2.5. Role of Hospitals in Hospital Supply Chain Partnerships

Hospitals play a role in advancing integration and collaboration with external organizations such as suppliers. In addition to all factors discussed in the preceding subsection, one study involves an additional factor: the dynamic capability of hospitals. Dynamic capability refers to a hospital's ability to obtain real-time relevant information about its business processes and changes in its business environment. Dynamic capability consists of VFS (visibility for sensing), VFL (visibility for learning), VFI (visibility for integrating), and VFC (visibility for coordinating) (Mandal, 2017).

2.6. Variables For System Dynamic Model

The variables used for the structure of the system dynamics model are derived from the literature review conducted in this study. Table 1 presents all the variables used and the sources for those variables.

Table 1. Variables for the system dynamics model

Actor	Variable	Source
Hospital	Hospital Demand	(Pan et al., 2013)
	Hospital Dynamic Capabilities	(Mandal, 2017)
	Hospital Supply Chain Performance	(Abdallah et al., 2017a; Alshahrani et al., 2018; Kitsiou et al., 2007; Mandal, 2017; Matopoulos & Michailidou, 2013; Setiawati et al., 2023; Setyawan Firmansyah & Siagian, 2022).
Hospital / Supplier	Hospital - PemasokSCM Integration & Partnership	(Abdallah et al., 2017a; Alshahrani et al., 2018; Kitsiou et al., 2007; Mandal, 2017; Matopoulos & Michailidou, 2013; Setiawati et al., 2023; Setyawan Firmansyah & Siagian, 2022).
	Level of Trust	(Sodhi & Son, 2009, Alshahrani et al., 2018, Setyawan Firmansyah & Siagian, 2022)
	Level of Information Sharing	(Sodhi & Son, 2009, Alshahrani et al., 2018, Setyawan Firmansyah & Siagian, 2022)
	Level of IT Utilization & Integration	(Alshahrani et al., 2018, Sodhi & Son, 2009)
Government	Government Healthcare Expenditure	(Pan et al., 2013, Dobrzykowski et al., 2019)
	Level of Government Regulation & Operational Control	(Pan et al., 2013, Dobrzykowski et al., 2019)

3. Methods

3.1. Systems Dynamics

System dynamics is an approach to studying complexity, comprising a set of conceptual tools enabling the understanding of the structure and dynamics of complex systems. It also serves as a rigorous modeling method, allowing the construction of formal computer simulations of complex systems to design more effective policies and organizations (Sterman et al., 2000). It is instrumental for decision-makers as it facilitates the identification of various factors influencing a system, aiding in intervention development and solutions based on insights gained from the model (Sterman et al., 2000).

The system dynamics process encompasses several stages, from problem formulation to the introduction of solutions into the system. This comprehensive approach is aligns systems thinking, which involves understanding the relationships between system components and their interactions to shape system behavior. System dynamics utilizes mathematical models to simulate complex systems, serving as a framework for an in-depth understanding of system dynamics. Despite potential biases and simplifications in modeling, these models aid in identifying and addressing limitations. They offer decision-makers valuable insights into complex systems, guiding effective interventions and providing tools to navigate their intricacies (Malbon & Parkhurst, 2023).

3.2. Causal loop Diagram

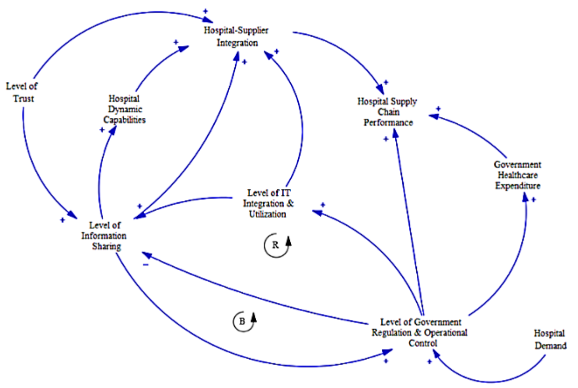

Figure 2. Causal loop Diagram of factors affecting hospital supply chain partnerships and performance

The Causal Loop Diagram (CLD) is a visual tool that depicts cause-and-effect relationships among variables within a system (Sterman et al., 2000). CLD aims to analyze systems as complex networks involving various components, factors, and variables, all working together to maintain and enhance a system (Baugh Littlejohns et al., 2021). A CLD consists of variables and connections (links) that link these variables. Each link is annotated with symbols such as positive (+) and negative (-) signs to indicate polarity. Loops are formed by relationships between variables that provide feedback. The nature of these feedback loops can be clarified by loop identifiers, indicating whether a loop is reinforcing or balancing feedback (Baugh Littlejohns et al., 2021; Sterman et al., 2000). The CLD model for this study is presented in Figure 2.

3.3. Stock Flow diagram

The Stock Flow Diagram (SFD) is a graphical representation used in system dynamics modeling to illustrate the dynamic relationships among various variables within a system. The two key components of an SFD are Stocks or levels and Flows, where Stocks represent accumulations that can increase and decrease, while Flows are processes that cause stocks to increase or decrease. Stocks and Flows are central concepts in system dynamics and feedback (Sterman et al., 2000).

SFD emphasizes the physical structure of a system by tracking the accumulation (Stock) and the rates of inflow and outflow that affect this accumulation. SFD illustrates how an accumulation changes over time due to these flows, providing insights into system dynamics and how different variables interact to influence its behavior. SFD aids in understanding complex system dynamics, identify feedback loops, and analyze different variables' impact on system behavior (Sterman et al., 2000).

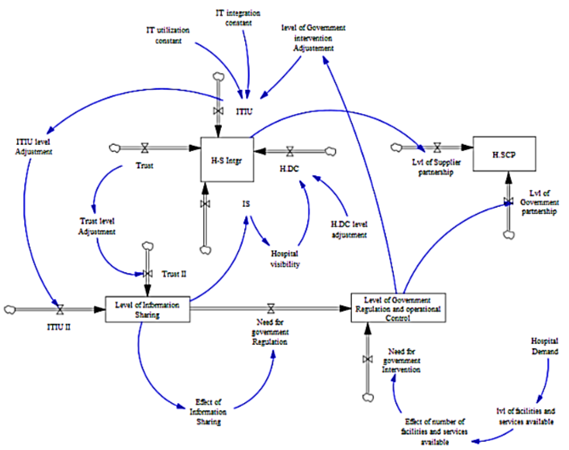

Figure 3. Stock Flow Diagram of factors affecting hospital supply chain partnerships and performance

In this study, the SFD will be designed based on the previously created CLD. The CLD can complement the SFD by illustrating feedback loops, identifying key variables, enhancing understanding of the modeled system dynamics, and enabling iterative modeling (Sterman et al., 2000). The SFD will utilize variables and the nature of interactions among variables as depicted in the CLD, with some additional auxiliary variables to complete the simulation model. Both the CLD and SFD will be modeled in the software Vensim PLE. Figure 3 presents the resulting SFD based on the CLD illustrated in Figure 2.

There are several additional variables in the SFD model serving as auxiliary variables. Those variables do not alter the logic structure derived from the CLD model. A summary of all the variables, their type, formula, and abbreviations in the SFD is presented in Table 2.

Table 2. Summary of all the variables in the SFD

Variable	Type of Variable	Formulas/Equations	Abbreviation
Hospital Supply Chain Performance	Stock	Lvl of Supplier Partnership + Lvl of Government Partnership	H.SCP
Level of Information Sharing	Stock	Trust II + ITIU II - Need for Government Regulation	-
Level of government regulation and operational control	Stock	Need for Government Regulation + Need for Government Intervention	-
Hospital-Supplier Integration	Stock	Trust + ITIU + H.DC + IS	H-S Intgr
Trust	Flow (Constant)	Min = 0 Max = 0.25	-
Information technology integration and utilization	Flow	IT utilization constant + IT integration constant + Level of Government intervention adjustment	ITIU
Hospital Dynamic Capabilities	Flow	Hospital Visibility + H.DC level adjustment	H.DC
Information Sharing	Flow	(Level of Information Sharing)/4	IS
IT Integration and Utilization II	Flow	ITIU Level Adjustment	ITIU II
Trust II	Flow	Trust Level Adjustment	-
Need for Government Regulation	Flow	Effect of Information Sharing	-
Need for Government Intervention	Flow	Effect of number of facilities and services available	-
Lvl of Supplier Partnership	Flow	(Hospital Supply Chain Performance)/2	-
Lvl of Government Partnership	Flow	(Level of government regulation and operational control)/2	-
Trust Level Adjustment	Auxiliary	Trust * 2	-
ITIU Level Adjustment	Auxiliary	ITIU * 2	-
IT utilization constant	Auxiliary (Constant)	Min = 0 Max = 0.33	-
IT integration constant	Auxiliary (Constant)	Min = 0 Max = 0.33	-
Hospital Visibility	Auxiliary	IS / 2	-
Hospital dynamic capabilities level adjustment	Auxiliary (Constant)	Min = 0 Max = 0.125	H.DC Level Adjustment
Effect of Information Sharing	Auxiliary (With Lookup)	Level of Information Sharing	-
Level of Government Intervention Adjustment	Auxiliary	(Level of government regulation and operational control) / 3	-
Hospital Demand	Auxiliary (Constant)	Min = 0 Max = 5	-
Lvl of Facilities and services available	Auxiliary (With Lookup)	Hospital Demand	-
Effect of number of facilities and services available	Auxiliary (With Lookup)	Lvl of Facilities and services available	-

3.4. Scenario Formulation

In this stage, the conditions of model variables are altered to yield different outcomes from the initial model. From these varied outcomes, the impacts of the changes are analyzed regardless of whether the differences are significant or not. In System Dynamics, there are two types of scenarios: parameter scenarios and structure scenarios. In parameter scenarios, the values of model parameters are modified. In structure scenarios, the model's structure is altered by adding additional feedback loops, introducing new parameters, and modifying the structure of feedback loops to form recommendations for new structures that can enhance system performance (Sterman et al., 2000).

This study employs parameter scenarios, where only the values of model parameters are altered, and the impact on the model output is observed. The results of the scenarios will be compared to a base run of the model with a set of initial values for analysis. The initial value for the base model simulation is presented in Table 3. Table 4 presents a summary of the scenarios.

Table 3. Initial value for the variables in the SFD

Variable	Initial Value (Base Run)
Hospital Supply Chain Performance	0
Level of Information Sharing	0
Level of government regulation and operational control	0
Hospital-Supplier Integration	0
Trust	0.125
IT utilization constant	0.165
IT integration constant	0.165
Hospital dynamic capabilities level adjustment	0.0625
Effect of Information Sharing	([(0,0)-(1,0.5)],(0,0),(0.2,0.1),(0.4,0.2),(0.6,0.3),(0.8,0.4),(1,0.5))
Hospital Demand	2.5
Lvl of Facilities and services available	([(0,0.5)-(5,0)],(0,0.5),(1,0.4),(2,0.3),(3,0.2),(4,0.1),(5,0))
Effect of number of facilities and services available	([(0,0.5)-(0.5,0)],(0,0.5),(0.1,0.4),(0.2,0.3),(0.3,0.2),(0.4,0.1),(0.5,0))

Table 4. Summary of the parameter scenarios

No.	Scenario	Explanation	Purpose
1	Change in the value of the level of Trust	Increasing the value of Trust to 0.25 and decreasing it to 0.05.	Examining the influence of the partnership between suppliers and hospitals on hospital supply chain management
2	Change in the value of IT integration and utilization level	Increasing the IT utilization constant and IT integration constant to 0.33 and reducing them to 0.066	
3	Change in value of the level of hospital dynamic capabilities	Increasing the H.DC level adjustment value to 0.125 and reducing it to 0.025	
4	Change in the value of the level of hospital demand	Increasing the hospital demand rate to 5 and decreasing it to 1	Examining the influence of the partnership between the government and hospitals on hospital supply chain management.

4. Results

4.1. Causal Loop Diagram Results

In the CLD presented in Figure 2, it is defined that the performance of hospital supply chains is influenced by partnerships and integration between hospitals and suppliers, as well as the level of regulatory and operational control by the government and government healthcare expenditure (GHE). Integration between hospitals and suppliers in this study is defined as the level of partnership between hospitals and their suppliers, while the level of regulatory and operational control by the government and GHE is defined as the level of partnership between hospitals and government entities.

An increase in these three variables leads to an improvement in the performance of hospital supply chains. Several factors drive successful supply chain integration between hospitals and suppliers, including levels of trust, information sharing, utilization and integration of information technology, and hospital dynamic capabilities. An increase in all these variables enhances the level of integration and partnership between hospitals and suppliers. Trust levels also affect information sharing; an increase in trust leads to increased information sharing. Information sharing is also influenced by the utilization and integration of information technology; if hospitals and suppliers effectively utilize and integrate IT, information sharing improves. Information sharing, in turn, affects hospital dynamic capabilities positively by aiding in gathering relevant information. From the government's perspective, the level of regulation and operational control is influenced by the demand for healthcare services and information sharing between hospitals and their suppliers.

An increase in information sharing necessitates an increase in government regulations to ensure the disseminated information is not detrimental or illegal. Therefore, increased government regulation and operational control may decrease information sharing. Increased demand for healthcare services also leads to heightened government regulation and operational control. Increased regulation and operational control also enhance the level of integration and IT utilization. From the relationships mentioned, one reinforcing loop and one balancing loop are created. The reinforcing loop encompasses relationships between IT utilization and integration, information sharing, and government regulation and operational control, resulting in an overall improvement in this loop. The balancing loop involves information sharing and government regulation and operational control. Table 6 summarizes the results of the CLD.

4.2. Scenario 1: Change in the level of trust

The first scenario involves the alteration of the trust level between hospitals and their suppliers. In this phase, the outcomes of variables such as the performance level of the supply chain, and the degree of integration between hospitals will be analyzed. Tables 6 and 7 present the resulting values for both the level of integration (H-S Intgr) and level of supply chain performance (H.SCP) respectively compared to the base run results for each variable.

Table 5. Summary of the CLD

Variables	Associated Variables	Polarity	Source
Hospital Supply Chain Performance	Hospital-Supplier Integration	(+)	(Abdallah et al., 2017a; Alshahrani et al., 2018; Kitsiou et al., 2007; Mandal, 2017; Matopoulos & Michailidou, 2013; Setiawati et al., 2023; Setyawan Firmansyah & Siagian, 2022).
	Level of government regulation and operational control	(+)	(Pan et al., 2013, Dobrzykowski et al., 2019)
	Government Healthcare Expenditure	(+)	(Pan et al., 2013, Dobrzykowski et al., 2019)
Hospital-PemasokIntegration	Level of Trust	(+)	(Sodhi & Son, 2009, Alshahrani et al., 2018)
	Level of Information Sharing	(+)	(Sodhi & Son, 2009, Alshahrani et al., 2018, Setyawan Firmansyah & Siagian, 2022)
	Level of IT Integration and Utilization	(+)	(Alshahrani et al., 2018, Sodhi & Son, 2009)
	Level of Hospital Dynamics Capabilities	(+)	(Mandal, 2017)
Level of Information Sharing	Level of government regulation and operational control	(-)	(Pan et al., 2013, Dobrzykowski et al., 2019)
	Level of Trust	(+)	(Sodhi & Son, 2009, Alshahrani et al., 2018)
	Level of IT Integration and Utilization	(+)	(Sodhi & Son, 2009, Alshahrani et al., 2018)
Level of Hospital Dynamics Capabilities	Level of Information Sharing	(+)	(Mandal, 2017)
Level of IT Integration and Utilization	Level of government regulation and operational control	(+)	(Pan et al., 2013, Dobrzykowski et al., 2019)
Government Healthcare Expenditure	Level of government regulation and operational control	(+)	(Pan et al., 2013, Dobrzykowski et al., 2019)
Level of government regulation and operational control	Level of Hospital Demand	(+)	(Pan et al., 2013, Dobrzykowski et al., 2019)
	Level of Information Sharing	(+)	(Pan et al., 2013, Dobrzykowski et al., 2019)

Table 6. Results of the variable H-S Intgr for scenario 1

Time (year)	Scenario_Trust_ 2 Decreasing Trust to 0.05 (H-S Intgr)	Scenario_Trust_ 1 Increasing Trust to 0.05 (H-S Intgr)	BASE RUN
0	0%	0%	0%
0.25	4.94%	9.94%	6.81%
0.5	10.64%	21.58%	14.74%
0.75	17.06%	34.79%	23.71%
1	24.19%	49.47%	33.67%
Mean	11%	23%	16%

Table 7. Results of the variable H.SCP for scenario 1

Time (year)	Scenario_Trust_ 2 Decreasing Trust to 0.05 (HSCP)	Scenario_Trust_ 1 Increasing Trust to 0.05 (HSCP)	BASE RUN
0	0%	0%	0%
0.25	0%	0%	0%
0.5	1.40%	2.02%	1.60%
0.75	4.40%	6.50%	5.20%
1	9.20%	14%	10.90%
Mean	3%	5%	4%

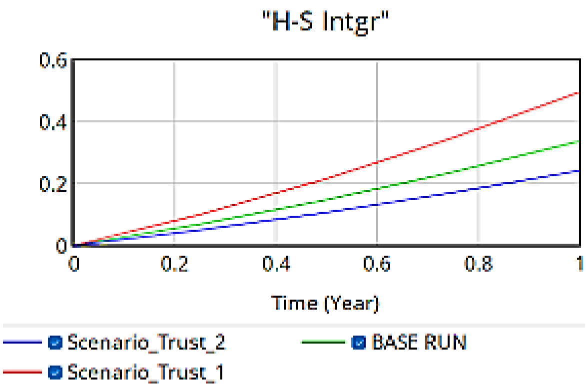

Figure 4. Graph of the variable H-S Intgr for scenario 1

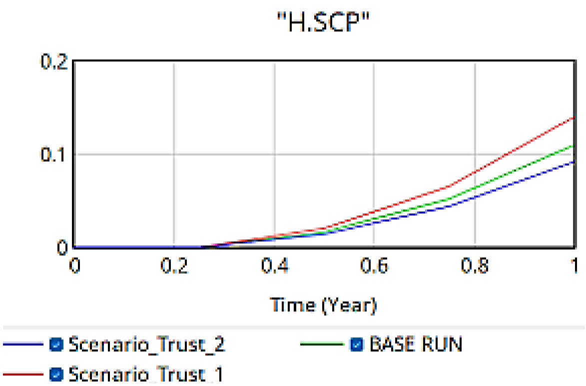

Figure 5. Graph of the variable H.SCP for scenario 1

Figures 4 and 5 show the graphical representation of the effects of increasing and decreasing the level of trust towards hospital-supplier integration and hospital supply chain performance.

4.3. Scenario 2: Change in the level of ITIU

The next scenario is a scenario of changing the values of Integration and IT Utilization levels. This is done by modifying the values of two auxiliary constant variables, the IT Integration constant and IT Utilization constant. In this scenario, three variables will be analyzed, namely the level of Information Sharing, H-S Intgr, and H.SCP. Tables 8 and 9 present the resulting values for both H-S Intgr and H.SCP respectively compared to the base run results for each variable.

Table 8. Results of the variable H-S Intgr for scenario 2

Time (year)	Scenario_ITIU_ 2 decreasing IT constants to 0.066 (H-S intgr)	Scenario_ITIU_ 1 increasing IT constants to 0.33 (H-S intgr)	BASE RUN
0	0%	0%	0%
0.25	5.58%	8.88%	6.81%
0.5	12.03%	19.25%	14.74%
0.75	19.32%	31.02%	23.71%
1	27.41%	44.09%	33.67%
Mean	13%	21%	16%

Table 9. Results of the variable H,SCP for scenario 2

Time (year)	Scenario_ITIU_ 2 decreasing IT constants to 0.066 (H.SCP)	Scenario_ITIU_ 1 increasing IT constants to 0.33 (H.SCP)	BASE RUN
0	0%	0%	0%
0.25	0%	0%	0%
0.5	1.48%	1.89%	1.63%
0.75	4.67%	6.09%	5.20%
1	9.79%	12.97%	10.99%
Mean	3%	4.19%	3.56%

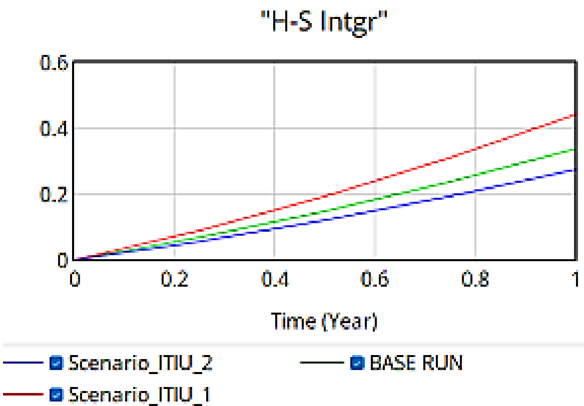

Figure 6. Graph of the variable H-S Intgr for scenario 2

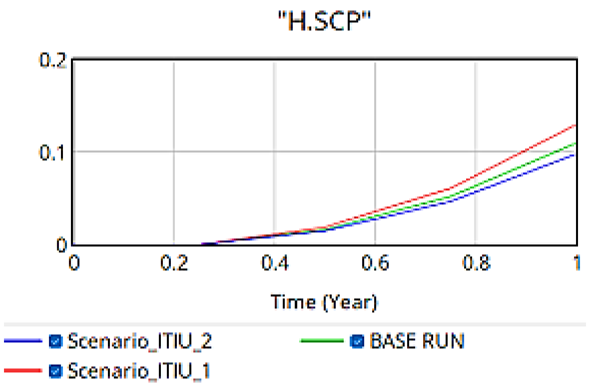

Figure 7. Graph of the variable H.SCP for scenario 2

Figures 6 and 7 show the graphical representation of the effects of increasing and decreasing the values of IT integration and utilization towards hospital-supplier integration and hospital supply chain performance.

4.4. Scenario 3: Change in The Level of Hospital Dynamic Capabilities

The next scenario involves a change in the value of the variable level of hospital dynamic capabilities. In this scenario, two variables will be analyzed, namely H-S Intgr and H.SCP. Table 10 and Table 11 present the resulting values for both H-S Intgr and H.SCP respectively compared to the base run results for each variable.

Table 10. Results of the variable H-S intgr for scenario 3

Time (year)	Scenario_HDC_ 2 Decreasing HDC to 0.025 (H-S Intgr)	Scenario_HDC_ 1 Increasing HDC to 0.125 (H-S Intgr)	BASE RUN
0	0%	0%	0%
0.25	5.58%	8.38%	6.81%
0.5	12.86%	17.86%	14.74%
0.75	20.90%	28.40%	23.71%
1	29.92%	39.92%	33.67%
Mean	14%	19%	16%

Table 11. Results of the variable H,SCP for scenario 3

Time (year)	Scenario_HDC_ 2 Decreasing HDC to 0.025 (H.SCP)	Scenario_HDC_ 1 Increasing HDC to 0.125 (H.SCP)	BASE RUN
0	0%	0%	0%
0.25	0%	0%	0%
0.5	1.52%	1.83%	1.63%
0.75	4.85%	5.79%	5.20%
1	10.28%	12.16%	10.99%
Mean	3.33%	3.95%	3.56%

Figures 8 and 9 show the graphical representation of the effects of increasing and decreasing the values for hospital dynamic capabilities towards hospital-supplier integration and hospital supply chain performance.

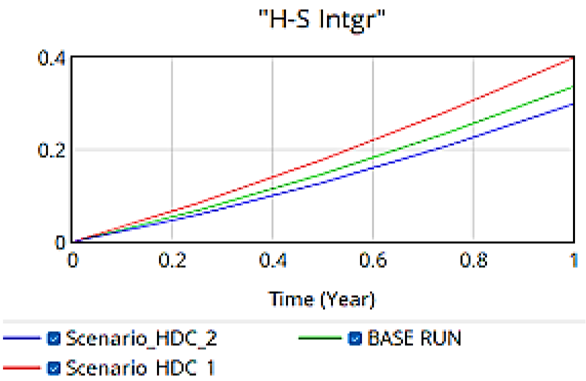

Figure 8. Graph of the variable H-S intgr for scenario 3

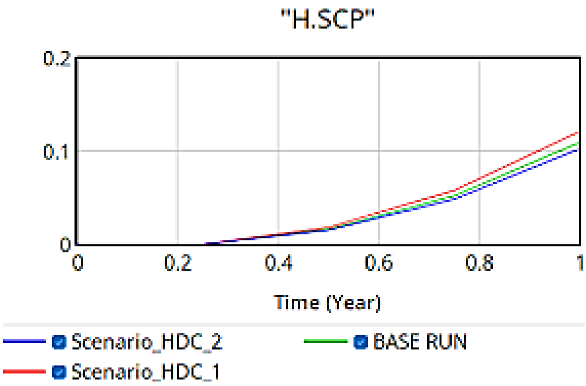

Figure 9. Graph of the variable H.SCP for scenario 3

4.5. Scenario 4: Change in The Level of Hospital Demand

Table 12. Results of the variable level of government regulation and operational control for Scenario 4

Time (year)	Scenario_HD_ 2 Decreasing Hospital demand to 1 (Level of Government regulation and operational control)	Scenario_HD_1 Increasing Hospital demand to 5 (Level of Government regulation and operational control)	BASE RUN
0	0%	0%	0%
0.25	2.50%	12.50%	6.25%
0.5	6.31%	26.31%	13.81%
0.75	11.29%	41.34%	22.56%
1	17.30%	57.50%	332.37%
Mean	7%	28%	15%

Table 13. Results of the variable H.SCP for scenario 4

Time (year)	Scenario_HD_2 Decreasing Hospital demand to 1 (H.SCP)	Scenario_HD_1 Increasing Hospital demand to 5 (H.SCP)	BASE RUN
0	0%	0%	0%
0.25	0%	0%	0%
0.5	1.16%	2.41%	1.63%
0.75	3.79%	7.56%	5.20%
1	8.13%	15.74%	10.99%
Mean	2.62%	5.14%	3.56%

The final scenario to be executed involves a change in the level of demand for hospitals. In this scenario, two variables will be analyzed: the Level of Government Regulation and Operational Control, and H.SCP. Tables 12 and 13 present the resulting values for both levels of government regulation and operational control and H.SCP respectively compared to the base run results for each variable.

Figures 10 and 11 show the graphical representation of the effects of increasing and decreasing the values for hospital demand towards the level of government regulation and operational control and hospital supply chain performance.

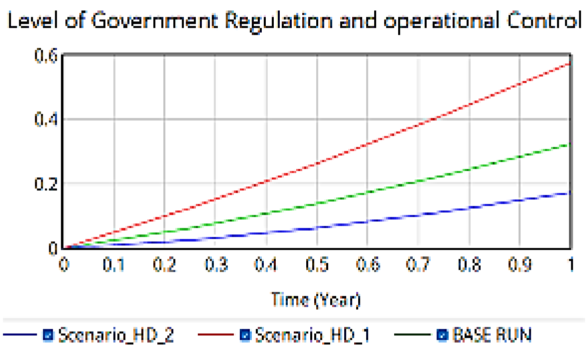

Figure 10. Graph of the variable level of government regulation and operational control for scenario 4

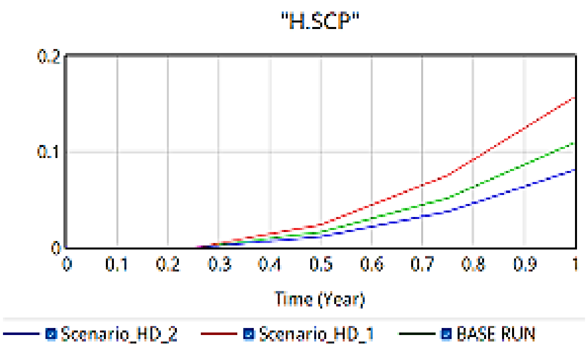

Figure 11. Graph of the variable H.SCP for scenario 4

4.6. Effect of Scenario 1 and 2 on The Level of Information Sharing

Both an increase in the level of trust and the level of ITIU will impact the level of information sharing which is also an important factor in the integration of both suppliers and hospitals. Tables 16 and 17 show the results for the level of information sharing for each scenario compared to the base run results.

Table 16. Results of the variable level of information sharing for Scenario 1

Time (Year)	Scenario_Trust_2 Decreasing Trust to 0.05 (Level of Information Sharing)	Scenario_Trust_1 Increasing Trust to 0.25 (Level of Information Sharing)	BASE RUN
0	0%	0%	0%
0.25	6.75%	16.75%	10.50%
0.5	12.92%	31.67%	19.95%
0.75	18.61%	45.07%	28.53%
1	23.92%	57.22%	36.40%
Mean	12%	30%	19%

Table 17. Results of the variable level of information sharing for Scenario 2

Time (Year)	Scenario_ITIU_2 decreasing IT constants to 0.066 (Level of Information Sharing)	Scenario_ITIU_1 increasing IT constants to 0.33 \(Level of Information Sharing)	BASE RUN
0	0%	0%	0%
0.25	8.03%	14.63%	10.50%
0.5	15.31%	27.68%	19.95%
0.75	21.98%	39.44%	28.53%
1	28.16%	50.14%	36.40%
Mean	15%	26%	19%

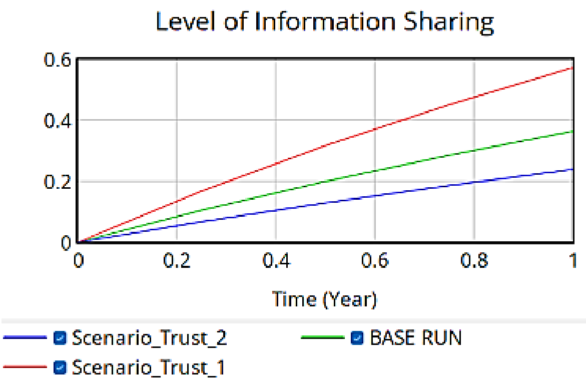

Figure 12. Graph of the variable level of information sharing for scenario 1

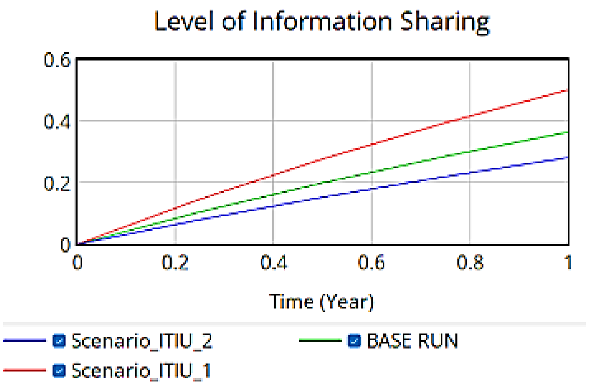

Figure 13. Graph of the variable level of information sharing for scenario 2

Figures 12 and 13 show the graphical representation of the effects of increasing and decreasing the values for trust and ITIU towards the level of information sharing.

5. Discussion

5.1. Analysis of Scenario Testing

After adjusting the values of each parameter according to the outlined scenario designs, the outcomes of the changes for each variable will be compared with the results obtained from running the base model. Overall, trust levels and the integration and utilization of IT will influence the integration between hospitals and their suppliers, ultimately impacting the performance of the Hospital Supply Chain (HSCP). Both High levels of trust will result in higher integration between hospitals and suppliers, as well as higher HSCP performance, while low levels of trust and IT integration will lead to lower levels of information sharing and integration, consequently resulting in lower HSCP performance due to a lower level of integration among suppliers and hospitals.

Hospital dynamic capabilities will affect the integration between hospitals and their suppliers, thus influencing HSCP performance. Higher levels of hospital dynamic capabilities will lead to increased integration between hospitals and suppliers, resulting in higher HSC performance, whereas lower levels of hospital dynamic capabilities will result in lower integration, ultimately leading to lower HSCP performance.

Hospital demand levels will influence the level of government regulations and operational control, subsequently affecting HSC performance. Higher hospital demand levels will lead to greater influence on government regulations and operational control, resulting in higher HSCP performance, while lower hospital demand levels will result in lower government regulations and operational control, subsequently leading to lower HSCP performance.

For the Level of Information Sharing variable, scenarios with high trust levels obtained the highest average value at 30% compared to 26% obtained by scenarios with the highest IT integration and utilization. Meanwhile, scenarios with low trust levels obtained the lowest average value at 12%. This implies that changes in trust levels have a greater influence on the Level of Information Sharing variable, although the differences in each average value are not significantly large.

For the H-S Integration variable, scenarios with high trust levels obtained the highest average value at 23%. In comparison, scenarios with high levels of hospital dynamic capabilities obtained the lowest average value among all other scenarios at 19%. Meanwhile, for scenarios with the lowest variable values, the trust level scenario obtained the lowest average value at 11%. This indicates that trust levels have the greatest influence on the integration between hospitals and their suppliers.

The hospital demand scenario obtained the highest average H.SCP value at 5.14% among all scenarios with the highest variable values. Meanwhile, the hospital dynamic capabilities scenario obtained the lowest value at 3.95%. For scenarios with the lowest variable values, the hospital demand scenario also obtained the lowest average HSCP value at 2.62%, meanwhile, the hospital dynamic capabilities scenario obtained a value not significantly different from the Base model at 3.33%. This suggests that changes in hospital demand significantly affect the performance of the hospital supply chain through changes in government regulations and interventions.

The findings, particularly concerning the impact of hospital demands, resonate strongly with recent real-world events, such as the unprecedented surge in patient numbers during the COVID-19 pandemic. This surge resulted in an overwhelming demand for hospital services and facilities, causing a strain on the supply chain and leading to shortages in medical resources, prompting swift government interventions worldwide.

Governments increased healthcare expenditures, implemented new regulations, provided direct aid such as purchasing protective gear for medical staff, and so on to manage the rising patient numbers, streamline processes, allocate resources efficiently, and ensure equitable access to healthcare services.

Overall, the simulation outlines positive impacts on a hospital's supply chain performance due to partnerships between all three entities in the HSC. The results of this paper are in accordance with the research done by Setiawati et al., 2023 which emphasized the critical role of partnership in a hospital supply chain and highlights the interdependence between hospitals, suppliers, and government entities within the supply chain.

5.2. Managerial Implications

Based on the study's results, it can be inferred that hospital administrators should prioritize fostering collaborative partnerships with key suppliers and government agencies. Investing in those relationships can enhance the performance of hospital supply chains, allowing hospitals to ensure a better and more timely delivery of medical resources to patients.

Regarding government partnerships, hospitals should invest resources in maintaining positive relationships with government bodies. Moreover, given the nuanced interplay between patient demand and governmental partnerships, hospitals should also focus on anticipating and managing patient demand effectively, as it significantly influences supply chain performance. Given the dynamic nature of the healthcare industry and supply chain operations, hospitals should prioritize continuous improvement and adaptation.

5.3. Limitations and Future Research

This study has several shortcomings. First, it predominantly concentrates on partnerships between suppliers, governments, and hospitals, neglecting the involvement of other entities within the healthcare industry's intricate supply chain, such as insurance companies and banks. Moreover, its focus solely on the hospital supply chain within a single setting fails to consider potential collaborations across diverse countries or healthcare systems.

Secondly, concerning government regulations, the analysis is restricted to regulations pertaining solely to information sharing, overlooking other crucial regulatory aspects such as quality and safety standards for medical products, and public health regulations, among others. Furthermore, the study lacks a comprehensive examination of factors critical to fostering effective partnerships with suppliers such as term negotiations, pricing strategies, and inventory management. Finally, there is a need for further exploration of the methodologies employed in the study, specifically system thinking and system dynamics.

Future research should use diverse analytical approaches to deepen understanding in this domain. It should explore partnerships involving a wider range of entities in the healthcare supply chain, such as insurance companies, banks, pharmaceutical manufacturers, and medical equipment suppliers. Additionally, studies should investigate collaborations across different countries or healthcare systems and analyze the impact of government regulations and other factors influencing effective partnerships not covered in this study.

6. Conclusions

This research aims to simulate and visualize the factors and intricacies within partnerships in a hospital supply chain by incorporating Causal Loop Diagrams (CLD) and Stock-Flow Diagrams (SFD). In conclusion, the simulation demonstrates the positive effects of partnerships among hospitals, suppliers, and governments on HSCP performance. The analysis demonstrates that trust levels, IT utilization, hospital dynamic capabilities, and hospital demand significantly influence the performance of the Hospital Supply Chain. High trust, IT integration, and hospital dynamic capabilities enhance HSC performance through better information sharing and hospital-supplier integration. Additionally, hospital demand levels significantly influence government regulations and operational control, further impacting HSC performance. The result of this study complements the research done by Setiawati et al. which attempts to simulate and provide a more quantifiable model based on the resulting CLD model of the previous research.

Theoretically, this study enhances understanding of how dynamic interactions and feedback loops among multiple stakeholders in the healthcare supply chain can be effectively modeled and managed to improve performance.

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