Beyond Revenue: Comprehensive Risk Management in Global Warehouse Networks

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ABSTRACT

In the volatile landscape of global pharmaceuticals, supply chain disruptions—ranging from natural disasters to pandemics—pose significant risks to operational continuity and healthcare delivery. This capstone project investigates the efficacy of a pharmaceutical company's current Business Continuity Management (BCM) and provides a framework to assess risk concentration within their warehouses. The study's focus centers on developing and applying a comprehensive risk management framework that quantitatively and qualitatively evaluates risk across the company's global warehouse network. By integrating non-clinical factors such as product values, quantities, transactions, customer revenue, and inventory levels alongside clinical trial scores, the framework assesses risks using a MinMaxScaler normalization process. The results underscore the necessity for dynamic BCM strategies that adapt to evolving global challenges and integrate clinical data to provide a holistic view of potential risks. Furthermore, the analysis reveals that while some warehouses show high resilience, others exhibit vulnerabilities, emphasizing the need for a dynamic, responsive BCM strategy. The findings not only provide insights into effective risk management but also contribute to the broader discourse on global health security and supply chain stability in the pharmaceutical sector.

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1. Introduction

Business Continuity Management (BCM) is a strategy deployed by organizations to guarantee the ongoing performance of essential operations and functions during disruptions. It involves predicting events that might affect the crucial functions and processes of an organization and ensuring that the organization responds to any such disruption in a structured manner (Pheng & Supriadi, 2018). Having a BCM in place is critical for several reasons, namely:

Resilience: BCM equips organizations with the ability to respond to emergencies quickly and efficiently. This not only saves time and money but also is crucial in protecting the company's reputation. The organization may potentially incur significant financial and reputational losses during prolonged disruptions if a BCM is not put in place.

Readiness: Standard operational plans implemented by organizations often fail to include potential disruptions from events like natural disasters, economic downturns or other unexpected incidents. A BCM ensures that these potential threats are included in the organizational strategy.

Minimizing Risks: A BCM provides a framework for the company to continue its operations, including delivering goods or services and maintaining revenue, by detailing responses during and after a crisis, which can greatly reduce potential losses during exigencies.

Business Stability: BCM is an integral part of a company’s strategy for managing changes that could halt business operations, whether they are internal or external. It focuses on the inevitability of such disruptions and the preparedness of the business to handle them.

1.1 Motivation

A lack of a robust BCM can thus lead to significant losses for the organization. One of the most notable examples of failure due to a lack of Business Continuity Management in the tech industry involves Ericsson and the fire at a Philips microchip plant in Albuquerque, NM, in 2000. Ericsson and Nokia were major clients of Philips at the time. Both organizations were impacted, but their responses were vastly different. Nokia acted swiftly, establishing relationships to secure alternative supplies and re-engineering their phones to use chips from other sources. Ericsson, on the other hand, waited, believing the fire would not cause a prolonged outage. This decision, combined with Ericsson's strategy of single-sourcing key components, ultimately led to a severe shortage of supply. As a result, Nokia’s handset market share grew from 27% to 30%, while Ericsson’s dropped from 12% to 9% (Stolker, et al, 2008).

Similarly, in the pharmaceutical sector, BCM plays a vital role in maintaining a consistent supply of essential medications, particularly during difficult situations such as natural calamities or pandemics. BCM in the pharmaceutical industry involves a series of interrelated activities and strategies. These include establishing product priorities based on therapeutic importance, regulatory requirements, and business significance. The assessment of these priorities must be a cross-functional activity involving various departments within the organization.

The primary objective of Business Continuity Management in this sector is to strike a balance between meeting patients' essential needs and the business investments necessary to prevent drug shortages. Achieving this equilibrium is vital for the enduring sustainability and competitive edge of pharmaceutical companies. When faced with uncertainty and overreliance on drug imports, the lack of a resilient supply chain can result in increased lead times, frequent stockouts, overstocking, and possible waste of drugs (Tirivangani et al., 2021). When demand exceeds supply, this will result in drug shortages with severe consequences, such as continued illness or the death of those in need. A robust BCM plan should include both traditional mitigation options, like redundancy of operations or stockpiling inventory, and an agility strategy for quick operational reactions. This blend of redundancy and agility typically offers the best resilience for continued supply. However, redundancy options like securing backup facilities or stockpiling inventory can be costly and complex to manage (Hustead, n.d.).

Despite its effectiveness, the implementation of BCM can be challenging due to its complex nature and the substantial investment in resources that is required. Disruptions in the pharmaceutical space have had serious consequences, impacting both operations and supply chains. For example, the COVID-19 pandemic has necessitated changes in the way pharmaceutical companies operate. Companies that were already accustomed to agile ways of working adapted faster to these changes, while others faced challenges in adjusting their operations. The pandemic highlighted several challenges in the supply chain, including reluctance to receive raw materials from impacted locations, sourcing issues, site closures, transportation disruptions, the introduction of counterfeit materials, and issues with coordination and traceability. These challenges underscored the need for pharmaceutical manufacturers to adopt multi-sourcing strategies, evaluate alternative distribution channels, manage safety stock effectively, and improve supplier development and information sharing (McKinsey & Company, 2021).

Our sponsor for this project is a multinational biopharmaceutical company that is involved in the development and commercialization of vital drugs and biologics for a wide range of medical conditions, including cancer, HIV/AIDS, cardiovascular disease, diabetes, hepatitis, rheumatoid arthritis, and psychiatric disorders. This company operates globally, with approximately 70% of its $46.1 billion in revenue coming from the US market, about 27% from the European market, and the remaining distributed in other regions. Potential threats multiply as supply chains burgeon in complexity, encompassing diverse functions across varied global locales. Operating in the pharmaceutical realm, the sponsor is exposed to many threats, including natural disasters, fires, cyber breaches, and supply interruptions. Through this capstone project, the sponsor seeks a method to identify and assess risk concentration in their global warehouse network.

1.2 Problem Statement

Our sponsor heavily depends on its Global Delivery Service (GDS) to bolster production. The primary focus of GDS is on two core areas: transportation and logistics, and warehousing. The ecosystem of these functions encompasses various partners, including third-party warehouses and carriers. The sponsor leans on third-party warehouses to provide storage and transshipment operations. However, these external facilities present a challenge: The sponsor neither controls nor influences how these third-party entities create and execute their BCM plans, as they might also cater to other clients. In regard to transportation and logistics, while brokers coordinate with carriers for overseas storage facilities, domestically, the sponsor's warehouse liaises directly with carriers to ensure the delivery of products to the final consumers. Each facet of the GDS is crucial to the sponsor's seamless operations.

Like its many counterparts in the pharmaceutical domain, the sponsor has devised a BCM plan to guide its actions during emergencies. The prevailing plan pinpoints potential risks, factoring in the revenue impact from each partner. Within this intricate network, some partners contribute substantially to the revenue and possess a robust business continuity management strategy. In contrast, others targeting emerging markets might not be as well-prepared. However, by evaluating partners based on revenue, the sponsor's current business continuity management framework may not prioritize smaller and more risk-susceptible partners. Additionally, this model remains rigid and lacks the agility to adapt and counter evolving challenges effectively.

In summary, the sponsor grapples with three pivotal issues:

1. A limited overview and influence on third-party warehouse operations,

2. An incomplete framework for assessing partner risks, and

3. A static business continuity management strategy that fails to adapt proactively.

1.3 Project Scope, Objectives, and Deliverables

The purpose of this project is to expand the sponsor's current risk management framework from a revenue-focused framework to a comprehensive framework that takes into consideration financial factors (revenue, volume, and transaction count); customer profiles (average customer revenue and customer count); and current Business Continuity Management practices (completion of annual risk assessment and business impact analysis, recovery time [RTO] and Business Continuity Plan /Crisis Management Plan testing). The scope of this project covers all warehouses within the sponsor's downstream "in-market" network. The "in-market" network is the last-mile delivery from the sponsor's warehouse to its patients. With the new risk management framework, we expect to deliver the following to the sponsor:

1. A risk concentration profile for each warehouse within the sponsor's global warehouse network that demonstrates risks from three main categories, as mentioned above.
    a. A Python-powered data analysis package will be shared with the sponsor for future modeling, testing, and expansion.
2. A user interface that allows the sponsor to test a variety of scenarios among the risk factors to understand its risk concentration from different perspectives.
    a. A Python (via xlwings or PyXLL) integrated Excel spreadsheet will be shared with the sponsor to simulate different scenarios. This tool will allow Python scripts to be run from Excel, enabling users to input values in the spreadsheet and get results computed by Python.

2. State of the Practice

Risk evaluation, a crucial aspect of Business Continuity Management (BCM), entails scrutinizing potential risks to products, business systems, and operational procedures. These assessments must account for factors like the dependability of manufacturing processes, the level of quality control, and the financial stability of partners. Aligning these assessments with broader governance, risk management, and compliance (GRC) or enterprise risk management (ERM) initiatives can enhance the thoroughness of the risk assessment process (Hustead, n.d.).

To complete a BCM, organizations first must identify threats that can potentially cause disruptions in their operations. To understand how susceptible an organization is to disruptions, it is imperative to conduct a Business Impact Analysis (BIA) and then a Risk Assessment (RA). A BIA's primary objective is to discern and prioritize critical functions, comprehend the repercussions of disruptions, and determine the resources needed to resume activities based on their criticality. A Risk Assessment (RA) framework, on the other hand, serves to comprehend the threats facing the organization, assess the likelihood and severity of potential events, and develop response plans.

An effective RA framework not only aids in creating contingency plans but also prevents resource loss in the event of a risk occurrence (Torabi et al., 2016). Conducting a risk assessment helps in identifying, analyzing, and mitigating risks associated with the supply chain.

Thus, recording and measuring the impact of threats is essential to analyzing risks in the supply chain. A commonly deployed risk assessment methodology is the Failure Modes and Effect analysis. The technique aids in identifying the potential failure nodes and the impact of the failure by assessing its likelihood, severity, and detectability. A high FMEA score denotes high risk. An FMEA is conducted by assigning a Risk Priority Number (RPN) to each failure node. The RPN is derived by the following formula:

Likelihood of failure x severity of failure x detectability of the failure

The process of conducting an FMEA consists of several stages (Curkovic et al., 2013, 252):

1. Identifying various categories of risks
2. Pinpointing potential risks
3. Assessing the likelihood, probability, and severity of each identified risk
4. Calculating the RPN for every risk
5. Prioritizing risks based on their RPN
6. Developing targeted strategies to address risks with high RPN values
7. Periodically revisiting and reassessing these risks through successive cycles of FMEA.

To develop a risk assessment tool for the sponsor, we have used the principle of FMEA. Using FMEA as a foundation, we categorized data collected from each warehouse into various groups, assigned a weight to each group based on business priorities, and calculated a score to rank the risk concentration. This process is further detailed below:

The Supply Chain Risk Management Process (SCRMP) is a framework that is used to identify potential risks, assess their impact, and mitigate the effects of a supply chain disruption. The SCRMP is executed through the following steps (Tummala & Schoenherr, 2011, 474-483):

1. **Identification of Risks**: This initial step of the SCRMP framework involves pinpointing the source of risks. To understand the potential threats, brainstorming sessions, interviews with key personnel and stakeholders, and reviews of historical data are conducted.
2. **Risk Assessment**: Once risks are identified, a risk assessment methodology like the FMEA discussed above is applied to rank the criticality of a potential threat.
3. **Risk Mitigation**: Based on the results of the risk assessment, modifications to the existing supply chain design or mitigation measures to control the impact of a threat are taken.
4. **Review and Monitoring**: The SCRMP is an ongoing process. Since the likelihood of threats changes with time and with business initiatives, regular reviews and updates must be made to keep the Business Continuity Plan updated.

In our discussions with the sponsor, we suggested applying a framework similar to the SCRMP to bolster the existing BCM. The scope of this project ends with Risk Identification and Risk Assessment. The methodology that we have developed is to be used in a broader framework like the SCRMP.

3. Methodology

The comprehensive literature review facilitates an in-depth understanding of Business Continuity Management (BCM) and its prevalent practices. This section outlines the methodologies and procedures employed in this project to better understand the risk concentration within the sponsor’s global warehouse network. Our approach is designed to ensure rigorous analysis, accuracy, and reproducibility of results while also addressing the specific challenges and requirements the sponsor poses.

3.1 Scope Definition

This initial phase involved a thorough examination of the sponsor's existing supply chain product flow. Complementary to this, interviews with company representatives were conducted to uncover latent vulnerabilities within the supply chain. Concurrently, a warehouse inspection was scheduled to substantiate and refine our approach. These dialogues aimed to crystallize the critical determinants for subsequent data analysis. A data collection template was developed to culminate this phase.

3.2 Data Collection and Standardization

Upon completing the data template, the data acquisition phase was initiated. The sponsor collaborated with their third-party logistics (3PL) partners to gather relevant data. The collected data included product details (such as name, stock-keeping unit [SKU], quantity, and financial values), customer information (name, address, destination city, and country), and transaction dates. Furthermore, the latest version of the supplier assessment report for all 3PL partners was obtained. These reports are vital, as they detail each site's current Business Continuity Management (BCM) practices, encompassing the Recovery Time Objective (RTO), annual risk assessments, business impact analyses, and the annual testing of business continuity and crisis management plans.

Following the receipt of data, we implemented data cleaning processes to standardize the dataset for in-depth analysis. During these processes, data from all 3PLs was consolidated into a single file. Numeric values were normalized using a standard procedure to fit within a zero-to-one scale, ensuring that the final risk concentration calculations also fell within this range. The supplier assessment report contains four key questions that were integral to calculating the current BCM practice risk factor. These questions answered with a simple “yes” or “no” were weighted equally in the risk factor score calculation. The questions assess whether 1) BCM Risk Assessments are conducted annually at the <3PL/Supplier> site and communicated to the sponsor with outcomes; 2) a Business Impact Assessment (BIA) is carried out, addressing specific process areas and customer impacts; 3) recovery times for critical processes (RTO) and IT support systems (RPO) are clearly defined; and 4) the critical supplier conducts annual testing of their plans (Business Continuity Plan/Crisis Management Plan), with results communicated to the sponsor.

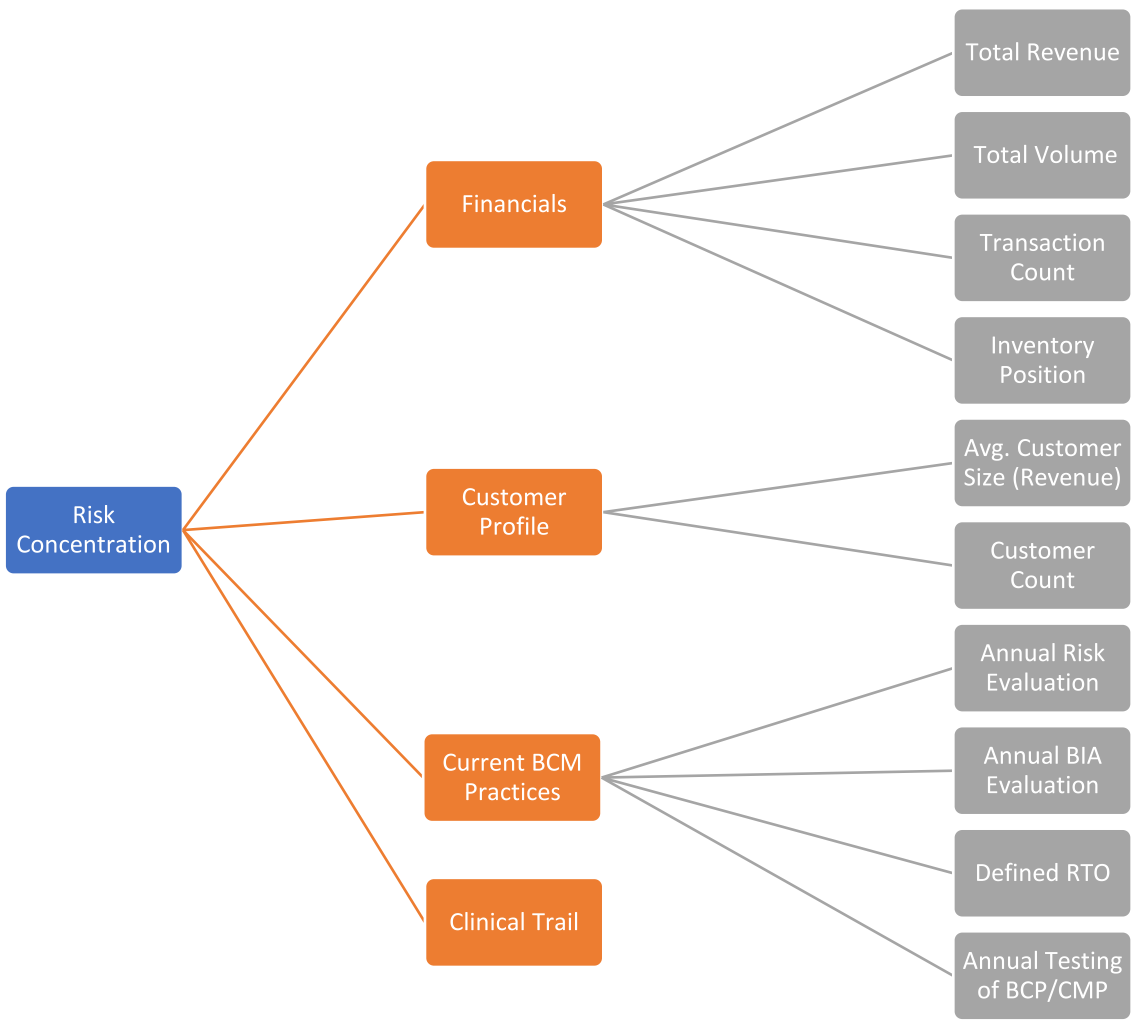
These essential data cover the movement of products in and out of warehouses, as well as inventory levels, organized by product and date, from January 2021 to August 2023.

3.3 Data Analysis: Risk Concentration Score Calculation

In our study, we developed a comprehensive framework to evaluate risk concentration quantitatively and qualitatively within the global warehouse system. The assessment framework calculates the risk concentration score from four main sectors (financials, customer profile, current BCM practice, and clinical trial), including nine risk factors in total, as shown in Figure 1.

Figure 1

Risk Concentration Framework and Risk Factors



This score is derived by aggregating various risk factors, each weighted according to its relative importance in determining the overall risk, along with a letter grade system to indicate the clinical impact. The formula is as shown by Equation 1:

$$\textbf{Risk Concentration Score} = \sum_i \boldsymbol{W} \sum_j \boldsymbol{F} \quad \textbf{(1)}$$

Where:

W_i = weight assigned to each risk factor

F_j = normalized risk factor scores for each risk factor within the warehouse portfolio

$F_j \in [0,1]$

$\sum_i W=1$

As shown in Figure 1, total revenue refers to the aggregate transactional revenue generated at each site. Total volume encompasses the cumulative quantity of products processed across each site. The transaction count denotes the total number of transactions conducted at each location. The inventory position represents the average monthly inventory value (in US dollars) held at each site. Average customer size (revenue) calculates the mean customer portfolio size served by each warehouse based on the transactional revenue of the customers. Customer count signifies the total number of customers each warehouse services. Annual risk assessment, annual Business Impact Analysis (BIA) evaluation, defined Recovery Time Objectives (RTO), and the annual testing of Business Continuity Plans (BCP)/Crisis Management Plans (CMP) are binary variables used to indicate the presence of current Business Continuity Management (BCM) practices at each warehouse. The resulting Risk Concentration score, calculated for each entity in our dataset, serves as a comprehensive measure of risk exposure, balancing both operational and financial aspects.

4. Results

The results section evaluates risk concentration in 10 countries based on non-clinical factors such as product values, quantities, transactions, customer revenue, and inventory levels, among others, presented in Tables 1 and 2. By applying the MinMaxScaler normalization, the study compares these factors uniformly. Scenario analysis, shown in Table 3, explores varying BCM score weights, revealing warehouse #10 (WH10) as a consistent high-risk entity, underscoring its substantial market activity. The inclusion of clinical scores alters the risk landscape, emphasizing the impact of health-related factors on risk perceptions.

4.1 Risk Concentration Analysis Without Clinical Data

In this study, we first evaluated the risk concentration across 10 countries by focusing on non-clinical factors: sum of product values, product quantities, transaction counts, average customer revenue, customer counts, average monthly inventory, BCM scores, and clinical trial scores (results are shown in Table 1 and Table 2). Each of these factors was normalized using the MinMaxScaler to facilitate comparison on a uniform scale.

Table 1

Risk Factor Results by Country

Warehouse	Product_Value	Sum_Product_Qty	Transaction_Count	Avg_Customer_Revenue
WH1	$ 104,379,775	95,305	7,119	$ 1,769,149
WH2	$ 1,542,614,874	321,506	3,060	$ 7,674,701
WH3	$ 195,213,019	966,099	1,504	$ 351,103
WH4	$ 3,342,764	41,684	2,953	$ 40,765
WH5	$ 93,679,307	533,398	12,152	$ 1,486,973
WH6	$ 583,983,160	2,362,777	36,035	$ 7,584,197
WH7	$ 97,109,550	106,764	4,885	$ 2,157,990
WH8	$ 11,173,213	8,611	1,617	$ 11,173,213
WH9	$ 75,151,903	119,663	370	$ 5,575,792
WH10	$ 36,199,236,594	35,689,710	89,404	$ 123,546,883

Table 2

Risk Factor Results by Country

Warehouse	Customer_Count	Avg_Monthly_Inventory	Avg_BCM_Score	Clinical_Score
WH1	59	$ 13,864,136	1	0
WH2	201	$ 2,333,655,932	1	0
WH3	556	$ 149,717,675	0.5	1
WH4	82	$ 33,373,387	1	0

WH5	63	$ 27,883,791	1	0
WH6	77	$ 479,492,533	1	0
WH7	45	$ 81,960,044	1	0
WH8	1	$ 6,232,604	1	0
WH9	9	$ 8,100,120	1	0
WH10	293	$ 4,316,632,540	1	1

Three scenarios were modeled to observe the impact of varying the weightage of BCM scores, reflecting its perceived importance in risk assessment. The scenarios are shown in Table 3 and the results are shown in Table 4.

Table 3

Risk Concentration Calculation Scenarios without Clinical Data

Risk Category	Risk Factor	Scenario 1	Scenario 2	Scenario 3
Financial	Total Revenue	10.00%	7.50%	5.00%
	Total Volume	10.00%	7.50%	5.00%
	Transaction Count	10.00%	7.50%	5.00%
	Inventory Position	10.00%	7.50%	5.00%
Customer Profile	Avg. Customer Size	5.00%	5.00%	5.00%
	Customer Count	5.00%	5.00%	5.00%
Current BCM Practice	Annual Risk Assessment	12.50%	15.00%	17.50%
	Annual BIA Evaluation	12.50%	15.00%	17.50%
	Defined RTO	12.50%	15.00%	17.50%
	Annual Testing of BCP/CMP	12.50%	15.00%	17.50%

Scenario 1 assigned the lowest weight to BCM scores (0.5). Under this setting, WH10 emerged as the most prominent risk concentrator, with a normalized value of 1.000. WH2 and WH3 followed with scores of 0.644 and 0.169, respectively, indicating a significant drop-off in risk concentration compared to WH10. This highlights WH10’s dominant market activities and potentially higher risk exposure due to extensive transaction volumes and product value.

Scenario 2 adjusted the BCM score weight to 0.6, slightly increasing its dominance in the risk calculation. This adjustment slightly increased WH3's risk concentration to 0.945, indicating a sensitivity of the risk model to BCM score weightage.

Scenario 3, with a further increased BCM weight of 0.7, continued to present the WH10 at the highest risk concentration but brought WH3 closer in alignment, with a normalized score reaching 1.000. This indicates that as the weight of BCM increases, other factors like transaction count and product quantity begin to have a more pronounced impact, reflecting a diversified view of risk that may be more representative of actual operational hazards.

Table 4 shows that WH9 has a score of 0, which results from its size. In the MinMaxScaler normalization process, the smallest score is assigned a value of 0.

Table 4

Risk Concentration Calculation without Clinical Data

Warehouse	Scenario 1	Scenario 2	Scenario 3
WH1	0.023	0.023	0.017
WH2	0.169	0.173	0.122
WH3	0.644	0.946	1.000
WH4	0.016	0.018	0.015
WH5	0.038	0.039	0.027
WH6	0.139	0.137	0.091
WH7	0.018	0.019	0.013
WH8	0.005	0.006	0.005
WH9	-	-	-
WH10	1.000	1.000	0.681

4.2 Incorporating Clinical Data in Risk Concentration

The inclusion of clinical scores, which reflect the impact of products on health outcomes, altered the risk landscape, illustrating the profound effect of healthcare-related factors on market risk assessments. Clinical scores were weighted heavily in all scenarios (0.5), underscoring their critical importance.

With clinical data incorporated, WH3's risk profile notably increased, particularly in Scenarios 2 and 3, where it achieved the highest risk concentration. This change underscores the impact of healthcare outcomes on perceived market risks, suggesting that WH3's market is strongly influenced by clinical outcomes relative to other countries. WH10 showed a relative decrease in risk concentration when clinical data was included, suggesting that other countries might have risk profiles that are comparably elevated by the inclusion of healthcare impact data.

Scenario 1 under clinical data integration still positioned WH10 as a high-risk country but showed a more balanced distribution among other countries, indicating that clinical impacts are substantial but not overwhelmingly skewed towards any single country. Scenarios 2 and 3 further demonstrated how the integration of clinical data could shift perceived risk distributions significantly, with WH3 taking a lead in the risk profile under Scenario 3, indicating the highest BCM and clinical score influence.

Table 5

Risk Concentration Calculation Scenarios with Clinical Data

Risk Category	Risk Factor	Scenario 1	Scenario 2	Scenario 3
Financial	Total Revenue	5.00%	3.75%	2.50%
Financial	Total Volume	5.00%	3.75%	2.50%
Financial	Transaction Count	5.00%	3.75%	2.50%
Financial	Inventory Position	5.00%	3.75%	2.50%
Customer Profile	Avg. Customer Size	2.50%	2.50%	2.50%
Customer Profile	Customer Count	2.50%	2.50%	2.50%
Current BCM Practice	Annual Risk Assessment	6.25%	7.50%	8.75%
Current BCM Practice	Annual BIA Evaluation	6.25%	7.50%	8.75%
Current BCM Practice	Defined RTO	6.25%	7.50%	8.75%
Current BCM Practice	Annual Testing of BCP/CMP	6.25%	7.50%	8.75%
Clinical	Clinical Y/N	50%	50%	50%

Table 6

Risk Concentration Calculation with Clinical Data

Warehouse	Scenario 1	Scenario 2	Scenario 3
WH1	0.007	0.006	0.005
WH2	0.054	0.047	0.035
WH3	0.886	0.985	1.000
WH4	0.005	0.005	0.004
WH5	0.012	0.010	0.008
WH6	0.045	0.037	0.026
WH7	0.006	0.005	0.004
WH8	0.002	0.002	0.001
WH9	-	-	-
WH10	1.000	1.000	0.909

5. Discussion

The analysis of this study delineates the stark differences in risk concentration profiles with and without the inclusion of clinical data. The findings accentuate how the inclusion of clinical data can shift the perception of risk across countries, indicating potentially underestimated risks when such data are omitted. Moreover, the variable impact of BCM scores across different scenarios highlights the need for industry-specific risk assessment models that can dynamically incorporate multiple dimensions of risk based on sector-specific realities.

The analysis has developed a nuanced understanding of risk concentrations across the sponsor's warehouse network, offering a view into how different risk factors interplay to affect overall vulnerability. The results of the study conducted without clinical data give us a few key insights. Comparing the results of Scenario 1 to Scenario 3, we see that WH10, which was highly concentrated in risk, becomes relatively less risky. Similarly, WH3 becomes highly concentrated in risk in Scenario 3. This suggests that the weights associated with each factor taken into consideration must be carefully decided, potentially considering the business needs of the sponsor.

5.1 Limitations

The sponsor's industry is heavily regulated, with laws varying across geographical regions. This affected the availability of relevant data in certain regions, and therefore we had to omit it from our analysis. We believe that for a complete understanding of relative risk concentrations, the inclusion of as much data from all areas where the sponsor is geographically present is required. Further studies could also explore the possibility of integrating data from alternative sources to overcome these data gaps.

The data associated with the risk factors that are considered in the study are dynamic. Financial, Customer, and BCM data may change often, affecting the validity of the model across quarters or even months. Our suggestion to the sponsor is to conduct this assessment regularly, incorporating real-time data changes to enhance the model's relevance. The data must be collected and synthesized at regular intervals and the model must be run each time to understand if the risks associated with each warehouse remain the same or have changed. In this analysis, we have considered three risk factors – Financial, Customer Profile, and Current BCM Practices. If possible, the sponsor can consider incorporating a broader range of risk factors, possibly incorporating social, political, and environmental factors that potentially could pose a threat to global operations.

6. Conclusion

Overall, this capstone demonstrates the dynamic and multifaceted nature of risk assessments, underscoring the significant impact of incorporating comprehensive, sector-specific data sets, including clinical outcomes, into risk evaluation frameworks. As global markets grow and start using more complex data, these methods will be essential for providing the clear insights needed for smart decision-making and strategic planning in international business and public health. Furthermore, the study reveals the critical need for robust, multidimensional risk management strategies that consider both economic activities and products' direct impact on health outcomes. The insights gained from this analysis not only benefit the sponsors but can also contribute to the broader field of supply chain management, offering a template for companies to adapt and build upon for better operational resilience. Policymakers and business strategists could use these insights to allocate resources more efficiently and tailor risk mitigation strategies to better meet the challenges posed by varying market dynamics.

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