Resource Optimization During Merger & Acquisitions Transactions

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ABSTRACT

Mergers and Acquisitions have become means of a quick transformation for companies while basic guidelines related to resource allocation during a transaction are not available. Therefore, this capstone project set out to determine a mathematical approach with the aim to estimate the number of human resources required to create a stable supply chain operation during the sequential merging and separating of subsidiaries.

We approached the problem in two steps. First, we used Mixed Integer Linear Programming (MILP) to calculate the optimal resource allocation number after divesture of the business units. The optimization was helpful to find the baseline resource requirement, but the result still generated backlog as the calculation was made under deterministic conditions. In step two we added flexibility to our model through functional simulations to capture the effect of uncertainties. Allowing us to adjust the center of amplitude related to backlog (performance metric for our system) as close to '0' as possible. After conducting the simulation-based optimization, we revealed the most advantageous resource allocation options while simultaneously providing beneficial insights for strategic decision making by the executive management. As a result, we were able to reduce the absolute number of required resources from 13.22 to 11.71 while enabling stable post-merger operation through a scalable and adaptable resource-allocation model.

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1. INTRODUCTION

1.1. Background

Mergers and Acquisitions have become a means of a quick transformation for companies globally in the wake of an economic depression or regulatory changes. A rise in the number of transactions and complexity of constraints render it one of the toughest tasks in business today. Studies show that 50% of all deals fail to create shareholder value and less than 30% create value noticeably higher than the industry's average return, hence there has been a lot of focus on post M&A integration activities.

A deal's failure to live up to expectations can be attributed to several reasons but certainly the most critical is the lack of supply chain alignment. The highest level of synergy stems from immaterial assets; transfer and integration of knowledge between resources leads to supply chain optimization and successful transactions.

In December of 2015, our sponsoring company announced a merger of equals and created the combined company, worth more than US$130 billion. The initial merger transaction took 6 months to complete, but 24 months after the merger, the sponsoring company started working on splitting its units into three independent, publicly traded companies in an attempt to assuage regulatory concerns about the size of the proposed merger. During this simultaneous process of merging and separating subsidiaries, supply chain management (SCM) is bound to face a bigger challenge in terms of securing stable operation to fulfill customer orders on time.

1.2. Problem Statement

The sponsoring company's focus and struggle in the past three years has been maintaining service level commitments to its customers while trying to both separate and merge logistics operations. However basic, systematic, and objective guidelines related to this challenge were not available. Despite its focus on maintaining service levels the company has failed to identify synergies in processes and capitalize on cost savings.

1.3. Key Research Question / Hypothesis

The objective of this capstone is to determine a mathematical approach which can estimate the number of human resources required for core supply chain components in order to create sustainable supply chain operations in an organization during the sequential merging and separating of subsidiaries. We started by analyzing the order fulfillment processes of legacy organizations (sponsoring company before divesture transactions, which consist of 2 separate independent, publicly traded companies in the chemical industry) to quantify the impact of cross-border operations implications.

1.4. Scope of the project

We focused on post-M&A transactions in Asia, specifically for single supply chain units that would (or could) be spun off into separate entities in order to enable the future integration of an optimized supply chain and increase synergistic gains. Capstone includes specific target locations from the entire order fulfillment operation at the 3rd party warehouses with any inbound and outbound-related operation that involves import, export, domestic transport, and warehousing.

Order fulfillment (OF) execution is one of the major factors that can be used to estimate the actual performance of the supply chain operation. External warehouses are important participants in this OF process, performing many logistics-related transactions for the sponsoring company. Additionally, the sponsoring company has enough relevant data from their ERP system to understand their OF-related operation for this project. Thus, we decided to look at the external warehouse locations.

We will produce a scalable and adaptable optimized resource-allocation model for post-merger integration while maintaining both business continuity and delivering cost savings at the legacy organizations' external warehouse locations. Figure 1 introduces the scope of our model and considers multiple layers of the various data criterions such as business unit, geography, and the role of each assigned personnel from the sponsoring company.

Finally, we will provide the following actionable deliverables for the sponsoring company to implement for immediate success as it prepares for divestiture. First, it will give an idea of the optimal human resource allocation to provide time and cost savings opportunities. Second, it will provide beneficial insights into interactions among number of shipments, productivity, and shipment number variation.

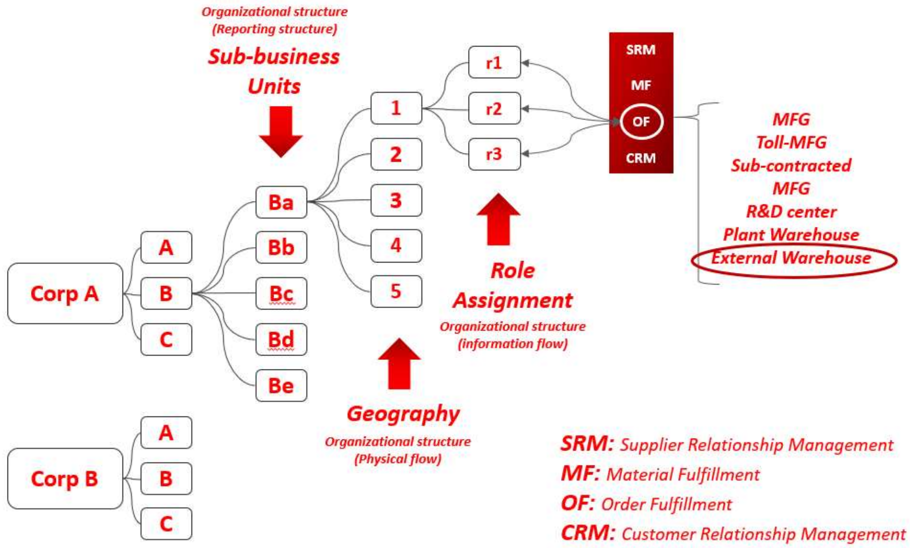

Figure 1. Scope of the model

2. Literature Review

The goal for corporate mergers or acquisitions is a quick transformation to increase shareholder value by leveraging synergies for operational efficiency. Ravenscraft & Scherer (2011) and Linn & Switzer (2001) demonstrate that market value of a stock increases both in anticipation as well as at the time of the deal's announcement. However, given the complexity of the transaction, the length of time required to integrate and the opportunity for management error almost always destroys the value of pre-transaction organizations hence there is either a decline or insignificant change in operating returns (Zhu & Jing, 2012).

Carline, Linn and Yadav (2002), present cases where organizations were able to reshape their supply chains synchronous to the organizational transformation required to capitalize on synergies in the immediate years subsequent to the transaction, confirming room for research and improvement in the area of operational integration.

The capstone project's main objective is to create a mathematical model to enable the allocation of an optimized resource count. An activity's number of resources which will be required to maintain the expected customer service level of on-time and in-full (OTIF) delivery requirement during the M&A transaction. We started by reviewing existing literature, exploring approaches previously undertaken by companies for similar transactions and challenges faced during work that has already been completed. This allowed us to better understand why we are seeing an increase in this area of the M&A practice, including what the benefits are and how they are linked with corporate strategies. We also learned why M&A transactions are gaining traction in the Asia-Pacific (APAC) region and why Supply Chain Management (SCM) is especially at risk during these transactions in this region. Finally, by studying reasonable problem-solving methods that can provide solutions to the question of optimal network, uncertainty-risk and cost of flexibility allowed us to develop a methodology which would authenticate our approach detailed in Chapter 3.

2.1. Need of the Mergers and Acquisition (M&A) transaction

Once a competitive advantage, mergers and acquisitions are increasingly becoming a survival mechanism for companies as a result of international competition in a global market. Companies which are unable to keep pace with the evolving market find themselves in a situation where they need to undergo a quick transformation to survive and thrive.

Transaction data clearly depicts that takeover activity comes in waves triggered by a period of economic recovery (usually preceded by some crisis such as war or economic depression), fueled by regulatory changes or driven by technological discovery or development.

The novelty in the recent wave of mergers and acquisitions is the size of transactions and their geographical dispersion; particularly the inclusion of Association of Southeast Asian Nations (APAC) in this arena behind European Union (EU), renders it a truly international phenomenon. Figure 2 shows an uptick in Asia's cross-border deal making and operations can be greatly attributed to European Union's loss of UK (Brexit) as a result of the referendum, coupled with closer cooperation within the ASEAN community.

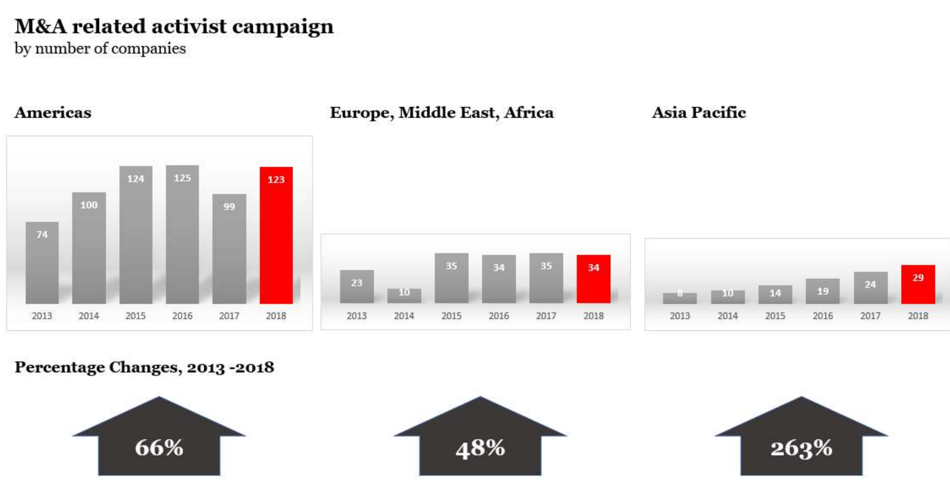

Figure 2. M&A related activist campaign.

(Data from M&A Report Bain & Company (2018))

2.2. Types of M&A transactions

M&A transactions can be characterized as one of two types: Horizontal or Vertical Integrations.

A horizontal integration is one which leads to a company increasing production of goods or services capability as a result of economies of scale at the same level of a supply chain. Earlier M&A transactions were within their respective industry, which Stigler (1950) describes as "merging to form monopolies." Antitrust laws and the drive to reduce earnings volatility later led to portfolio diversification through takeovers in new product markets.

A vertical integration (often as a result of corporate restructuring) is a single entity ownership of the supply chain which helps the company differentiate based on increased control (manufacturing, warehousing and distribution) and capitalize on supply coordination (Lukas et al., 2012; Kogan & Tapiero, 2007).

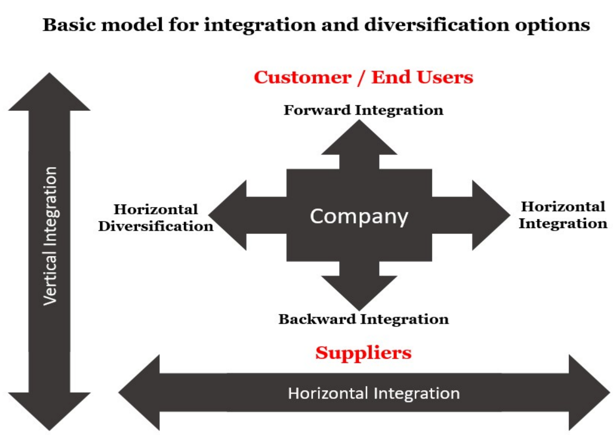

Figure 3. Basic model for integration and diversification options.

(Data from Corporate Level Strategies, Kaysee Das (2012))

Regardless of the type of transaction or nature of consolidation, the underlying motivation is to create shareholder value through increased market share, competitive operational advantage or influencing the supply chain for efficiency. While a successful merger or acquisition can transform companies, it is not without risk; the shear complexity of such an undertaking leads to their high-risk classification and the outsourcing of many tasks and functions to external consulting firms and specialists during the transformation is testament to the complexity. Some of the most common pitfalls for transaction failure are 1. financial risks linked with company valuation 2. operational risk areas related to corporate systems during process integration; and 3. organizational risk as a result of cultural clash between various functions of the organization.

2.3. Landscape in Asia

Companies in Asia were conventionally restrained within borders due to myriad languages in the region, varying forms of government, economic systems and the human development indicators (HDI). The region's rising demand and productivity growth served as a catalyst for the ongoing industrialization and urbanization, which in turn led to cross-border deals and operations facilitated by charters such as ASEAN.

The driver behind Asia's cross-border M&A activity differs slightly from what has been observed in the past both in the US and the EU. Conventional M&A transactions by western companies were cost saving efforts to solidify their competitive advantage and market share or leverage low-cost countries for their supply chains. In contrast, the deal driver for emerging market acquisition is access to wider customer base and technology, supported by government policies, capital and strengthening currencies.

Younger, mid-sized companies are actively engaged in deal making, and what is striking is not the acquisitions of such firms in Asia but rather their acquisitions in the rest of the world. Examples include such companies as Geely (Hangzhou based Chinese auto manufacturer), which acquired Volvo (one of world's most famous auto manufacturer) for $1.8 billion in 2010, and Tata Tea (Indian commodity tea producer), which acquired British Tetley (world's second largest tea producer, three times its size) by outbidding Nestle & Sara Lee for $450 million in 2000.

2.4. Risk to supply chain operation from M&A transaction

Most operational challenges faced by merging or acquired companies originate from structural and cultural adjustments during the integration process, as this is the stage at which the deal is most vulnerable and to which most failures are attributed.

In a vertical integration where two organizations come together under a single ownership, they intend to promote supply chain operation efficiency and consumer benefit (Lukas et al., 2012; Kogan & Tapiero, 2007). Research also proves this type of M&A to be an effective way to mitigate risk, as it aims to the minimize cost (Alptekinoglu & Tang, 2005) or maximize expected profit (Lukas et al., 2012).

However, vertical M&A requires each company to spin off certain redundant business units. These newly created units become a threat to the overall supply chain operation, as the resulting chain could have a vastly different organizational structure and would require a change of both process and resource assignment (Herd, Tom, Saksena & Stegar, 2005). Therefore, a specific contribution of our capstone project is focused on more strategic considerations of keeping the operational capability of the supply chain management sector, which includes the logistics operation at the 3rd party warehouse locations.

2.5. Modeling the logistics operation process in the supply chain

Supply chain operation has a complicated set of relationships among several different criterion and M&A adds to the complexities. In order to create an effective supply chain environment while considering the given complexities associated within the targeted M&A, organizations need to examine studies which developed mathematical models to achieve optimized result. (Meena & Sarmah, 2013; Sawik, 2013; Daskin et al, 2007).

Our capstone project's objective function is to minimize the total number of backlogged shipments for each location. This is because the goal is to find the optimal full time effort (FTE) value while preventing any customer order fulfillment (OF) failures that may occur during the M&A process.

Such failures are recorded when an external warehouse location does not do one or more of the required procedures of picking / packing / shipping / record at a specified time. One way in which results are recorded is backlogged shipment. Therefore, this capstone project is checking the record of the OF work performances based on the shipment log (backlogged orders) and utilize record data to derive the optimal number of FTE resources.

Considering these conditions, we looked at predictive and prescriptive models prior using Mixed Integer Linear Programming (MILP) to produce the optimized result of the intended objective function. Because we found the commonality among different mathematical optimization models focus on a single objective and this project model also requires one single object, that is the number of backlogged shipments at each country location.

2.6. Review of the optimization result by applying the simulation model

Given the stochastic nature of the logistics operating environment, the fluctuation of demand represented by the changes in the number of shipments should not be disregarded, as it is an integral part of all the operational models.

Therefore, this project additionally implements another step by examining the seasonality impact and individuals' productivity impact on backlogged shipment count. We also applied the simulation model to the result of the optimization model representing various scenarios. Scenarios such as a company that is considering spinning off one of its logistics operation organization before the actual vertical M&A transaction with another company's assets or organizational restructuring to counter competitive threat.

Such scenario simulation is important to understand and introduce design flexibility, as it is becoming more widely recognized that relatively minimal challenges in business continuity can bring a huge disruption to the entire performance of the supply chain (Carvalho et al, 2012). A simulation optimization approach reveals underlying issues and hidden costs.

Industrial Dynamics (Forrester, 1961) also introduced a methodology using the dynamic simulation models, which was inherited from the systems dynamics (Sterman, 2000) study. Feedback from the dynamic simulation model can enable control theory and decision-making processes, therefore our project applied the simulation concept to identify the correlation between factors under consideration (demand, productivity, competitive threat).

Although conditions such as number of shipments, an individual's productivity, and the impact of the seasonality from the optimized model can provide meaningful insight to system design; the key consideration while creating a sustainable supply chain model is assigning the most plausible number of resources and capabilities.

3. Data and methodology

3.1. Data Types

The sponsoring company provided a data package covering several components that are essential to the Order Fulfillment (OF) operation. It has two main area, 1. Human Resource (HR) data that includes organization and role details 2. Transaction data from the logistic operation record. It comprises a total of 743,189 data attributes extracted from their enterprise resource planning (ERP) system. There are other data sources included, such as organization structure and number of human resources which we use to examine the baseline productivity of the assigned human resources at each country.

We were provided a total of 17 months of data, which contains key data for describing both the physical and information flow of the logistics operation of the company. We used the attributes of the data set as they were using it in the sponsoring company's ERP system. For a better understanding of the reader, we first present the abbreviations used by the company in Table 1:

Table 1. Data names from the ERP

Term	Explanation
Post Goods Issue (PGI)	A record of the date, time, and quantity of goods that have been packed and left the warehouse.
Mth	A record of month after PGI take place.
SH	A record of physical location where shipping activities are made.
ID	Identification of the Shipment record
Weight	Weight of the product
FTE	The decimal measure of the number of people required to perform a specific task for one year

Section 3.1.1 will introduce the details of each data element provided, data characteristics, and the sanitization process and assumptions.

3.1.1. ERP transaction data

This data includes the shipment record data with material identification number, unique shipment identification number, type of shipment such as inbound or outbound shipment details, weight details of each shipment, and the actual date of post goods issue (PGI).

Table 2. Data names from the ERP transaction data

Name	Description
Shipment Type	Inbound and outbound shipment
Business Group	Name of business group in numeric order expression
Shipment type details	Different transaction type details among standard sales trade transaction/stock transfer order transaction/consignment transaction
Ship From Area	Regional-level details about the shipping location
Ship From Country	Country-level details about the shipping location
Shipping Plant ID	Unique identification number in ERP system about the shipping location
Receiving Plant ID	Unique identification number in ERP system about the destination location
Delivery Number	Unique identification number in ERP system about the delivery
Ship To Customer ID	Unique identification number in ERP system about the receiving entity name
Ship To Area	Regional-level details about the destination location
Ship To Country	Country-level details about the destination location
Material ID	Unique identification number in ERP system about the product material information
Carrier(SH) ID	Unique identification number in ERP system about the transportation carrier information
Shipment Number	Unique identification number in ERP system about the shipment
Dt - (DH) Good Issue Actual Mth	Actual date of outbound shipment made at the warehouse location in ERP system
Weight – Net	Actual weight of material information per each material ID
Weight – Net:	Actual weight of material information per each material ID

3.1.2. Organization-related data

Organization-related data includes initial allocation of the resource numbers, role of each resource, location of the assigned resources, and the average productivity level of the assigned resource for each country level. The detailed description of the data is as follows:

Table 3. Data names from the organization data

Name	Description
Employee name	Numeric order expression
Role	Role of the assigned employee
Region	Regional location of the employee in numeric order expression
Location	Country location of the employee in numeric order expression
Experience Level	Level of experience based on the number of service years in 3 categories - High (H) / Medium (M) / Low (L)

3.1.3. Operation-related data

Operation-related data set includes both the organizational structure and the business unit structure for each region/country. It has two separate data packets: 1) Before the divesture, 2) After the divesture. The detailed description of the data is as follows:

3.1.3.1. Before the divesture

Before the divesture data refers to the organization and its OF operation record details about the legacy company before the divestiture transaction took place.

Table 4. Data names from the operation-related data – before the divesture

Name	Description
Functional Role and Job Title of the employee	Role of the assigned employee
Name of the employee	Numeric order expression
Location	Country location of the employee in numeric order expression
Full Time Effort (FTE)	Required resource number in decimal
Hours per Week	Number of required working hours to conduct the assigned task

3.1.3.2. After the divesture

After the divesture data refers to the organization and its OF operation record about the newly created company after the divestiture transaction took place.

Table 5. Data names from the operation-related data – after the divesture

Name	Description
Business Unit (BU) name	Numeric order expression
Mode or Role	Role of the assigned employee
Country or Location	Country location of the employee in numeric order expression

3.2 Data Integrity

Data from the sponsoring company covers the targeted scope of the project. It has both transaction record and the relevant HR information which supported the calculation of the historical productivity along its resource allocation details. Specifically, the data contains departure, destination, materials, delivery details and the actual date of goods issue at each location about any logistics operation-related activities.

However, some of the value took the qualitative inputs from the sponsoring company, such as the level of experience and the role of the assigned individual. Thus, we could expect some level of possible human error when calculating the result, considering the possible subjective inputs from the sponsoring company. Therefore in order to minimize the impact of these potential errors, we created a variety of assumptions for both data cleaning and its calculation to support the model creation step, which will be discussed in section 3. 3.

3.3. Data sanitization and assumptions

Upon request from the sponsoring company, we had to protect the identity of the data for confidentiality purposes. Therefore, we sanitized the data by removing or replacing the geographical information, corporate name, employee name, and unique ERP data identifier information. Simultaneously, to achieve the highest level of data integrity and better result of the project, we carried out the following steps during the data sanitizing process:

1. Preserved several key data elements by replacing their name with a numeral identifier. For example, employee name “Peter” is replaced by “Employee 1”.

2. Removed country information that showed negligible numbers of transaction records from the master file. There were several locations where the records showed a very small amount of transaction data with zero variation to normalize the data.

3. Encrypted most of the unique identifier elements from ERP data while continuing to use proprietary data,

4. Differentiated the level of productivity based on each individual’s experience level, by applying the simplified metric with H (=1.11) / M (=1) / L (=0.89) where 1 stands for 100% productivity relative to the average number of shipment/FTE.

3.4. Data Analysis

To get a more accurate data analysis result, we first extracted only the necessary elements that are needed for calculating the targeted value. For this reason, we sorted the data by the number of goods receipts performed at each external warehouse, the location of the warehouse, and the date the goods receipts were recorded. As a result, we extracted the necessary data attributes from the historical shipment record and it was reduced from 743,149 to 393,453.

Data analysis work was carried out with two main goals.

a. Features and basic information shown in extracted data values

b. Summary of basic values for Mixed Integer Linear Programming (MILP) and simulation

3.4.1 Features of the data shown in extracted data values

At a high level, we could examine the shipment transaction values from the given data set. The data for each shipment shows different mean values with different ranges of standard deviation. We incorporated the key characteristics into our simulation model in order to test the potential implications on the overall supply chain operation using the result of the optimization model.

We classified the data as "Inbound" and "Outbound", and presented the mean, median, and standard deviation values by country in Table 6.

Table 6. Shipment transaction data with standard deviation factor

	Country	Mean (Shipment)	Median (Shipment)	Standard Deviation (Shipment)	Covariation
Inbound	0	55.50	56.00	7.46	0.13
Inbound	1	37.81	37.00	9.26	0.24
Inbound	2	228.00	233.50	28.05	0.12
Inbound	3	6.13	5.50	3.67	0.60
Inbound	4	0.00	0.00	0.00	0.00
Inbound	7	51.00	50.00	8.02	0.16
Inbound	9	3.81	3.50	2.19	0.57
Inbound	11	11.50	11.00	5.15	0.45
Inbound	12	51.69	55.00	11.28	0.22
Outbound	0	128.35	126.00	33.19	0.26
Outbound	1	88.41	86.00	19.17	0.22
Outbound	2	1203.76	1068.00	326.53	0.27
Outbound	3	11.06	11.00	2.92	0.26
Outbound	4	360.88	367.00	44.86	0.12
Outbound	7	200.53	201.00	22.21	0.11
Outbound	9	7.71	7.00	2.74	0.36
Outbound	11	38.76	36.00	12.83	0.33
Outbound	12	91.71	97.00	13.49	0.15

As shown in Table 6, the covariation that can measure the variability shows that the variation is around 25% at most locations, indicating the results of a fairly stable operation. This result was used as an important basis when determining the amount of variation to be considered in the simulation stage.

3.4.2 Summary of basic values for Mixed Integer Linear Programming (MILP) and simulation

The input values used for MILP calculation are as follows:

i. Estimated shipment processing capability before divesture

ii. Estimated productivity of individual (H/M/L)

iii. Number of average shipments at each location before divesture

"Estimated shipment processing capability before divesture" refers to the amount of incoming and outgoing goods that can be processed by one person for one year which is calculated by dividing the total amount of shipments processed by one person who were assigned by the organization prior to the company being split up. In light of this assumption, the project calculated the number of people allocated by the organization before it was diversified and summarized each country's total shipment number for the same period.

In order to calculate the number of people assigned, the number of people needed was calculated based on 1 person = 40 working hours / week using the total working hours data obtained by the organization before the divestiture. In addition, some tasks were found to be related to the entire region rather than being country specific.

Therefore, the corresponding workload is evenly distributed to all countries, and the results are summarized in the Adjusted Working Hour column in the table below. We used total number of hours data collected on a weekly basis, then adjusted the total working hours (person x hour / week) / 40 (hour / week) and performed calculation to converted it to the total effort required to perform the work Full Time Effort (FTE). The resulting value is shown in Table 7.

Table 7. Working hour data for each country

Country	Working Hour	Adjusted Working Hour	FTE#
Country 0	59.34	68.46	1.71
Country 1	60.6	63.64	1.59
Country 2	160.11	163.15	4.08
Country 3	2.42	5.46	0.14
Country 4	6.4	9.44	0.24
Country 7	47.73	50.77	1.27
Country 9	28.3	31.34	0.78
Country 11	18	21.04	0.53
Country 12	112.3	115.34	2.88
Regional Role	3.04	-	-

Lastly, the total shipment quantity was summarized by country, referring to the historical data. Using the data above, we calculated the estimated shipment processing capability before divesture that an individual can handle in a particular country. The summarized results are shown in Table 8 below.

Table 8. Transaction data for each country with average productivity level of processing the shipment

Country	**0**	**1**	**2**	**3**	**4**	**7**	**9**	**11**	**12**
Mean (Shipment/Month)	183.8	126.2	1,431.7	17.1	360.8	251.5	11.5	50.2	143.3
Standard Deviation (Shipment/Month)	34.0	21.2	327.7	4.6	44.8	23.6	3.5	13.8	17.5
Resource number (FTE)	1.71	1.59	4.08	0.14	0.24	1.27	0.78	0.53	2.88
Estimated shipment processing capability before divesture (Shipment/Year)	1,275.0	944.7	5,017.2	1,377.7	26,000	2,685.9	167.2	1,252.9	540.6
Experience Level (Categorical: H/M/L)	L	M	M	H	L	H	M	M	M

For the “Estimated productivity of individual (H/M/L)” we reviewed historical data to establish individual work capacity differences related to work efficiency in handling incoming and outgoing orders. We summarized the total number of years of experience of the assigned personnel before the divesture in Table 9 and Figure 4. From the summary, we can observe the different numbers of shipments and its fluctuation level along with the different level of individual’s experience level.

Table 9. Data table for reviewing the individual’s level of experience

Country name	Average Shipment number	Average Productivity (Shipment per year)	Year of Experience	Experience Level	Fluctuation
Country 0	2,182.00	1,275.00	5.00	L	0.20
Country 1	1,503.00	944.71	11.67	M	0.23
Country 2	20,464.00	5,017.27	10.50	M	0.26
Country 3	188.00	1,377.71	25.00	H	0.42
Country 4	6,135.00	26,000.35	15.00	M	0.13
Country 7	3,409.00	2,685.93	14.00	M	0.14
Country 9	131.00	167.21	11.67	M	0.47
Country 11	659.00	1,252.95	21.00	H	0.38

Interesting point from this data summary, when looking at the historical data, years of experience do not show any positive relationship with the level of productivity. Therefore, we would need to test the full range of productivity changes during simulation to understand any potential impact.

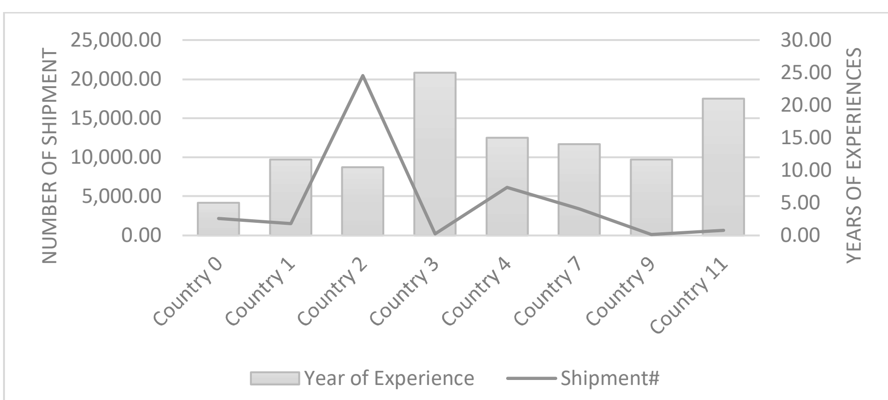

Figure 4. Comparison between years of individual experience and the expected number of shipments

Since the basic fluctuation boundary has to be established, the monthly maximum and minimum monthly shipments of each country's entry and exit volumes are summarized.

Based on these values, we have averaged the monthly volatility, (see Table 9) – fluctuation column above. The largest value among the calculated values was 0.47 (relative to the average incoming and outgoing quantity), and the smallest variation was 0.13. The total amount of variability available here was maximum (0.47) – minimum (0.13) = 0.34, and the project planned to use the productivity levels of the personnel input in three categories. Therefore, we decided to proceed with the calculation by setting the difference of 0.11 for each category.

H (High Proficient) =1.11

M (Medium Proficient) = 1

L (Low Proficient) = 0.89

Finally, "Number of average shipments at each location before divesture" reflects the total amount of shipments processed for each year in each country, including both inbound and outbound shipments.

Table 10 and Figure 5. show the values of total quantity by country, and the monthly quantity which will be used not only for MILP calculation but also for simulation model process.

Table 10. Total number of shipments for each country

Country	**Total Shipment** (Shipment/Year)
Country 0	2,182
Country 1	1,503
Country 2	20,464
Country 3	188
Country 4	6,135
Country 7	3,409
Country 9	131
Country 11	659
Country 12	1,559

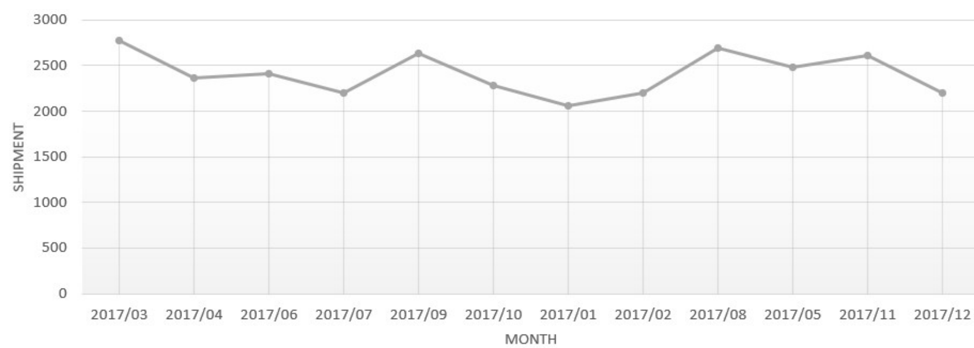

Figure 5. Total number of shipments for each month

3.5. Methodology

Our methodology is broken down into two steps.

3.5.1. Step 1: Mixed Integer Linear Program (MILP) model for calculating the optimized resource allocation result after divesture of the business unit

We created a schematic design sought to find a solution to the potential logistic operations issues, considering capability of processing the expected number of the shipments and estimated number of backlogged shipments.

Then we applied a novel discrete single-objective optimization model in order to establish the minimum number of backlogged shipments which would prevent the logistics operation related disruption. This insight enabled the organization's leadership team to understand the optimal number of resource while also securing resiliency of the operation. The model is as follows:

Indices

Country Location i (1)

Input Data

Si = Estimated shipment processing capability before divesture (2)

Pi = Estimated productivity of individual (H/M/L) (3)

Ti = Average number of shipments at each location before divesture (4)

Decision Variables

Vi = Variables (= assigned number of resources at each location) (5)

$$Min \quad bi = \sum_{i=0}^{n}((Si \times Pi \times Vi) - Ti)) \tag{6}$$

$s.\ t.$

$$Vi \geq 0 \ \forall i \tag{7}$$

$$Si \times Pi \times Vi > Ti \tag{8}$$

The objective function (6) minimizes the number of failures for processing the assigned shipment at each node (1), and also minimizes the total number of resources (5) that need to be allocated. The result is presumed to be the most economical decision.

More specifically, our model describes (2) Average shipment processing capabilities for each node before divesture, (3) Individual shipment processing capabilities before divesture, and (4) Actual operational capabilities that determines the number of backlogged shipments. Average shipment processing capabilities before divesture (2) are associated with both the total number of the shipment and the assigned FTE (Full Time Effort resource) number from the previous organization. In addition, input from (4) can be used to calculate the objective function which yields the optimized allocation of FTE. This number can in turn be used to create a sustainable topology of the logistics operations and minimize vulnerability to disruptions.

Constraint (7) enforces local level requirements, such as language and regulatory requirement to meet the local authority related restrictions while Constraint (8) ensures the operational balance and require that all demanded shipments of each node will be satisfied. Moreover, we set some of the location's value to be the integer so those location will at least have 1 FTE resource at a minimum who is capable of leading any local specific requirement activities.

3.5.2. Step 2: Additional validation of the supply chain operation impact by applying the simulation model

Given the stochastic nature of the logistic operation environment, fluctuation of the demand represented by the changes in the number of shipments should not be disregarded as it is an integral part of the entire operational model.

Therefore, we added another step by considering the seasonality and individual's productivity impact. We did this by applying a simulation to the optimization result under various scenarios in which a company is considering spinning off one of their operational unit prior to the actual vertical M&A transaction:

a. Effects of seasonality on the number of shipments per location and country

b. Productivity variance due to resources (legacy employee, skillset and language)

c. Resource assignment limitations from certain locations due to local regulations and licenses requirement.

Scenario (a) considered the different levels of fluctuation for each location due to the seasonality impact which was observed at the data review step. This scenario can help us to identify the most vulnerable location that is lacking the required resources to prevent the potential failure of the shipment processing role. And scenario (b) can be used to test the impact of the possible resource changes during the period as we can expect frequent change of the resources due to the voluntary resignation and repatriation of the assigned contractors. Lastly, scenario (c) supported the simulation result to be realistic as it considered the particular constraint during resource allocation step if the location must assign 1 or more resources to meet the local regulatory requirement.

During the simulation step, extreme constraint conditions will be used to test the overall resilience of the model. Resilience results will be represented by the total number of backlogged shipments at each node.

APPENDIX-A shows the conceptual design of the simulation model. Using the result of the optimization model, various extreme conditions will be applied such as a higher standard deviation of the shipment number or having less experienced resources at each node in order to minimize the number of back-logged shipments.

In order to see the change of the result value for various hypotheses, we built a basic model using Vensim and conducted various tests to understand the dynamics of the result by changing some of the key variables under certain conditions. Example of the basic structure of the model can be found in APPENDIX – B.

4. Analysis and results

The objective of the project is to mathematically implement the appropriate resource number calculation process when the existing operating units need to create an independent, standalone operating units during the carve-out transaction from M&A. In view of this purpose, two major steps have been taken here.

First step to derive the target result, MILP was performed using the pre-calculated data values. And the result is shown on Table 6. The total number of resources needed after the divestiture is calculated to be 18.131, this means the newly created operating units should consider to assign at least 18.131 person This is calculated result in Table 11 used the productivity of the organization and the inbound and outbound shipment numbers expected for one year.

Table 11. Total number of required FTE for each country calculated by MILP

	Inbound	**Outbound**	**Sum**
Country 0	0.823	1.923	2.746
Country 1	0.682	1.591	2.273
Country 11	0.140	0.474	0.614
Country 12	1.587	2.883	4.470
Country 2	0.763	4.079	4.842
Country 3	0.064	0.123	0.187
Country 4	0.000	0.236	0.236
Country 7	0.322	1.269	1.591
Country 9	0.389	0.783	1.172
		Grand total	**18.131**

This value was increased by about 37% compared to the total number of 13.22 people that the legacy organization predicted and expected before divestiture the organization, which did not give the most optimized result because the result require some countries hire more people than the expected and it leads the increase of the cost during the transition period.

Table 12. Difference of the required FTE from each country between previous data and MILP result

	Calculated FTE before divesture (A)	After MILP calculation (B)	Differences (B) – (A)
Country 0	1.71	2.75	1.03
Country 1	1.59	2.27	0.68
Country 11	4.08	0.61	-3.46
Country 12	0.14	4.47	4.33
Country 2	0.24	4.84	4.61
Country 3	1.27	0.19	-1.08
Country 4	0.78	0.24	-0.55
Country 7	0.53	1.59	1.07
Country 9	2.88	1.17	-1.71
Sum	**13.22**	**18.13**	**4.92**

Some extreme cases have been found, as shown in the Table 12, focusing on the variables used in the MILP to understand the cause of this problem. The probable reason for the extreme result is assumed to be the excessive number of the estimated shipment processing capability number for certain country. Some countries showed very high number (26,000 shipment/year) than the other country (average about 2,000 shipment/year).

Here, we presuppose that there would be no errors in the recorded values, given that the historical data were from ERP. Based on this assumption, the problem was the total work time calculated by the legacy organization before the other input, divestiture. In fact, it was confirmed that the data provided were collected by the individual country managers based on their subjective judgement. Considering this part, it was concluded that the data collection or calculation process provided a distorted result.

The total number of required people (FTE) calculated by the legacy organization and the results obtained during the MILP process shows a very large difference in some countries. We assume the problem is related to the estimated shipment processing capability data and the specific reason can be determined by further investigation. But this result helped to understand the particular relationship and discovered the greatest impact in various assumed situations. And as there are other validation steps to derive optimal result, it was concluded that this part would not be a big problem in carrying out the project and confirming the result.

The purpose of the simulation is to use the optimal FTE value obtained from the MILP and the given data, but to change each data value under certain conditions, and simultaneously apply the data considering the variability of the monthly input and output volume.

After the MILP step, we checked the total number backlogged shipments to see if they can be continuously suppressed through the simulation approach. Therefore, we tried to understand the shortcomings and limitations of the results under different conditions, and to review any conditions with the optimal number of resources.

Two input variables are set for this step. One is the mean value and standard deviation value of each month's total number of inbound and outbound shipments. Another input variable is the simplified value (H / M / L) of the average productivity level of processing the shipment of the assigned personnel.

The simulation frequency was fixed at the month period and the total simulation period was set at 55 months. In addition, we wanted to ensure that our results would be plausible even in extreme conditions. Because there could be situations where unexpected exogenous factors cause volatility to exceed normal or expected levels, the simulation included variability that was double the actual number. This volatility was established by doubling the standard deviation of each month's number of inbound and outbound shipments as shown in Table 13.

Table 13. Input variables for simulation

Original Data	**Country 0**	**Country 1**	**Country 2**	**Country 3**	**Country 4**	**County 7**	**Country 9**	**Country 11**	**Country 12**
Level of experience	0.89	1.00	1.00	1.10	1.00	1.00	1.00	1.10	0.89
Assigned FTE#	2.75	2.27	4.84	0.19	0.24	1.59	1.17	0.61	4.47
Average Productivity	182.17	125.58	1,705.67	16.00	511.58	284.42	11.25	55.25	130.25
Shipment number_Mean	183.85	126.22	1,431.76	17.18	360.88	251.53	11.52	50.26	143.39
Shipment number_STD	21.29	327.73	4.69	44.86	23.61	3.50	13.83	17.58	34.01

In the first simulation run, the simulation was performed without any changes to the conditions of the FTE inputs by country and the average productivity level of processing the shipment of the deployed personnel.

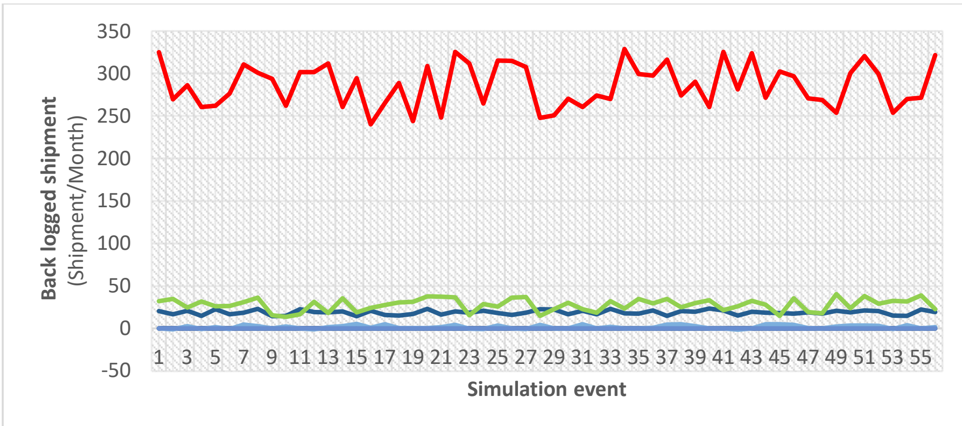

Figure 6. Result of the 1st simulation condition

(No changes in FTE and individual's productivity level)

Figure 6 shows the result that a certain number of backlogged shipments are steadily occurring in some countries, while a small number of backlogged shipments are generated in some other countries. And this result clearly brought us to the conclusion that the MILP did not provide the most efficient solution to the addressed problem.

Based on the above results, in order to find better result, other assumptions were considered. First of all, we checked if there is any improvement that the average productivity level of processing the shipment could bring, the second simulation was performed by resetting the average productivity level of processing the shipment of all assigned personnel to the maximum value.

Interestingly, after applying the changes and conduct another simulation run for comparing the results with the previous one, Figure 7 did not show identical results without significant improvement. Therefore, it could be concluded that replacing the backlogged shipment generation with relatively experienced or efficient personnel would not have a great effect.

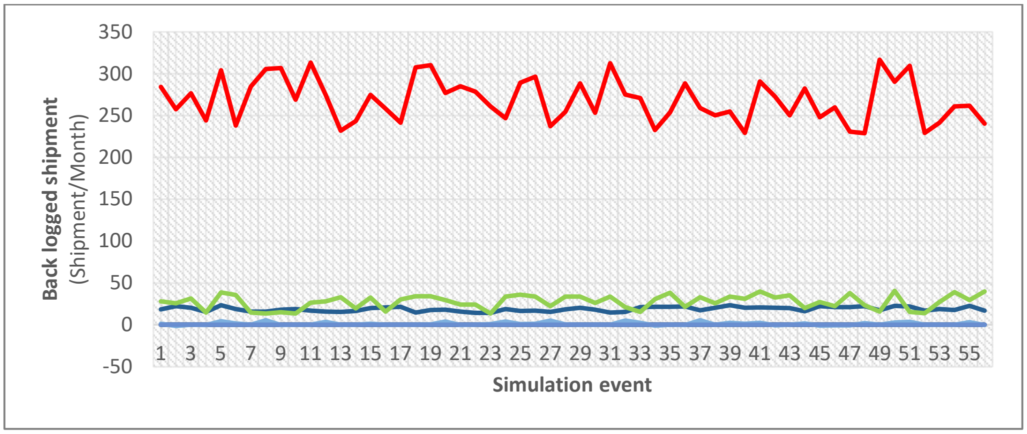

Figure 7. Result of the 2nd simulation condition

(No changes in FTE while changing the individual's productivity level to the maximum level)

Unlike the previous simulation method, many FTEs were put into a region where backlogged shipments are relatively high, and its results are shown in the Figure 8. The backlogged shipments are effectively controlled, showing similar results with other countries' trends. It can be inferred that the new condition was able to suppress backlogged shipments.

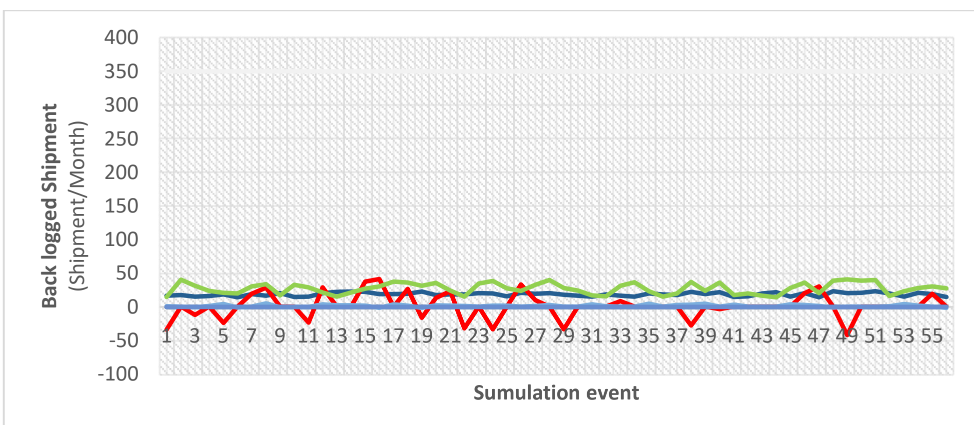

Figure 8. Result of the 3rd simulation condition

(Made changes in FTE no changes in individual's productivity level)

Another interesting point is that out of the nine countries used in the simulation, only four countries have seen back logged shipments. From these estimates, the remaining five countries that do not appear in the results show that the amount of backlogged shipments is zero, which is completely controlled.

However, this result brought additional challenges as more people were assigned than the we might need after the change, therefore we could assume that this is not the ultimate outcome value desired for this project goal.

Based on the results of the simulations and the insights found above, a large number of simulations were carried out and the number of FTEs input by country was arbitrarily adjusted. We changed the number of assigned FTEs manually until we see the lowest number of FTE while suppressing its backlogged shipment level at low. Through these procedures, we found the conditions under which the incidence of backlogged shipments could be close to zero, and the results are summarized in Figure 9.

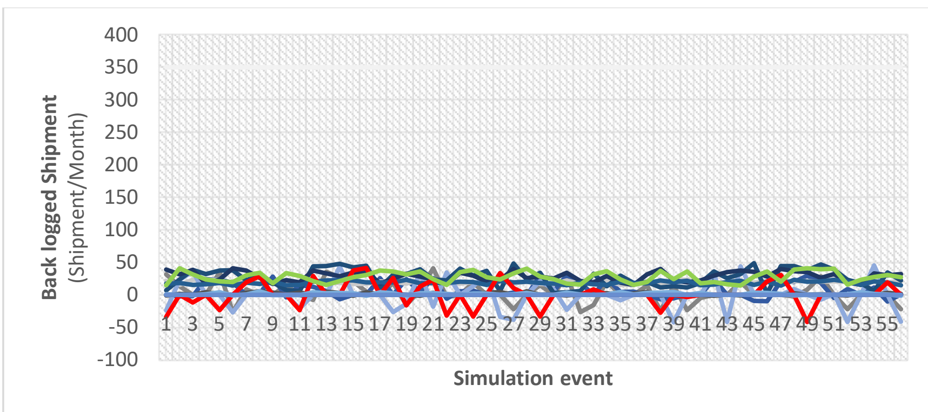

Figure 9. Result of the 4th simulation condition

(Made changes in both FTE and individual's productivity level)

After the calibration step, it can be seen that backlogged shipments are effectively suppressed in all regions, and that all countries are properly controlled with some positive / negative incidence, which is the closest to the goal of this project.

5. Discussion and managerial recommendations

After completing all the simulation steps, specifically, the amount of change in the input number of each simulation was compared.

In Simulation 1 and 2, the MILP identified 18.31 optimized FTE numbers. In Simulation 3, additional FTEs were added as a way to curb back-logged shipments in some countries, resulting in the highest total number of 21.44. Finally, in Simulation 4, while recognizing the positive / negative generation amount for the backlogged shipment quantity, the optimal FTE number that minimizes the total number of occurrences was searched through iterative simulation. The final result was 11.71 people. Details are summarized in Table 14.

Table 14. FTE number comparison among separate simulations

Assigned FTE#	Country 0	Country 1	Country 2	Country 3	Country 4	Country 7	Country 9	Country 11	Country 12
Simulation 1	2.75	2.27	4.84	0.19	0.24	1.59	1.17	0.61	4.47
Simulation 2	2.75	2.27	4.84	0.19	0.24	1.59	1.17	0.61	4.47
Simulation 3	2.75	5.10	4.84	0.19	0.72	1.59	1.17	0.61	4.47
Simulation 4	1.30	1.10	1.30	0.19	0.72	0.88	1.17	0.59	4.47

It is important to note that the simulation reduced the amount of FTE input. Any colors shaded in green indicate the result that is smaller than the previous one while the red one indicates the larger number than the previous outcome. If we look at the result in more detail, when the absolute value of the fluctuations decreased, we could not adjust the fluctuation by increasing FTE amount.

This means that if an organization chooses to obtain an optimal backlogged shipment deterrent by setting a maximum of less than '0' per month, the consequence will be an excessive FTE resource allocation condition. This may mean that it may not be the strategic decision to take.

Therefore, one way to find the optimal FTE input while considering the given amplitude is to perform an iterative simulation in an effort to find the intermediate value of the maximum and minimum amplitudes of the variation so the total number of backlogged shipments converges as close to zero as possible. Figure 10 shows the actual result of this point.

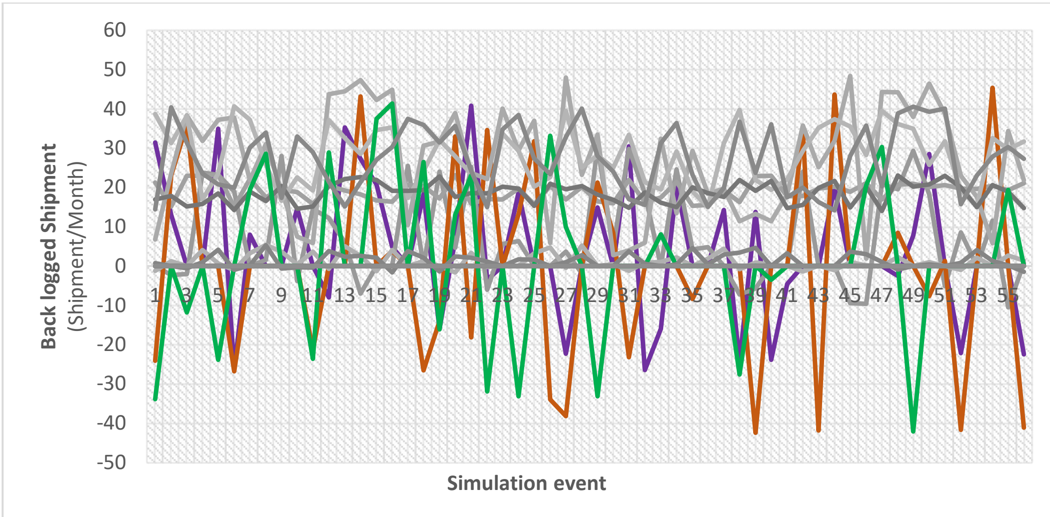

Figure 10. Result of the 4th simulation condition

(Variation of the backlogged shipment number for each country)

Of course, if the absolute value of the amplitude is large enough, this method can create a concern that the utilization rate of the staff will be significantly lower than in other locations. However, this problem can be solved by sharing FTE resources with other countries or by other means. Detailed verification of this area should be revealed through a separate study.

It is not possible to control the variability in the number of shipments that occur every month. This is because the number of shipments is determined by customers' order, and customer order quantity cannot be controlled within the organization.

Through the addition of more FTE resources, it is possible to limit the number of backlogged orders being generated so that the maximum amplitude associated with the monthly backlogged shipment numbers less than zero. However, this potentially could lead to the problem of excessive resource allocation. Therefore, we adjusted the center of amplitude related to backlogged shipments to '0' as much as possible. The most reasonable solution may be to expect that a certain amount of backlogged shipments will be positive in some periods and negative in the remaining periods. However, this result also has a constraint that it is only feasible on the premise that the amplitude variation must be periodic and constant.

Considering all the above constraints, when calculating the appropriate FTE amount to operate a stable supply chain while minimizing the potential interruptions in the operation, a solution is to first calculate the appropriate input FTE amount considering the absolute shipment amount and the monthly shipment amount changes.

Following this approach, we could measure the maximum and minimum amplitude values of the backlogged shipment variation. If the FTE number can be adjusted where the amount of positive and negative value of backlogged shipment occurs at the symmetric position based on "0", we were able to reduce the absolute amount of backlogged shipment while enabling stable post-merger operation through a scalable and adaptable resource-allocation model. Using our model, companies will not only be able to identify the most advantageous resource-allocation options but also gain beneficial insights into effects of uncertainties on their system for future strategic decisions by the executive management.

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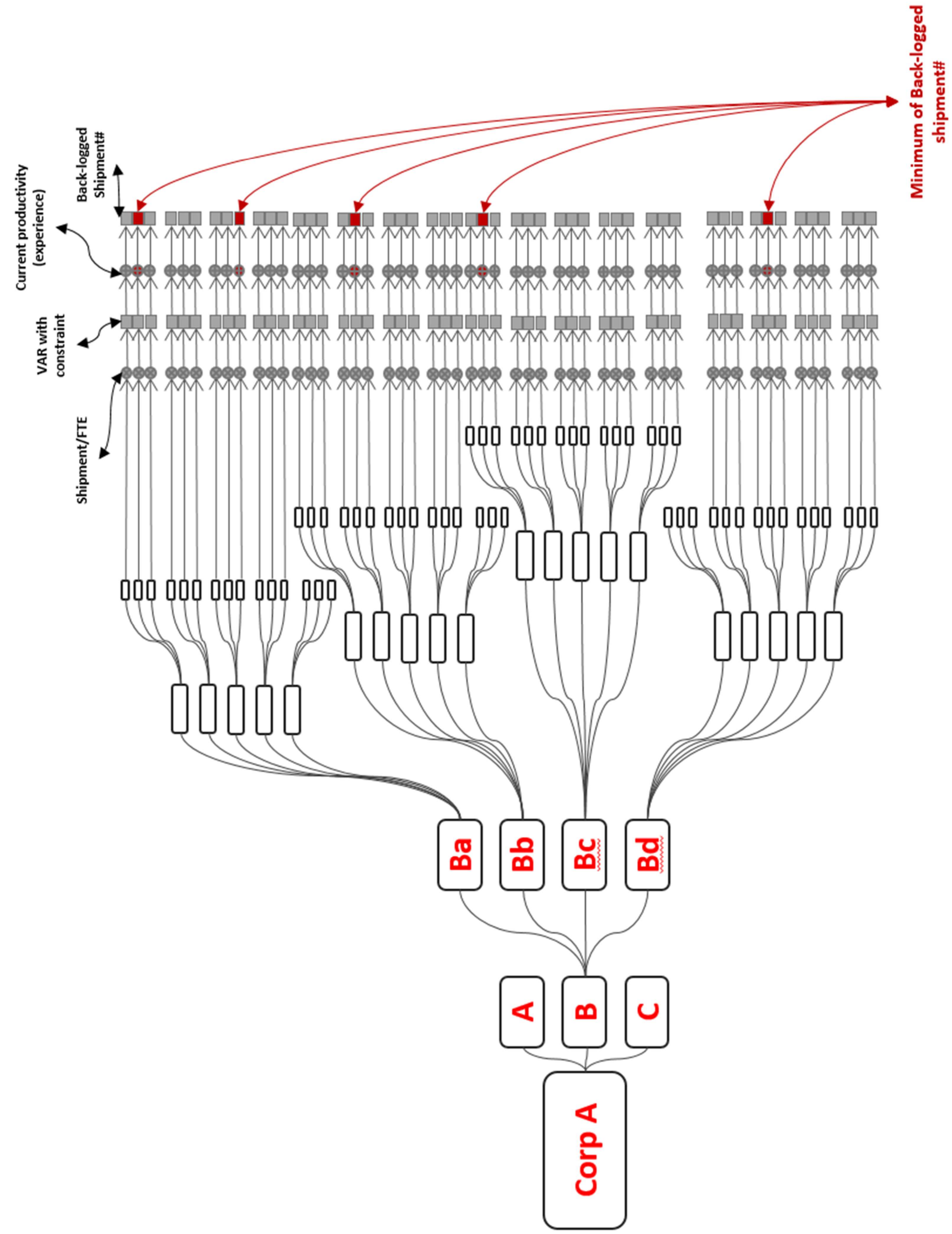
APPENDIX A - Scheme of the simulation model



APPENDIX B - Simulation mode example