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Enhancing Operational Efficiency and Cash Flow through Supply Chain Optimization in the Oil and Gas Sector

Vinit Roshan[1]

[1] MBA Finance, BITS Pilani, India & Bachelor's in Technology- Manufacturing Engineering, NIAMT, India

Correspondence: Vinit Roshan, MBA Finance, BITS Pilani, India & Bachelor's in Technology- Manufacturing Engineering, NIAMT, India. E-mail: vinitroshan@hotmail.com

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Abstract

The oil and gas industry continues to play a vital role in meeting the world's energy needs. As renewable energy sources gain traction, there is an imperative to refine operational models, prioritizing sustainability, and cost-effectiveness. This study employs a comprehensive conceptual framework integrating critical analysis of business scenarios, product positioning, and market segmentation. The study adopts supply network optimization, encompassing demand forecasting, inventory management, transportation, production scheduling, cash flow management, and data analytics. The research evaluates three supply models: Satellite Manufacturing, Hub Manufacturing, and Contract Manufacturing. It employs scenario analysis to assess the impact of supply chain strategies on operating and cash cycles. The analysis reveals that Hub- based contract manufacturing is the most effective model. The research demonstrates that optimizing supply networks directly influences the operating and cash cycles of companies in the Oil and Gas industry. By reducing inventory levels, optimizing supplier payment terms, and streamlining production processes, organizations can achieve cost savings, improve efficiency, and enhance cash flow management. The study underscores the importance of thorough analysis and strategic decision-making in selecting supply chain models to enhance cost efficiency, operational effectiveness, and cash flow management. The study is limited to midstream and downstream services and may vary based on industry contexts. Future research could explore additional supply chain strategies across different sectors. This research contributes to the sustainable consumption and value co-creation literature by offering practical insights for businesses operating in the oil and gas industry or similar contexts. It provides a framework for optimizing supply chain models to improve cost efficiency and cash flow management, thereby enhancing overall business performance.

Keywords: oil and gas industry, supply chain optimization, business performance, cost efficiency, sustainability

1. Introduction

The oil and gas industry, long regarded as the bedrock of global energy supply, is undergoing a profound transformation amid the rise of renewable energy sources and increasing sustainability imperatives. Amidst this backdrop, optimizing operational frameworks within the industry has emerged as a pressing imperative. The optimization of Supply Chain Management (SCM) holds significant importance for businesses aiming to bolster efficiency, trim costs, elevate customer satisfaction, and gain a competitive edge. Cost reduction is achieved through streamlined processes, minimized inventory holding costs, and enhanced resource utilization (Alkahtani, 2022; Sulem & Tapiero, 1995). SCM optimization, thus, enhances operational efficiency, slashes lead times, and boosts productivity across the entire supply chain network. Meeting customer demands becomes more feasible with timely deliveries, reduced stockouts, and heightened service levels facilitated by SCM optimization (Attia et al., 2019; Gupta et al., 2022; Liu et al., 2019).

The Midstream and Downstream sectors, responsible for crucial activities such as transportation, storage, refining, and distribution of oil and gas products, present significant opportunities for operational efficiency. Amid rising cost pressures, there is a need to enhance sustainability practices, as sustainability practices, such as reducing carbon emissions and promoting environmentally friendly operations, are facilitated by SCM optimization (Liu et al., 2019; Attia et al., 2019; Gupta et al., 2022). Additionally, optimized supply chains are better equipped to tackle disruptions, mitigate risks, and respond swiftly to changes in demand or supply chain dynamics (Das Roy & Sarker, 2021). Furthermore, SCM optimization enhances operational efficiency, slashes lead times, and boosts productivity across the entire supply chain network (Alkahtani,2022; Sulem & Tapiero, 1995). Efficient resource utilization, including raw materials, production capacity, transportation assets, and labor, leads to cost savings and enhanced profitability (Alkahtani, 2022; Sulem & Tapiero, 1995). In summary, SCM optimization serves as a cornerstone for bolstering overall business performance, driving growth, and ensuring sustainability in today's competitive and dynamic business landscape.

Midstream and downstream operations are there across the world, and this requires a lot of material movement between different countries and thus lead time dictates the inventory levels and cost of capital. Depending on from where material is being shipped and the manufacturing strategy of the company. Rapid swings in the price of oil can have outsize effects on the companies involved in midstream and downstream operations. Businesses involved in sales of products like valves, wellheads used in midstream and downstream application has a strong demand correlation with oil prices. An abrupt decline in oil prices can swiftly pose significant challenges to cash flow, budgets, and other financial aspects, particularly dependent on the duration of operation and cash cycle of businesses. Fluctuations in demand will synchronize with the current economic cycle, intensifying the consequences. In an upward cycle these businesses can operate well with a high inventory scenario and with longer operating and cash cycle. But a downward cycle can drag them to bankruptcy as well. Based on given context, the present study aims to provide an optimized solution through supply network mapping to cut down operating cycle, cash cycle, inventory of this industry so that midstream and downstream services companies can better manage business cycle due to oil price volatility.

The primary objective of this research is to delve into the intricate interplay between supply chain dynamics and operational performance within the Midstream and Downstream sectors of the oil and gas industry. By elucidating the impact of diverse supply models on cost efficiency, operational efficacy, and cash cycle management, this study seeks to furnish actionable insights that can empower companies to navigate the complex operating landscape more adeptly. The aim is to construct a variety of scenarios that assess the effects of diverse supply chain decisions on the cash conversion cycle, to gauge whether changes in the supply network can influence costs and the efficiency of cash conversion. Furthermore, the research aims to contribute to the evolving discourse on sustainable practices and value creation literature within the oil and gas domain, thereby offering a roadmap for industry stakeholders to achieve long-term viability and resilience.

This research distinguishes itself by its comprehensive exploration of supply network optimization strategies within the Midstream and Downstream sectors of the oil and gas industry. While existing literature has touched upon various aspects of supply chain management, this study endeavors to offer a holistic perspective by dissecting the influence of diverse supply models on key operational parameters. By delving into the nuances of supply chain dynamics, including the make vs. buy deliberation, demand forecasting, inventory management, and logistics, this research seeks to uncover novel insights that can drive tangible improvements in operational performance.

Moreover, the uniqueness of this study lies in its focus on actionable outcomes, aiming not only to elucidate theoretical concepts but also to offer practical guidance for industry practitioners. By grounding the research in real-world scenarios and industry best practices, this study bridges the gap between academic theory and operational reality, thereby enhancing its relevance and applicability in the context of contemporary oil and gas operations. Ultimately, by shedding light on innovative strategies for supply network optimization and resilience-building, this research aims to chart a course towards sustainable growth and value creation within the oil and gas industry.

2. Research Method

The study aims to investigate the impact of supplier network mapping on the operating and cash cycle in different supply chain models: satellite manufacturing, hub-based manufacturing, and contract manufacturing. Data is gathered through critical review and analysis of various companies' business scenarios, studying product positioning, and market segmentation within the midstream and downstream sectors of the oil and gas industry. Quantitative data is collected through empirical analysis of financial statements, operational metrics, and supply chain performance indicators obtained from relevant industry reports, databases, and case studies. Scenario analysis is employed to validate the proposed framework using data on demand forecasting, inventory management, transportation and distribution, production scheduling, and cash flow management. A scenario represents a structured narrative describing a coherent set of factors that probabilistically define alternative future business conditions. Scenario analysis addresses many of the limitations found in traditional extrapolative forecasting methods (William, 1988). Effective method for decision making and strategy formulation function (Kosow & Gaßner, 2008).

Real-world scenarios are used to evaluate the effectiveness of different supply network optimization strategies in improving operating and cash cycles in the oil and gas industry. This study assumes that part of the company considered in this case study is a suitable candidate for both Make or Buy from a pricing strategy perspective. The study compares each supply model with its supply network to see which can deliver the best operating and cash cycle. The study is designed to establish that supply network mapping directly impacts cost, operating, and cash cycle through scenario analysis.

3. Scenario Development and Analysis Criteria

Supply network optimization require analyzing and redesigning of the entire supply chain, from sourcing raw materials to delivering finished products to customers. The key focus areas of study to achieve these goals include Demand Forecasting, Inventory Management, Transportation and Distribution, Production Scheduling, and Cash Flow Management. To create a guideline for the procurement team, Scenario were created and analyzed, built on data to understand the importance of supplier network mapping for different supply models which directly impacts the operating and cash cycle. The three-supply model used in the study include: Satellite manufacturing, Hub-based manufacturing, and Contract manufacturing.

The following key ratios were used to analyze various scenarios to understand the influence of supply network mapping on cost, operating, and cash cycle.

Activity Ratios:

- DOH- Days of Inventory on Hand
- DSO- Days of sales outstanding
- DPO- Days of payables outstanding

Liquidity Ratios:

- Cash Conversion Cycle = (DOH+DSO-DPO)

As DSO (Days Sales Outstanding) has no impact due to supply chain strategies (assuming equipment is delivered on time to the customers), the overall effect on the cash cycle will be studied through the minimization of inventory and an increase in supplier payment terms. The study is based on three assumptions which are detailed as we discuss the various criteria's used for the scenario analysis in the following section.

3.1 Operating and Cash Cycle

Understanding the sequence and duration of processes is essential for optimizing supply chain management, reducing lead times, managing inventory effectively, and ensuring efficient cash flow management. The operating and cash cycle is explained in Figure 1. After the order for a product is placed with a supplier, suppliers start manufacturing the product; once the committed delivery date arrives, the supplier ships the part to the customer. Once the material arrives at the customer site, it initiates the operating cycle. The cash cycle starts when the customer pays the supplier. Each process ends when the customer uses the material to make finished parts, delivers it to the client, and gets paid.

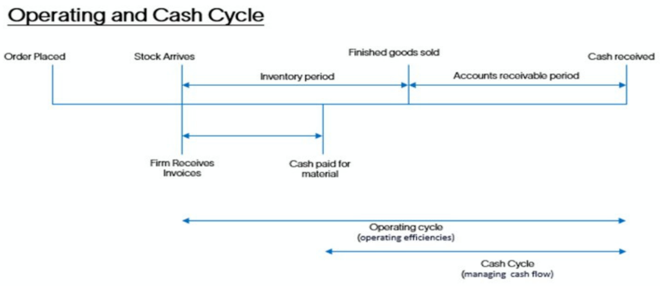

Figure 1. Operating and cash cycle

3.2 Supply Models

Three supply models namely satellite manufacturing, Hub manufacturing, and contract manufacturing is used for this study. The salient features of the three supply models are detailed as follows.

Satellite Manufacturing: The mother plant stays close to headquarters, where the design center is located, and small manufacturing units are built to support local needs in various parts of the world. Input material can come from low-cost countries, and assembly can be done at the point of use.

Hub Manufacturing: The hubs are in a strategic region with a design center that can cover more prominent end-use points with the shortest lead time. Ideally, the location of hub manufacturing needs to be in low-cost countries that are self-sustainable in manufacturing various grades of steel as customers require and can supply skilled Labour to support manufacturing. Countries are selected based on the PPP index, manufacturing capability, and maturity of the supplier base. Supply coming out of hub manufacturing may need to be supported by distribution centers (preferably owned by suppliers) to meet customer needs, resulting in a lower inventory level for customers. The distribution center will help us to optimize the cash flow situation. The Hub manufacturing model will support multiple business lines from one location. It can be internal or external (suppliers), and the scope can be limited to turnkey machined parts, forgings, and castings. Once we reach a maturity level of creating manufacturing hubs for customers, we will also move contract manufacturing under the scope of the hub.

Contract Manufacturing: Design responsibility is with the customer owning design, and the supplier is responsible for manufacturing products utilizing customer design and quality control plan. Sourcing of raw materials is the responsibility of the supplier. This approach enables businesses to reduce costs, achieve faster delivery times, resulting in shorter operating and cash cycles, and foster better supplier relationships.

Figure 2. Supply models: several types of supply strategies

3.3 Commodities Chosen for the Case Study

A gate valve (as shown in figure 3) is considered a final product that will be produced using the three earlier-mentioned supply models. Forgings, Machined Parts, and steel will be used to make the assembly, and each supply model will have its supply network.

Figure 3. Gate valve

Source: https://www.slb.com

Study Assumption I: The gate valve will be assembled in Saudi Arabia using one of our Satellite centres. The manufacturing process of gate valve is detailed in figure 4.

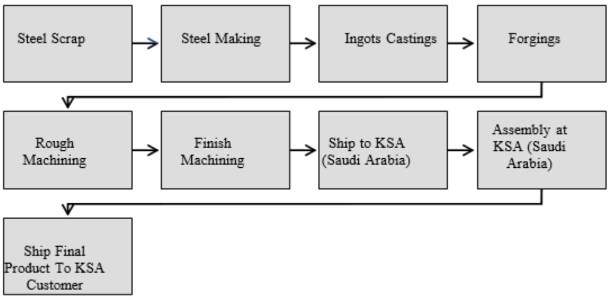

Figure 4. Forged gate valve: the manufacturing process

3.4 Regional Differentiation

Before delving into regional disparities among commodities, it is imperative to grasp the cost structure unique to each manufacturing commodity, a crucial aspect addressed within this investigation. Further understanding various countries' Purchasing power parties (PPPs), labor indices, energy landscapes, and exchange rates is important for incorporating them effectively into the cost analysis models. So, lets understand the geographical footprint of different manufacturing commodities used in gate valves.

3.4.1 Forgings Supplier Base

Global Forgings' market size was valued at USD 84 billion and is to grow at a CAGR (Compound Annual Growth Rate) of 5.0%. Fifty-one percent of the world's output comes from Asia. China and India are Asia's leading producers of forgings, followed by Japan and Korea. About 20% of the world's forgings come from China, and 35% of our forgings' parts come from China. As we see a shift in the US and China relationship, The company understudy, is proactively dual-sourcing all sole-source parts out of China to ensure uninterrupted global supply.

Table 1. Forgings cost models

Raw Material	Energy (USD/MWh)	Labor (Hourly wages)	Others
55%	15%	12%	18%

3.4.2 Castings Supplier Base

The global metal casting market was valued at USD 123.8 billion and is expected to grow at a CAGR of 5.3%. Iron casting is the biggest and constitutes 69.4% of the market share. About 65% of the world's casting is produced in Asia. China has over 25% of the castings (49.4m tons), and21% of casting parts for the company X in this study comes from China.

Table 2. Castings cost models

Raw Material	**Energy (USD/MWh)**	**Labor (Hourly Wages)**	**Others**
47%	20%	16%	17%

3.4.3 Machined Parts Supplier Base

The global machined parts market is valued at USD 353 billion; the expected growth is at 4 - 5.0% CAGR. Key industries - Automotive (31%), Electronics (20%), Construction & Mining (12%), Aerospace (11%), Oil & Gas and others (26%). Thirty-seven percent of the world's output comes from Asia, followed by Europe (29%) and NAM (23%). China($67B) and India($33B) are the primary sources in Asia. As the company see further risks in the US and China relationship, the China+1 Strategy was implemented to proactively dual source China's spending to ensure uninterrupted global supply.

Table 3. Machined part cost model

Raw Material	Energy (USD/MWh)	Labor (Hourly Wages)	Others
41%	5%	35%	19%

3.4.4 Steel Manufacturing Supplier Base

Figure 5 represents contribution of counties to crude steel. China being the number one producer followed by India and Japan.

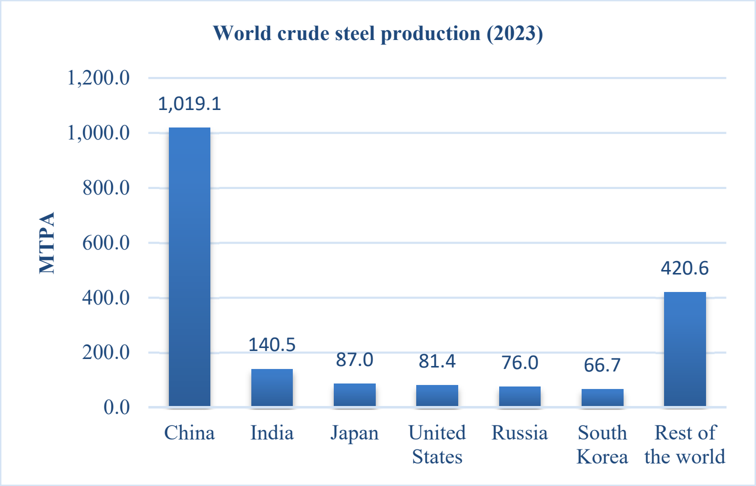

Figure 5. Crude steel production

Source. Worldsteel.org.

India offers the most competitive pricing for low alloy steel, with China and Europe following suit. Given the recent volatility in steel prices, establishing forging and casting operations near these regions can effectively mitigate the impacts of price fluctuations through increased cycle counts and lead times. Selecting forging companies located in India, China, or Europe is crucial to maintaining the lowest possible input steel costs.

3.5 Logistics Cost Between Lanes

Logistics rates are mentioned in table 3, including tariffs between different lanes. These rates do not include land transportation costs from the supplier factory to the port. This data changes quarterly based on the existing situation (congestion situation) between lanes. "Ex Works," means that the seller makes the goods available at their premises, and the buyer is responsible for all transport costs.

Table 4. Logistics cost between lanes

Origin Country	Destination Country	EXW (Ex Works) Cost OH%
China	Mexico	30%
	Romania	22%
	Italy	25%
	USA	42%
	Singapore	10%
	Canada	25%
	Brazil	30%
	UK	10%
	UAE	10%
	Saudi Arabia	15%
	India	15%
India	USA	23%
	Italy	25%
	Romania	30%

	Singapore	21%
	UAE	25%
	China	30%
	Brazil	30%
	Saudi Arabia	15%
Italy	China	20%
	Saudi Arabia	20%
	Brazil	30%
	USA	20%
	Singapore	15%
	Mexico	23%
	Romania	10%
Romania	Saudi Arabia	20%
Singapore	Saudi Arabia	15%
USA	Saudi Arabia	10%

3.6 Forgings Cost Comparison by Region

3.6.1 Study Assumption II

The USA, Romania, and Singapore can buy forgings from India (50%) + China (50%) or Italy, whichever combination is cheaper. Steel for forgings will be sourced from local steel mills in India, China, and Italy by forgings experts. The grade of steel considered for this study is 4130 and F22 (Alloy Steel).

Table 5. Steel grade 4130 vs f22

Grade	**Country**	**$/MT**	**Diff**
4130	USA	1690.5	0%
	China	1370	-19%
	India	1190	-30%
	Europe	1470	-13%
	Brazil	1781	5%
	Singapore	1473.45	-13%
	Romania	1609.2	-5%
Grade	**Country**	**$/MT**	**Diff**
F22	USA	2528.07	0%
	China	1830	-34%
	India	1998	-28%
	Europe	2400	-13%
	Brazil	2379	-14%
	Singapore	2215.29	-20%
	Romania	2415	-13%

	CN to USA	India to USA	Average	Italy to USA
4130: Selection of Forging Source for USA, Singapore & Romania. Brazil to buy from China	$ 1,945.40	$ 1,463.70	$ 1,704.55	$ 1,690.50
	CN to Singapore	India to Singapore	Average	Italy to Singapore
	$ 1,507.00	$ 1,439.90	$1,473.45	$ 1,690.50
	CN to Romania	India to Romania	Average	Italy to Romania
	$ 1,671.40	$ 1,547.00	$ 1,609.20	$ 1,617.00

F22: Selection of Forging Source for USA, Singapore & Romania. Brazil to buy from China	CN to USA	India to USA	Average	Italy to USA
	$ 2,598.60	$ 2,457.54	$2,528.07	$ 2,760.00
	CN to Singapore	India to Singapore	Average	Italy to Singapore
	$ 2,013.00	$ 2,417.58	$ 2,215.29	$ 2,760.00
	CN to Romania	India to Romania	Average	Italy to Romania
	$ 2,232.60	$ 2,597.40	$ 2,415.00	$ 2,640.00

3.7 Machined Parts Cost Models and Regional Differentiation

Based on PPP (Purchasing Power Parity), energy cost, and labor cost, a regional comparison of machining cost is determined based on cost models to measure which region will be more effective when managing the cost and inflation of machined parts. This information is needed as a selection of supply locations is vital (to order lead time and inventory) while selecting the best country for the supply to optimize the operating and cash cycle with the lowest cost. Based on our analysis, Mexico, Romania, India, China, Romania, Brazil, and Vietnam are the best locations when it comes to the lowest machine hour rate for machining operations.

Table 6. Cost difference between USA and the countries

Country	**Per Hour Cost w/o Labor**	**Labor**	**Total Machining Cost per Hour**	**Difference to the USA**
USA	$61.0	$ 3.27	$ 94.2	0%
China	$30.5	$ 6 .79	$37.3	-60%
India	$30.5	$ 2.95	$33.4	-65%
Italy	$ 40.7	$ 24.71	$65.4	-31%
Brazil	$ 30.5	$ 6.52	$37.0	-61%
Singapore	$30.5	$ 24.81	$ 55.3	-41%
Romania	$ 30.5	$ 8.31	$ 38.8	-59%

3.8 Turnkey Machined Parts Cost Comparison by Region

Based on the recommendation on input raw material and forgings source (discussed under forgings cost comparison by region) and machined part source, the comparison below is drawn from derived calculations to show the landed cost difference between countries when a turnkey machined part needs to be delivered to Saudi Arabia (KSA) for assembly of gate valves.

Table 7. Tariff and logistics costs between lanes

Material Grade	**Manufacturing Country**	**Raw Material**	**Final Price after forging and Machining**	**Shipping**	**Total Landed Cost in Saudi**	**Cost of Inventory**	**Reduction From USA Price**
4130	USA	$ 18.70	$ 100.00	10%	$ 110.00	$ 3.44	0%
	China	$ 15.15	$ 54.04	15%	$ 62.15	$ 0.68	45%
	India	$ 13.16	$ 47.88	15%	$ 55.07	$ 0.15	51%
	Italy	$ 16.26	$ 75.24	20%	$ 90.29	$ 0.92	20%
	Brazil	$ 19.70	$ 62.13	15%	$ 71.45	$ 2.51	35%
	Singapore	$ 16.30	$ 68.04	15%	$ 78.25	$ 1.18	30%
	Romania	$ 17.80	$ 59.86	15%	$ 68.84	$ 1.57	38%
Material	**Manufacturing**	**Raw**	**Final Price after**	**Shipping**	**Total Landed**	**Cost of**	**Reduction**

Grade	Country	Material	forging and Machining		Cost in Saudi	Inventory	From USA Price
F22	USA	$ 18.70	$ 100.00	10%	$ 110.00	$ 3.44	0%
	China	$ 12.40	$ 49.03	15%	$ 56.39	$ 0.62	50%
	India	$ 13.54	$ 48.56	15%	$ 55.85	$ 0.15	51%
	Italy	$ 16.26	$ 75.24	20%	$ 90.29	$ 0.92	20%
	Brazil	$ 16.12	$ 55.62	15%	$ 63.96	$ 2.24	42%
	Singapore	$ 5.01	$ 65.70	15%	$ 75.55	$ 1.14	32%
	Romania	$ 16.36	$ 57.25	15%	$ 65.83	$ 1.50	41%

3.9 Analysis of Various Supply Route for Forgings

At part of the study various supply routes for forgings namely: USA to Kingdom of Saudi Arabia (KSA), China to KSA, India to KSA, Italy to KSA and Brazil to KSA, Singapore to KSA, and Romania to KSA are analyzed for the Steel Grade 4130 and F22. The various models used are as follows:

1). USA to Kingdom of Saudi Arabia (KSA)

4130 Forgings from Italy to the USA (Lowest Cost), Machining in the USA, and Delivery to KSA. F22 Forgings, 50% each from India and China to the USA (Lowest Cost), Machining in the USA, and Delivery to KSA.

2). China to KSA

Forgings and Machining in China and Delivery to KSA.

3). India to KSA Forgings and Machining in India and Delivery to KSA.

4). Italy to KSA

Forgings and Machining in Italy and Delivery to KSA.

5). Brazil to KSA

4130 Forgings, 50% each from India and China to Brazil (Lowest Cost), Machining in Brazil, and Delivery to KSA.F22 Forgings, 50% each from India and China to Brazil (Lowest Cost), Machining in Brazil, and Delivery to KSA

6). Singapore to KSA

4130 Forgings, 50% each from India and China to Singapore (Lowest Cost), Machining in Singapore, and delivery to KSA. F22 Forgings, 50% each from India and China to Singapore (Lowest Cost), Machining in Singapore, and Delivery to KSA.

7). Romania to KSA

4130 Forgings, 50% each from India and China to Romania (Lowest Cost), Machining in Romania, and Delivery to KSA.F22 Forgings, 50% each from India and China to Romania (Lowest Cost), Machining in Romania, and Delivery to KSA.

Table 8. Logistics lead time between lanes in days

From	To	Days
China	USA	69
China	Singapore	35
China	Romania	60
China	Brazil	71
China	KSA	40
India	USA	69
India	Singapore	25
India	Romania	56
India	Brazil	65
India	KSA	10
Italy	USA	37
Italy	Singapore	25
Italy	Romania	7
Italy	Brazil	40
Italy	KSA	25
USA	KSA	45
Singapore	KSA	25
Romania	KSA	25
Brazil	KSA	60

3.10 Cost of Capital Considered for this Study

The cost of capital considered for the study is 10 percent per Annum, for example, every $1 in inventory has a lost opportunity equal to $ 0.000274 per day due to the cost of capital equal to10%.

3.10.1 Total Lead Time and Inventory Carrying Cost Calculation

Study Assumption III: Total Lead time (Manufacturing lead time of supplier+ Purchase Order (PO) release time, PO acknowledgment time, Shipping time, Custom clearance time, goods receipt (GR) time in SAP). This study assumes that manufacturing Lead time for raw material, forgings, and machining is constant across all suppliers in different regions; the total inventory impact will be due to variations in shipping, customs clearance, and GR time between other lanes.

In this study, we are focusing on the below factors affecting the inventory level.:

a. Manufacturing lead time

b. Shipping (between lane- ocean). The choice of lanes and custom clearance time will dictate the inventory level at the final assembly site to avoid any stock-out situation and fulfill customer demands.

Table 9. Cost due to cost of capital linked to source selection and inventory position

Material Grade	RM	Forgings	Machining	Finished Product Shipped From	Finished Product Shipped To	Total Lead Time	Cost of Capital per 100$ of shipment	Cost of Capital on Final Source Selection
4130	Italy	Italy	USA	USA	Saudi Arabia (KSA)	82	$ 2.25	2.2%
	China	China	China	China	Saudi Arabia (KSA)	40	$ 1.10	1.1%
	India	India	India	India	Saudi Arabia (KSA)	10	$ 0.27	0.3%
	Italy	Italy	Italy	Europe	Saudi Arabia (KSA)	37	$ 1.01	1.0%
	50% each from India and China	50% each from India and China	Brazil	Brazil	Saudi Arabia (KSA)	128	$ 3.51	3.5%

	50% each from India and China	50% each from India and China	Singapore	Singapore	Saudi Arabia (KSA)	55	$ 1.51	1.5%
	50% each from India and China	50% each from India and China	Romania	Romania	Saudi Arabia (KSA)	83	$ 2.27	2.3%
F22	50% each from India and China	50% each from India and China	USA	USA	Saudi Arabia (KSA)	114	$ 3.12	3.1%
	China	China	China	China	Saudi Arabia (KSA)	40	$ 1.10	1.1%
	India	India	India	India	Saudi Arabia (KSA)	10	$ 0.27	0.3%
	Italy	Italy	Italy	Europe	Saudi Arabia (KSA)	37	$ 1.01	1.0%
	50% each from India and China	50% each from India and China	Brazil	Brazil	Saudi Arabia (KSA)	128	$ 3.51	3.5%
	50% each from India and China	50% each from India and China	Singapore	Singapore	Saudi Arabia (KSA)	55	$ 1.51	1.5%
	50% each from India and China	50% each from India and China	Romania	Romania	Saudi Arabia (KSA)	83	$ 2.27	2.3%

3.11 Assembly Cost Calculation

According to the General Authority for Statistics (GASTAT), the average monthly wage for Saudi workers across four sectors is SAR 10,238. In the private sector, the average monthly wage is SAR 7,339. Given the current exchange rate of 1 USD to 3.75 SAR, this equates to an hourly wage of USD 11.64. Typically, the average number of working days per month is 21, with 8 hours allocated per working day.

Table 11. Labour Cost by country

Country	KSA	USA	China	India	Italy	Brazil	Singapore	Romania
Cost/Hour	$11.64	$33.27	$6.79	$2.95	$24.71	$6.52	$24.81	$8.31

4. Scenario Analysis

To comprehend the effects of supply planning and supply network mapping on operational and cash cycles, Four Scenario are outlined for company X. At the core of these scenarios lies a product containing seven turnkey machined parts must be assembled for company X. These machined parts, identical in nature, are procured from a supplier based in the USA at a unit cost of $100. The assembly process, spanning ten days (equivalent to 80 hours), assemble all seven parts into the final product. Consumables and ancillary components essential for assembly, such as bolts, washers, gaskets, and sealants, are provided to the assembly shop without incurring any additional costs. Importantly, the assembly operation solely entails labor expenses, with no equipment costs factored in. Subsequent to assembly, the final product is destined for delivery to a customer in Saudi Arabia (KSA), with whom Company X has established payment terms requiring settlement within a net period of 70 days following receipt of the product. The supplier payment term of company X is shown in table

Table12. Company X Supplier payment terms(in days) by region

Country	KSA	USA	China	India	Italy	Brazil	Singapore	Romania
Payment Terms	45	50	80	80	60	70	70	70

4.1 Description of the Scenarios considered for the study

The four Scenarios are:

Scenario 1: 1 part purchased from each supplier country and assembled in KSA.

Scenario 2: All parts purchased from the lowest-cost country and assembled in KSA.

Scenario 3: All parts are purchased from China, assembled in China, and delivered to KSA.

Scenario 4: All parts are purchased from India, built in India, and delivered to KSA.

Later, using the Make vs Buy methodology, we will recommend an appropriate supply network mapping to ensure the best cost, operating, and cash cycle.

5. Results and Discussion

The table 13 presents a scenario analysis of assembly costs per hour for a product in different countries. It compares the total assembly cost and part count across four scenarios for various countries.

Table 13. Scenario analysis

Scenario 1

Country	Assembly Cost Per Hour	USA	China	India	Italy	Brazil	Singapore	Romania
KSA	$ 11.64	$ 113.44	$ 62.83	$ 55.22	$ 91.20	$ 73.96	$ 79.43	$ 70.40
Part Count	80	1	1	1	1	1	1	1
Total Cost	$ 931.20	$ 113.44	$ 62.83	$ 55.22	$ 91.20	$73.96	$ 79.43	$ 70.40
Assembly Cost	$ 1,477.67							

Scenario 2

Country	Assembly Cost Per Hour	USA	China	India	Italy	Brazil	Singapore	Romania
KSA	$ 11.64	$ 113.44	$ 62.83	$ 55.22	$ 91.20	$ 73.96	$ 79.43	$70.40
Part Count	80	0	0	7	0	0	0	0
Total Cost	$ 931.20	$ -	$ -	$ 386.53	$ -	$ -	$ -	$ -
Assembly Cost	$ 1,317.73							

Scenario 3

Country	Assembly Cost Per Hour	USA	China	India	Italy	Brazil	Singapore	Romania
China	$ 6.79	$113.44	$ 54.04	$ 55.22	$ 91.20	$ 73.96	$79.43	$70.40
Part Count	80	0	7	0	0	0	0	0
Total Cost	$ 543.20	$ -	$ 378.31	$ -	$ -	$ -	$ -	$ -
Assembly Cost	$ 921.51							
Landed Cost	$ 1,059.73							

Scenario 4

Country	Assemly Cost Per Hour	USA	China	India	Italy	Brazil	Singapore	Romania
India	$ 2.95	$ 113.44	$ 62.83	$ 47.88	$ 91.20	$ 73.96	$ 79.43	$70.40
Part Count	80	0	0	7	0	0	0	0
Total Cost	$ 236.00	$ -	$ -	$ 335.19	$ -	$ -	$ -	$ -
Assembly Cost	$ 571.19							
Landed Cost	$ 656.87							

Scenario 1: Base Scenario: KSA (Saudi Arabia) has the highest assembly cost per hour at $11.64. The part count for each country is 1, with the total cost for KSA being $931.20. The total assembly cost across all countries is $1,477.67.

Scenario 2: Shift to India: The part count shifts to 7 for India, with the assembly cost per hour for KSA remaining at $11.64. The total cost for KSA remains the same at $931.20, but India's total cost increases to $386.53 due to the increased part count. The total assembly cost across all countries is $1,317.73, indicating a reduction from Scenario 1.

Scenario 3: Shift to China: The part count shifts to 7 for China, with the assembly cost per hour for China being \$6.79. The total cost for China increases to \$378.31 due to the increased part count. The total assembly cost across all countries is \$921.51, indicating a further reduction from Scenario 2. The landed cost, which includes additional expenses such as transportation and import duties, is \$1,059.73.

Scenario 4: Shift to India with Lower Assembly Cost: The assembly cost per hour for India is reduced to \$2.95. The part count shifts to 7 for India, with the total cost for India increasing to \$335.19. The total assembly cost across all countries is \$571.19, indicating a significant reduction from Scenario 3. The landed cost is \$656.87, which is lower than the previous scenarios.

Shifting assembly to countries with lower assembly costs per hour, such as India and China, significantly reduces the total assembly cost. The reduction in assembly cost per hour has a more substantial impact on the total cost than the increase in part count. The landed cost considers additional expenses beyond assembly, which can affect the overall cost-effectiveness of the shift. The analysis suggests that shifting assembly to countries with lower labor costs can lead to significant savings in total assembly costs. However, it's essential to consider other factors such as quality, logistics, and additional expenses when making such decisions.

Below is the calculation of DOH/DIO (Days inventory on hand) and cash cycle for different scenarios.

Table 14. Cost comparison

Scenario	1	2	3	4
Cost	$1477.67	$1317.73	$1059.73	$656.87

The table displays a financial comparison across four distinct scenarios, delineating the cost associated with each. In the first scenario, the cost is registered at \$1,477.67. The second scenario shows a slightly reduced cost of \$1,317.73. The third scenario presents a further decrease in cost, amounting to \$1,059.73. Lastly, the fourth scenario indicates the lowest cost among the presented options, which is \$656.87. Thus, the analysis reveals that Scenario four which is a hub-based contract manufacturing, delivers the best cost to company X.

Table 15. Cash conversion cycle

Scenario	1	2	3	4
Days	174	-25	-35	-35

The table provides an analysis of the cash conversion cycle across four different scenarios. In Scenarios 2, 3, and 4, there is an opportunity to relax payment terms with customers and suppliers so that they can improve their cash cycle. Scenario one is not in favor of company X.

6. Conclusion

Choosing the right supply chain model is vital. It is important to acknowledge that scenarios may evolve due to varying inputs and critical decision points. It is thus, imperative for the supply chain team to conduct a detailed evaluation of the overall costs and the time required to meet a customer's demand. This helps identify the most cost-effective and efficient strategy to enhance the company's pricing structure and cash flow. Thus, the supply chain team should constantly review cash conversion cycle numbers based on supply model recommendations to minimize DIO (days of inventory on hand) and maximize DPO (Days of payment outstanding) to keep the cash conversion cycle at the lowest possible level. The research findings indicate that employing a hub-based contract manufacturing approach is the most cost-effective model for midstream and downstream. The study has highlights that fine-tuning the supply network can significantly impact the operational and financial performance of companies, especially in the oil and gas sector. By reducing inventory levels, optimizing supplier payment terms, and streamlining production processes, organizations can achieve cost savings, improve efficiency, and enhance cash flow management. The study underscores the importance of thorough analysis and strategic decision-making in selecting supply chain models to enhance cost efficiency, operational effectiveness, and cash flow management. This study offers a blueprint for refining supply chain strategies to optimize supply chain models to improve cost efficiency and cash flow management, thereby enhancing overall business performance.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Canadian Center of Science and Education.

The journal and publisher adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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