



Procurement and Supply Chain Management

ACEA7011

Improving Supply Chain Performance

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List of Abbreviations

- FMEA - Failure Mode and Effects Analysis
- RPN - Risk Priority Name
- CWM - Coal Water Mixture
- SCV - Supply Chain Vulnerability
- JIT - Just In Time
- SCN - Supply Chain Networks
- SCC - Supply Chain Collaboration
- SCA - Supply Chain Agility
- SCV - Supply Chain Visibility
- SCVe - Supply Chain Velocity

1. Introduction

The global coal industry has come under significant scrutiny to improve supply chain sustainability and performance. Coal is still in high demand, in 2022, coal demand reached a new record high of 8515 Mt, increasing by 4%. The increase was mainly backed by growth in countries that rely heavily on coal, such as China and India (IEA, 2023)

The supply chain for coal is not as straight forward as you may think, it has many variations of complexity which can be detrimental to the company these might involve multiple entities and processes before reaching the client. These various factors can have a major effect on the supply chain management. The factors can be cost, production costs, profit and capital investment, decline in use, fossil fuels are deemed to have a negative impact on the environment etc.

The company could use a management tool called FMEA (Failure Mode and Effects Analysis). The FMEA provides a structured approach to the analysis of root causes (of failure), the estimation of severity or impact, and the effectiveness of strategies for prevention. The ultimate output is the generation of action plans to prevent, detect or reduce the impact of potential modes of failure. FMEA emerged from the US Military in the late 1940s as a tool to improve the evaluation of reliability of equipment, FORD adopted the principle in 1970s, since then it has become a core tool in product development in many organisations and is recommended as a part of an organisation quality management system. (FMEA, CAM 2024)

The FMEA uses a scoring system of 1 -10, with 1 being the lowest score and 10 being the highest, the ranking system is determined by the severity, occurrence, and detection which then calculates the Risk Priority Number (RPN). The RPN provides a numerical result, and offers an intuitive approach to risk assessment, basically the higher the RPN value then higher the risk.

The second part of this research will concentrate on the six steps that will benefit the organisation's international supply chain and provide recommendations to the company to make their international supply chain more resilient and robust.

2. Failure Mode and Effects Analysis

2.1 Background

FMEA is a widely adopted approach for failure analysis and risk assessment. Each step of the FMEA process is crucial for a successful analysis, the risk assessment element is key to zeroing in on the most risk sensitive areas that must be addressed in order to meet the corporation's quality and safety objectives (Relyence, 2020)

The FMEA lists all possible failures and goes into specific detail on why they have or are failing, whereas the RPN provides an easier way to risk assess and develop a mitigation plan.

- **Severity:** Denotes the seriousness of the problem if it happens, with a focus on the consequences. The higher the number, the greater the severity.
- **Occurrence:** Denotes how likely the issue is to occur. To determine the rate of occurrence, look at all of the potential causes of a failure and the chance that those causes will. The higher the number, the greater the probability of occurrence.
- **Detection:** Denotes how easy or difficult it is to identify the problem. A higher rating means an issue is less likely to be detected either by engineers during the test phases of product development. The higher the number, the less likely the failure is detected. (Relyence, 2020)

The coal industry can be affected by many variations for external contributing factors, this is why an FMEA will provide valuable information to the corporation. In the following sections, it will concentrate on the above segments and provide an in-depth description on their purpose.

2.2 Severity

The severity for each description is arrived by the scale of 1 -10 and by its detail, as detailed in Table 1.

Effect	Design in FMEA	Process in FMEA	Ranking
Minor	Results in dissatisfaction by average customer.	Minor disruption / minor effect on production work.	1
Low	Results in comfort and convenience at a reduced level.	Minor disruption in operations (product may require rework)	2-3
Moderate	Results in customer discomfort	Minor disruptions in operations (no sorting but some scrap).	4-6
High	Makes product operable at reduced performance (customer dissatisfaction).	Minor disruption in operations (May require sorting and some scrap).	7-8
Very High	Makes produce inoperable. Affects safe operation with warning. Affects safe operation without warning.	Major disruption in operations (100% scrap). May endanger machine or operator with or without warning.	9-10

Table 1: Severity Classification FMEA, 2024

2.3 Occurrence

The occurrence for each description is also worked out on a scale 1 to 10, with 1 being remote, so it has very little chance of occurring whereas 10 is almost inevitable it will happen, as detailed Table 2.

Effect	Description	Failure Rates	Percentage Defective	Ranking
Remote	Failure is eliminated through preventive control.	≥ 1 in 1,500,000	0.000007%	1
Very Low	No observed failures associated with almost identical design.	1 in 150,000	0.0007%	2
Low	Only isolated features associated with almost identical design.	1 in 15,000	0.007%	3
Moderate	Isolated, occasional & frequent failures associated with similar designs.	1 in 400	0.25%	4-6
High	Failure is uncertain & likely with new design, new application, or change in duty cycle / operating conditions.	1 in 20	5%	7-8
Very High	Failure is evitable with new design, new application, or change in duty cycle / operating conditions. New technology / new design with no history.	≥ 1 in 2	50%	9-10

Table 2: Occurrence Classification FMEA, 2024
(Lean Six Sigma, 2024)

2.4 Detection

Detection in FMEA works on the assumption that the potential failure will be caught or detected before reaching the end user. The existing detection mechanism for each identified failure mode is also evaluated to know whether the failure can be detected through the existing system / process or not.

Ratings are now reversed from Severity and Occurrence, the colours in Table 3 will change from the previous tables. Ratings are given on a scale 1 to 10, with the failures most likely to be detected getting the lowest ratings and high ratings given to those failures which cannot be detected by the present control methods. (AIG, 2024)

Effect	Design FMEA Detection	Process FMEA Detection	Ranking
Very High	Design control will almost certainly detect cause mechanism and subsequent failure.	Current control almost certain to detect cause mechanism and failure mode.	1
High	Very remote chance that design control will detect cause mechanism and subsequent failure.	High chance that process control to detect cause mechanism and subsequent failure.	2-3
Moderate	Moderate chance that designs control will detect cause mechanism and subsequent failure.	This will remain the same as Design.	4-6
Low	Low chance that designs control will detect cause mechanism and subsequent failure.	Low chance that process control to detect cause mechanism and subsequent failure.	7-8
Very Low	Vey Low / No chance that design control will detect cause mechanism and subsequent failure.	No known process control to detect cause mechanism and subsequent failure.	9-10

Table 3: Detection Classification FMEA, 2024

2.5 Risk Priority Number

The RPN is calculated as Severity x Occurrence x Detection. Using a 1 to 10 scale for each factor results in RPN values ranging from 1 to 1000. Table 4 illustrates the RPN classification.

Risk Level	Numerical Range
Low	0-96
Medium	97-196
High	197-1000

Table 4: RPN Classification FMEA, 2024

2.6 Failure Mode and Effects Analysis on the Supply Chain of Coal

Legend	
SEV	Severity
OCC	Occurrence
DET	Detection
R.P.N	Risk Priority Number

POTENTIAL FAILURE MODES & EFFECTS ANALYSIS (F.M.E.A) Title: Failure Mode and Effects Analysis on Coal Supply Chain						Team: Davies Mining Company					FMEA Ref: DMC Rev 1
No.	Function Description	Potential Failure Mode	Potential Effect of Failure	SEV	Potential Cause of Failure	OCC	Current Controls	DET	R.P.N	Recommended Actions	Responsibility / Target
1	Mining	Exposure to dangerous working conditions.	Serious health and safety concerns to workers.	8	Inadequate protective equipment	4	Use of up-to-date PPE	5	160	Frequent monitoring to ensure workers are safe.	Coal Mining Corporation
2					Inadequate training and education	4	None	5	192	Workers need to be trained to a high compliant standard.	
3					Lack of proper ventilation	6	None	5	240	Company needs to provide adequate ventilation system.	
4		Non effective Mining procedures	Wasted Resources	6	Lack of Experience	7	Create network communications with other mining companies	7	294	Investment in education to learn newer technologies	Coal Mining Corporation
5			Increased Costs	6	Insufficient or outdated equipment	7	Regular inspections	5	210	Automated mining services which will prevent production wastage.	
6		Faulty Equipment	Loss of production	6	Poor Inventory	7	Important to keep correct and updated inventory	6	252	To install inventory system (Kanban).	

7	Mining		Unplanned downtime	6	No PPM (Pre Planned Maintenance)	8	Planned maintenance checks	7	336	To critically assess & test faulty equipment, to prevent further breakdown.	Coal Mining Corporation
8		Environment impact and regulatory compliance	Fines	7	Insufficient attention to environmental concerns	5	Regular audits of mining operations	6	210	Provide sufficient training to employees	Coal Mining Corporation
9			Legal action	8		5		6	240	Monitoring systems can track facility services	
10			Reputational damage	8	Poor community engagement	3	Need to improve	5	120	Need to engage with local communities to gauge an understanding.	
11		Poor Occupational H&S conditions	Risk of Accidents	8	Inadequate safety equipment	6	Conduct regular inspections and audits.	4	192	Professional H&S training.	Coal Mining Corporation
12			Injuries	8		5	Safe systems of work.	4	160	To be recorded to prevent future injuries.	
13			Fatalities	10		2	Frequent tests for employees	4	80	High monitoring of H&S stats.	
14		Political Instability	Supply chain breakdown	5	Social Unrest	5	To be assessed	5	125	Frequent political monitoring	Coal Mining Corporation
15			Operational Challenges	5	Conflict	4	To be assessed	5	100	Local community engagement	
16		Regulatory compliance	Fines	8	Poor regulation standards	3	Carry out regular internal audits	7	168	Instruct strict compliance on policies and procedures.	Coal Mining Corporation
17			Profitability and sustainability	7	Lack of resources to comply with regulations	3	Install software that allows all data to be recorded.	5	105	Engage in consultation to provide professional guidance.	
18		Financial Impact	Product demand	5	Poor market research	8	Coal cost in a volatile market	2	80	Market value to increase / decrease.	Professional Financial Guidance

										Financial trading assessments	
19	Marketing / Business	Delays	Missed deadlines	5	Transportation disruptions	7	Developing contingency plans for potential delays	7	245	Investigations and analysis on why deadlines are missed, prevent future delays.	Professional Financial Guidance
20			Poor customer services	5	Customs clearance issues	8	To provide all relevant shipping do customs	6	240	Keep up to date with changing requirements.	
21			Lost business opportunities	6	Supply chain inefficiencies	5	Improve communications	7	210	Regular auditing of suppliers	

Table 5: Failure Mode Effects Analysis on the Supply Chain of Coal, 2024

3. Six Steps to Improve the Resilience of The International Supply Chain

3.1 The future of Coal

Coal has become a very reliable natural resource, especially as a power plant. Coal is very easy to distribute and does not require a special place to store it. It is calculated that at least 30% of the world's energy and 40% of the energy sources for power generation use coal as the main material. Coal has many benefits such as:

- **Produce Gas:** Natural gas derived from coal is obtained naturally from the ground using advanced technology. The coal is processed to make various products such as industrial fuel, hydrogen products, diesel products and gas power plants.
- **Supporting Industrial Aluminium Products:** Coal can produce natural gas while it is still underground. Then the gas and heat of coke from coal can separate some steel products to form aluminium products.
- **Assisting with Cement Production:** Coal is a raw material for the manufacture of cement. Although it is not used as a raw material for cement production, coal is used in the combustion process to make cement.
- **Transportation Fuel / Other Minerals:** Transportation fuels such as Coal Water Mixture (CWM) which is fuel mixture between coal and water with the help of additives to form a homogeneous and stable viscous suspension can be used as a substitute for fuel oil (BBM). (AMB empowering energy, 2024).

To develop a robust supply chain resilience then the ability and time need to recover the supply chain's original shape and level of performance following a disruption. Disruptions could come in many forms such as natural disasters i.e. Earthquakes, Volcanic eruptions, Landslides, Tsunami's and river flooding, Industrial action, Terrorist Attacks by land, sea and air to name but a few.

3.2 Step One: Supply Chain Vulnerability

There are many factors that contribute to Supply Chain Vulnerability (SCV), there needs to be a focus on efficiency rather effectiveness, the globalisation of supply chains can frequently change due to stocks and shares and market volatility, there is a need to have focused factories to central distribution. Coal can be mined in most countries around the world, so there is a need to have a network of central global delivery points, SCV could come down to the lack of transparency and control procedures.

SCV can be affected by JIT deliveries, stockless production, lean manufacturing & operation systems, increasingly complex supply chain networks (SCN). Other contributing factors are corruption (fraud), quality failures, Taxes, lack of visibility in the supply chain, difficult to forecast the need for the product – coal is still in global high demand.

Supply chain vulnerabilities can significantly impact their operations in several ways:

- 1) Operational Disruptions. Risks like transportation delays, natural disasters, or cyberattacks can lead to operational disruptions, causing delays, missed deadlines, and increased costs.
- 2) Reputational damage, inefficient risk management can tarnish the reputation of freight forwarders, leading to loss of customers and decreased competitiveness in the market.
- 3) Financial losses: Supply chain disruptions can result in financial losses, including penalties, fines, additional storage costs, and damaged or lost product.
- 4) Customer dissatisfaction: Delays, inadequate communication, or compromised quality due to SCV can lead to dissatisfied customers, impacting long-term relationships and future business opportunities.

3.3 [Step Two: Mitigating Supply Chain Risks](#)

Mitigating supply chain risks requires a proactive approach and effective risk management strategies. Here are three important strategies that can help logistics service providers mitigate common supply chain risks:

- **Protect your business with Adequate Insurance Coverage.** Insurance plays a crucial role in mitigating supply chain risks by providing financial protection against potential losses. Consider obtaining freight forwarder insurance policies tailored to your specific needs, such as cargo insurance, liability insurance, errors and omissions insurance. These policies can help cover risks related to damaged goods, theft, liability claims and professional errors.
- **Use Freight Software for Enhance Visibility and Control.** Supply chain software is an important enable of visibility and control over the entire shipping process. Freight software solutions that offer real-time tracking capabilities, robust reporting features, warehouse inventory management, and integration with various stakeholders in the supply chain. The more you can consolidate and streamline systems to avoid manual errors, the better off you are in terms of reducing risk.
- **Establish a Proactive Risk Management Culture.** Foster a risk-aware culture within your organisation, encouraging employees at all levels to identify and report potential risks. Promote a proactive mindset that emphasises continuous improvement and risk mitigation. Employees should be trained on risk identification and mitigation, invest in employee training programs that educate staff on identifying and addressing supply chain risks. Collaborate with trusted suppliers, customers, and service providers who share your commitment to risk management.

3.4 [Step Three: Supply Chain Collaboration](#)

The complexity and interconnected nature of today's supply chains makes them more prone to severe impacts from disruptions. In response to disruptions, supply chain resilience has become a priority for enterprises. Supply chains need to be able to handle disruptive events without breaking. To manage that feat, they need to get better at collaboration.

Supply chain collaboration is about coordinating with internal departments and external partners to sustain an optimized flow through the supply chain. It means establishing real-time shared visibility and processes with supply chain partners to facilitate identification and resolution of issues.

To resolve issues in the most efficient manner, supply chain teams should be able to share information with stakeholders and collaborate with the right people at the right time. To do that, they need the right tools and workflows in place to make that collaboration seamless across all parts of the supply chain. (GEP, 2024)

Collaboration has two dimensions: vertical collaboration between suppliers and customers, and horizontal collaboration between competitors and other supply chain actors. This is illustrated in Figure 1 below. Vertical collaboration is more common and easier to implement than horizontal collaboration. However, supply networks that achieve both will gain significant business benefit.

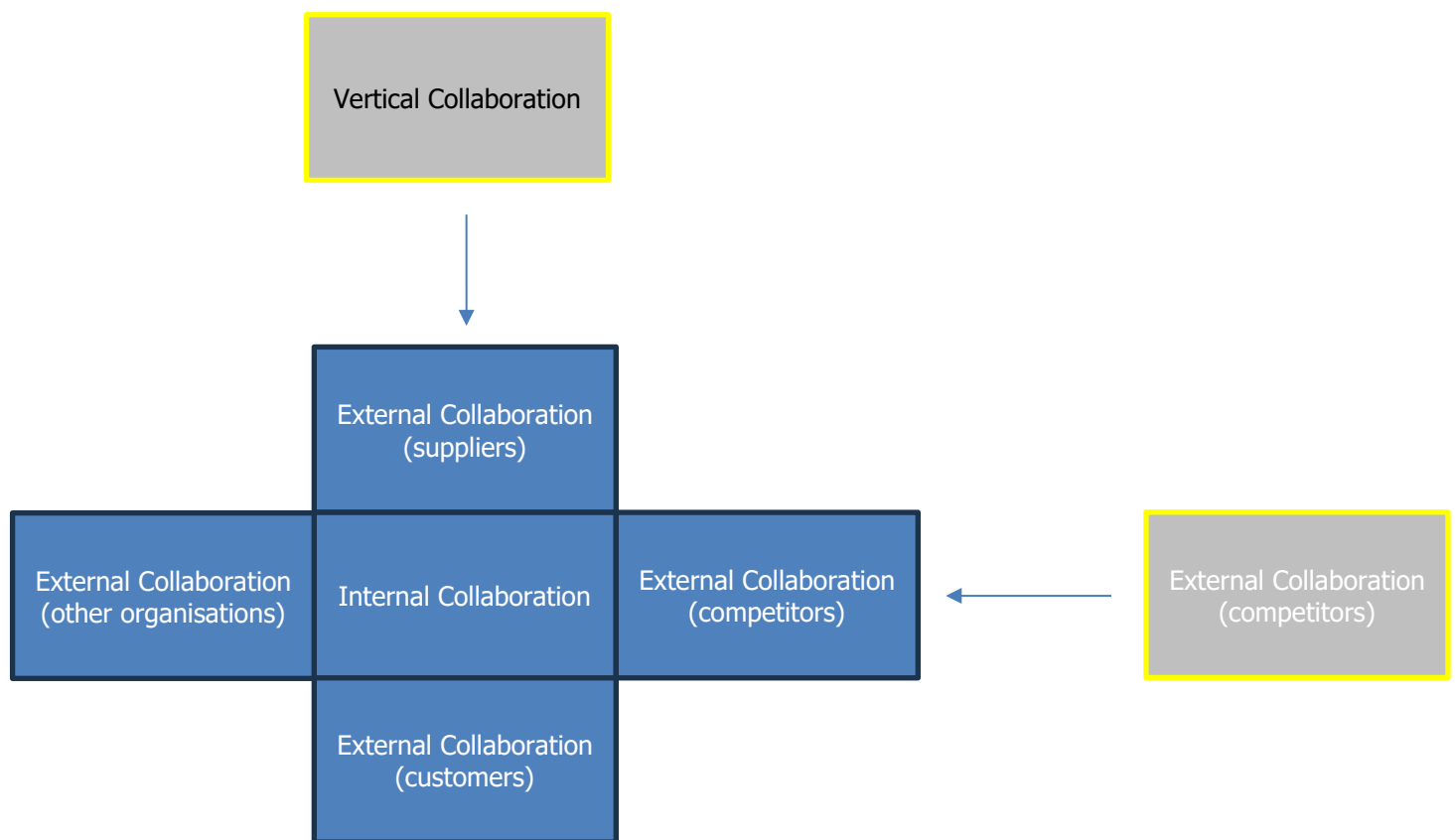


Figure 1: The two dimensions of collaboration, Wiley 2016

3.5 Step Four: Supply Chain Agility

The Supply Chain Agility (SCA) is to respond to changes in demand or supply, it is the ability to respond efficiently and avoid making harsh / ill-timed reactions / decisions to fluctuations in consumer demand as well as the effects of market vulnerabilities such as geopolitical crises, shortages of labour or raw materials, and acts of nature.

SCA is to move quickly and easily goods. In a supply chain, the goods to handle variations in the market, demand and supply while capitalizing on new opportunities. The goal is to remain informed and flexible in the face of economic uncertainty.

The SCA tends to require high responsiveness and the ability to forecast capacity accurately, rather than predicting the next hit product, and being prepared to switch into high-priority production when the time comes. The challenge for the Mining company is to know how to satisfy their customers as they migrate from predictable to unpredictable operating environments.

Following the events of the Covid-19 pandemic then it has highlighted the fact that most supply chains are incredibly static. As manufacturing centres in Asia closed down and shipping ground to a halt, most company's supply chains went into freefall as they struggled to nearshore or desperately tried to onboard new suppliers.

Even outside of sudden global pandemics, the way that customers are influencing supply chain logistics is changing. Companies like Amazon have grown exponentially based on their ability to provide unparalleled customer choice and rapid response delivery. In turn, customers have come to expect companies to fulfil their demands, rather than simply making do with what has already been brought to market. An agile supply chain allows companies to be both internally and externally flexible. Internally, businesses are able to transform their supply chain when the need arises, and externally, they are able to rapidly deliver on customer demand and take full advantage of short profit windows, giving them a significant competitive advantage. (Jiga, 2024).

3.6 Step Five: Supply Chain Visibility

Supply Chain Visibility (SCV) is the ability to see all stages of the supply chain from one end to the other (both upstream and downstream). The upstream process is getting materials to the manufacturer, while the downstream process is getting products from the manufacturer to the client. It is important to note that these two processes work different, they do however affect one another. The image below in Fig 2. Illustrates the process.

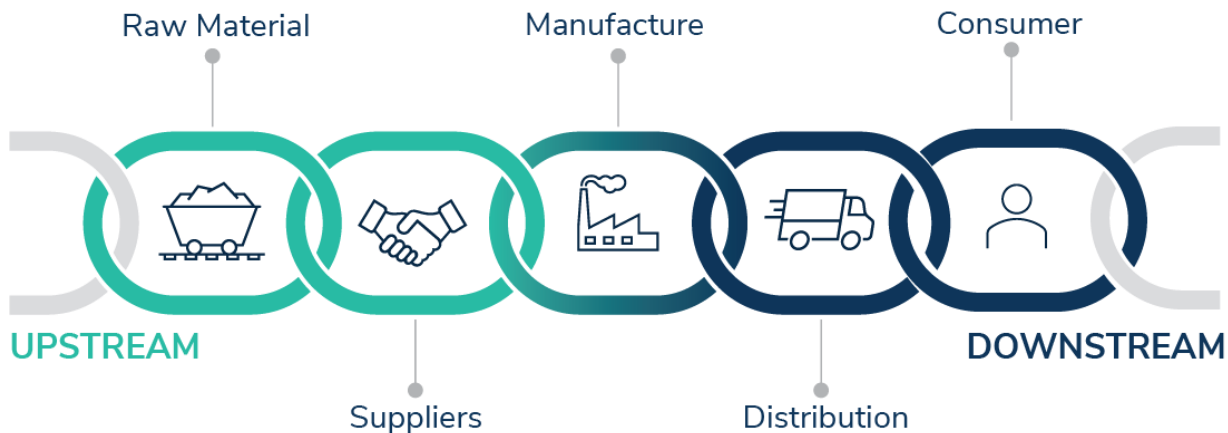


Figure 2: Upstream / Downstream Process, Youredi, 2024

SCV helps you track different goods and / or products in transit, giving a clear view of the inventory and activity. It enables shippers to improve customer service and cost controls through management of inventory in motion, proactive status updates, limited disruptions, and risk mitigation. As a result, the supply chain will become stronger and more agile in the process of having good visibility. (Robinson, 2023).

- Sharing information and data is beneficial to the corporation as you share information between the tiers of the supply chain.
- Interruptions in the supply chain can lose control over the incoming supply network due to the breakdown of visibility.

There are many key benefits of SCV these can be all lead to improved workflow, and increased profits. The corporation will benefit from having better visibility which allows to cut costs for their clients and reduce risks.

The corporation could benefit from mitigating disruptions, if they can be predicted then the chances of them causing issues are decreased. When data is heavily recorded and shared then it will limit potential breakdowns and issues.

As the corporation needs to be agile in the market, then SCV will allow the corporation to be one step ahead of its competitors and boost productivity. The business revolves around meeting customers demand, as without their customers then the business will fall, so with being said then the supply chains need to be flexible, pro and reactive and act fast rather than respond slowly would be the course of action.

3.7 [Step Six: Supply Chain Velocity](#)

Supply Chain Velocity (SCVe) is the time taken for the initial inputs to the supply chain to reach the end-user. In reality, the client will be more interested in the time taken from when it places the order until it receives the coal. *“SCVe is defined as the ability to complete an activity as quickly as possible (Carvalho et al., 2012). Velocity can also be explained as distance over time thus to increase velocity, time must be reduced i.e. to – end pipeline time or the total time it takes to move products and materials from one end of the supply chain to the other”* (Christopher & Lee, 2004).

SCVe refers to the speed at which activities within the supply chain are completed, as well as the speed at which orders move through the supply chain, from processing to consumers arrival.

SCVe allows for the speed of each supply chain stage and process, this includes procurement, production lead times, warehouse storage and costs, inventory management, ordering processing and logistics. The SCVe shortens order cycle time, reduces delays and lead times and streamlines the supply chain process, this in turn results in customers receiving orders at a much quicker time.

The importance of SCVe cannot be understated, there are many contributing factors to make sure the supply chain is managed effectively and including a strong velocity to the manifest is only a beneficiary to the organisation.

SCVe enhances customer satisfaction, modern day consumers are used to instant results and gratification, they expect orders to be delivered ASAP. A high velocity supply chain ensures that products / materials are available when and where customers need them, leading to improved customer satisfaction and loyalty.

A huge incentive for the corporation to include SCVe would be optimized inventory system, velocity is the solution to excessive inventory levels. This is achieved by streamlining processes and reducing lead times, this will allow the corporation to maintain lean inventories without the risk of stockouts. As for any business / company their main drive is to maximise profit and minimise cost, if they can move their product quickly through the supply chain, there's less room for inefficiencies, such as excess storage costs, obsolescence, and overproduction.

Rapidly changing market and customer dynamics require the corporation to adapt swiftly. A high-velocity supply chain enables the business to adjust their production and distribution strategies in real time, ensuring that they stay competitive and capture emerging trends. (Forbes, 2024).

4. Conclusion

The aim of this report is to carry out an FMEA risk assessment on the Coal and how it affects the international supply chain. By the author carrying out the FMEA risk assessment then it has alerted the reader to the issues that might come within the industry and has flagged up the contributing factors in how external parties can have a negative impact on the assessment.

The author wanted to discover what the overall purpose of the FMEA was to achieve, the FMEA is to take actions to eliminate or reduce failures, starting with the highest-priority ones, FMEA also documents current knowledge and actions about the risk of failures. The author has concluded that the FMEA is used in the early stages of the company to prevent failures but as the company grows then the FMEA is used for control. It is a structured way to identify and address potential problems, or failures and their resulting effects on the system or process before an adverse event occurs. The FMEA can be a very effective management tool which allows the users to pay attention to high-risk areas of the service they provide. By the FMEA addressing the potential effects and causes of failures, their severity and occurrence then it allows the company to address them accordingly and successfully.

The completed FMEA has alerted the mining company to many areas of concern, however it appears that the most contributing factor is the exposure to dangerous working environment with ill-affected Health & Safety procedures, the driving force for a successful outcome would be to dramatically improve working conditions, training and supervision, have qualified people working on qualified skilled jobs.

The mining company will also need to concentrate on the six steps to make sure its international supply chain becomes more resilient. It is essential to identify how to important it is to diversify suppliers and utilise modern and available technologies to track and monitor supplies which in turn will mitigate risks and decrease the supply chain vulnerability.

The corporation has to improve on its legislative and regulatory standards, the information they share between local governing and parliamentary bodies, there is a need to build a culture of risk management across the suppliers, to improve their alert and warning systems which will increase productivity.

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