Artificial Intelligence for Business Intelligence

Week 6: BI for Supply Chain Management

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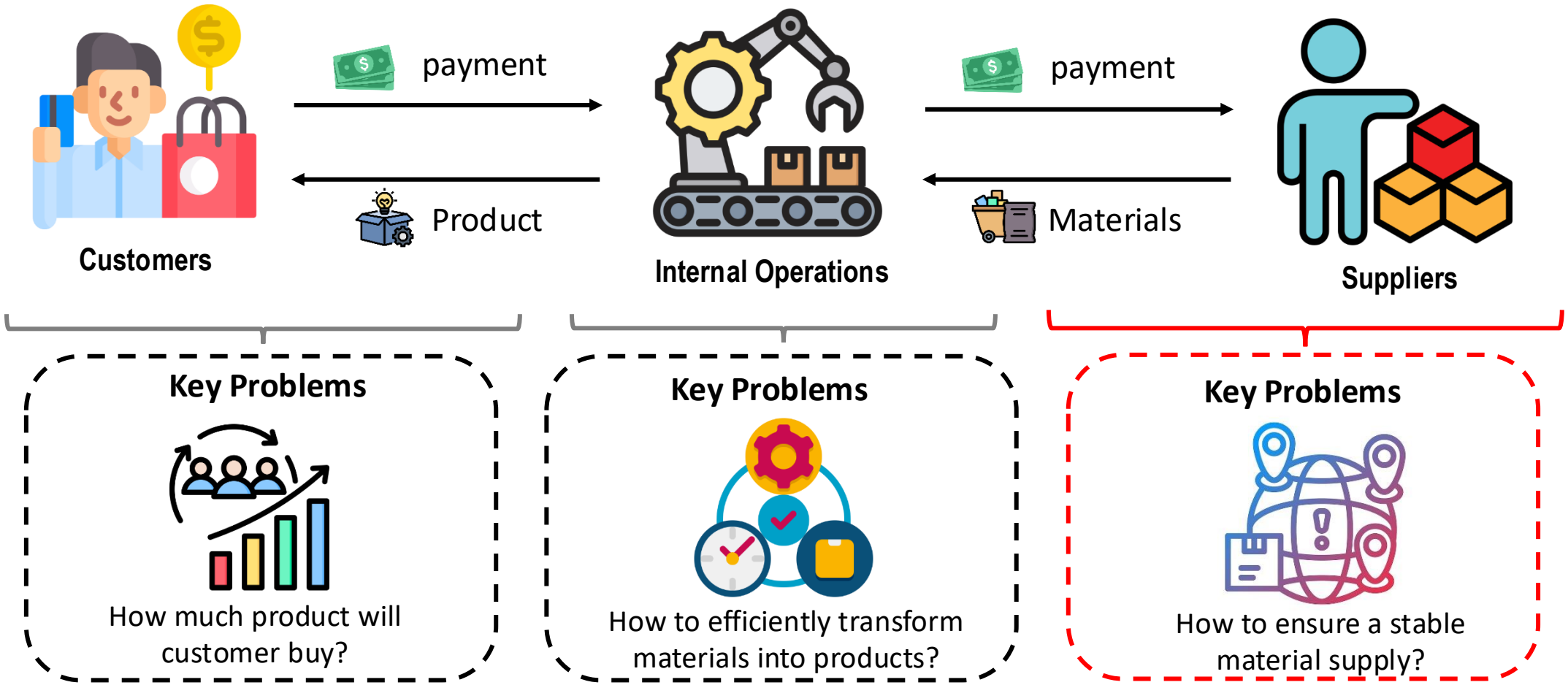
Online M.S. in AI for Business

Today’s Learning Objectives

- Understand the background and concept of supply chain risk management and supply chain resilience.
- Describe the key challenges in addressing the supply chain visibility gap and identifying risk propagation.
- Understand the data sources to build the supply chain network and identify risk signals.
- Explain the common AI methods for supply chain analytics and their corresponding data characteristics.
- Understand how supply chain analytics delivers business value through dashboards and risk treatment decisions.

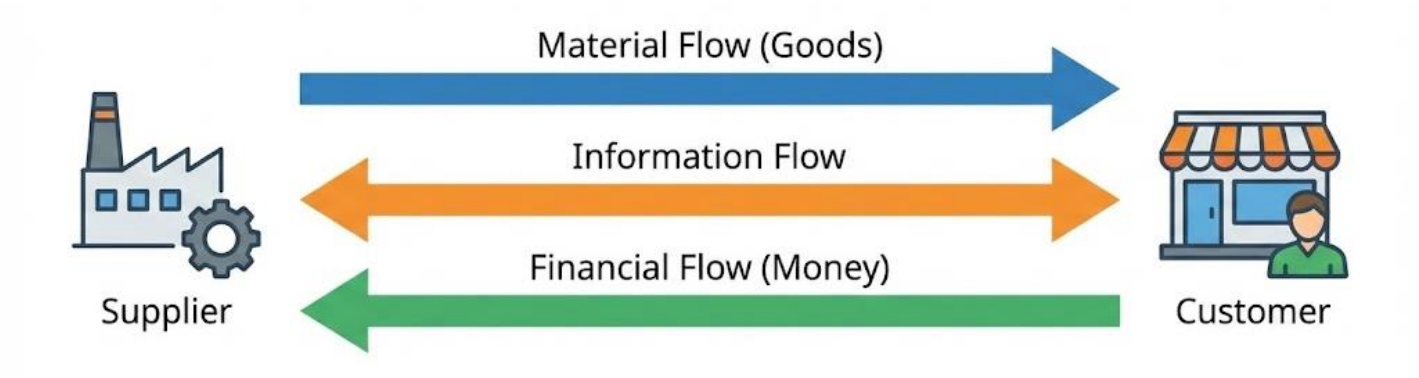
Business Operation



Supply Chain

- Suppliers provide goods for a company to support its business operations.

- Three distinct types of flows exist between a company and its suppliers:
  - **The Product Flow:** The movement of goods.
  - **The Financial Flow:** The movement of capital, credit terms, and payments.
  - **The Information Flow:** The bidirectional exchange of orders, demand forecasts, and delivery statuses.



Supply Chain

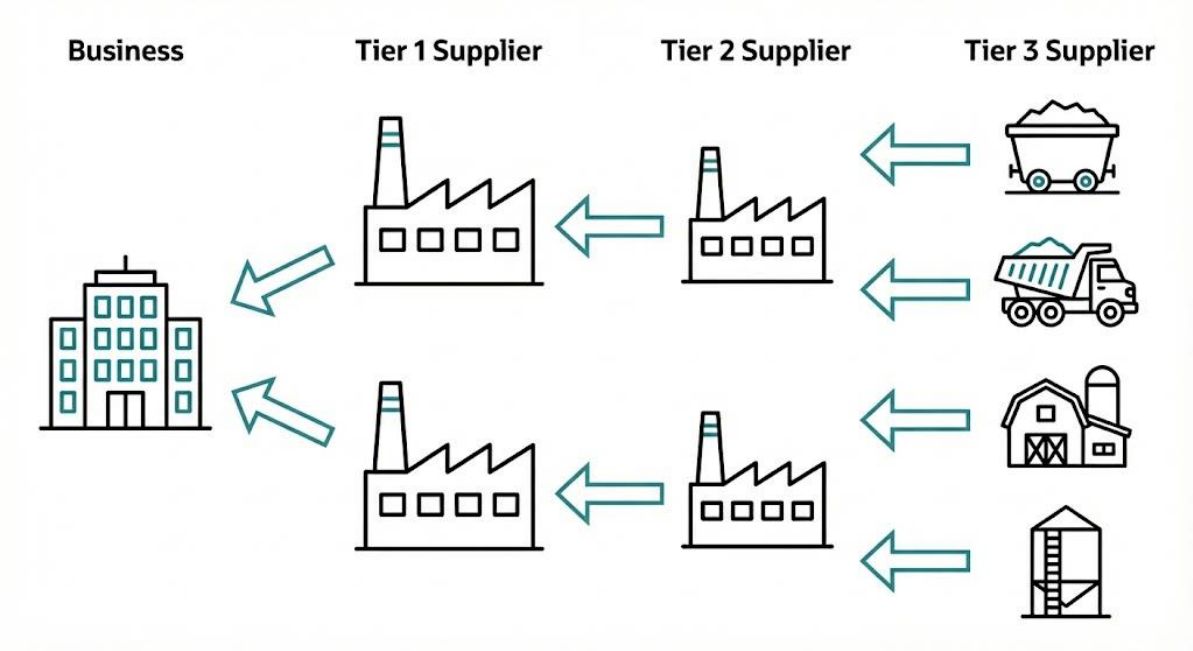
- A company usually has many suppliers, each providing a distinct type of goods.
  - To produce these goods, suppliers rely on upstream partners (suppliers' suppliers).

- For example, to assemble an **iPhone**, Apple has to source the **A19 chip** from TSMC, **OLED display** from Samsung Display, and **Camera Sensors** from Sony.
  - To manufacture those chips, TSMC has to source **silicon wafers** from GlobalWafers.

- These relationships form a complex and highly interdependent structure, commonly known as a **supply chain**.

Supply Chain – The Tiered Structure

- A supply chain is often in a tiered structure**:**
  - **Tier 1 Suppliers:** direct partners that we have a contract with and talk to every day.
  - **Tier 2 Suppliers:** provide goods for tier 1 suppliers
  - **Tier 3 and Higher-tier Suppliers:** usually provide the sub-components and raw materials (e.g., metal, chemicals, energy)



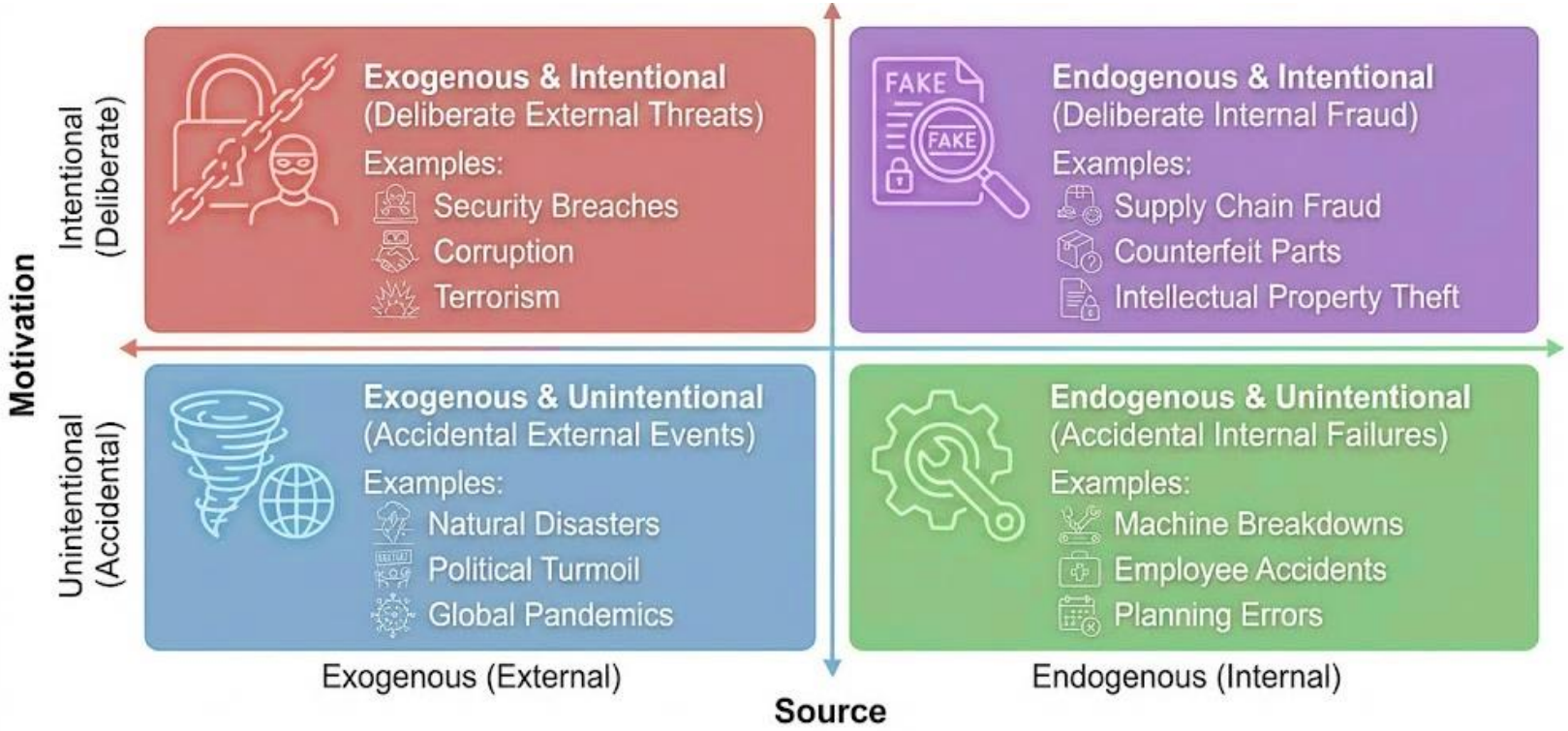
Supply Chain – The Tiered Structure

- Most companies have high visibility into Tier 1 (T1) suppliers as they have close interaction with them.

- However, Tier 2 and beyond is often a black box, creating potential risks in the supply chain.

Supply Chain Risks

- **Supply chain risks** refers to probabilistic event could disrupt the flow of goods, information, and money.
  - These risks can be classified by their **source** and **motivations**.

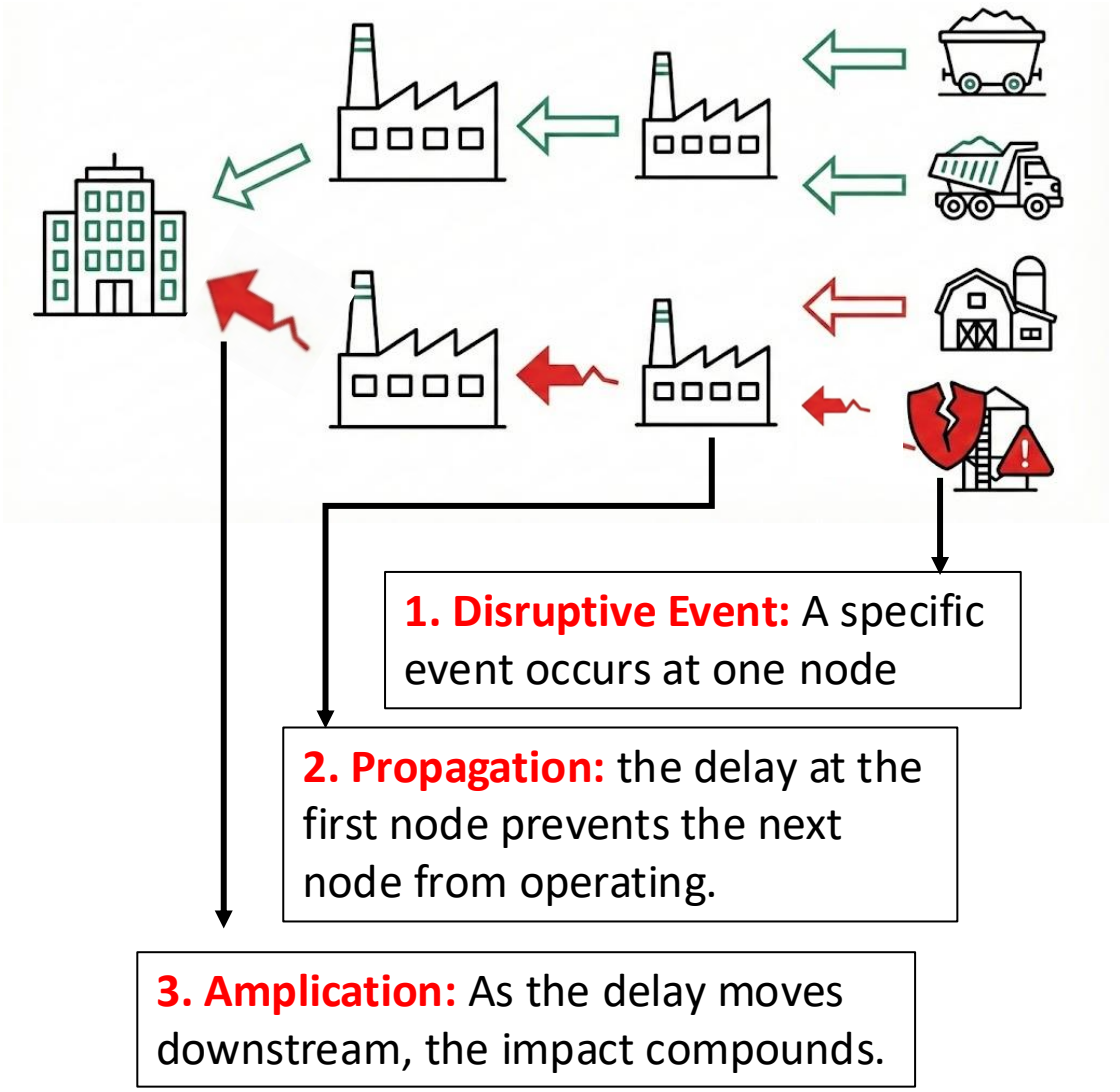


Reference: Wicaksana, A., Ho, W., Talluri, S., & Dolgui, A. (2022). A decade of progress in supply chain risk management: risk typology, emerging topics, and research collaborators. *International Journal of Production Research*, 60(24), 7155-7177.

Supply Chain Risks

- When supply chain risk materializes, it can trigger **disruption** through the **ripple effect.**
  - E.g., border closures, statewide lockdowns, or workforce limitations.

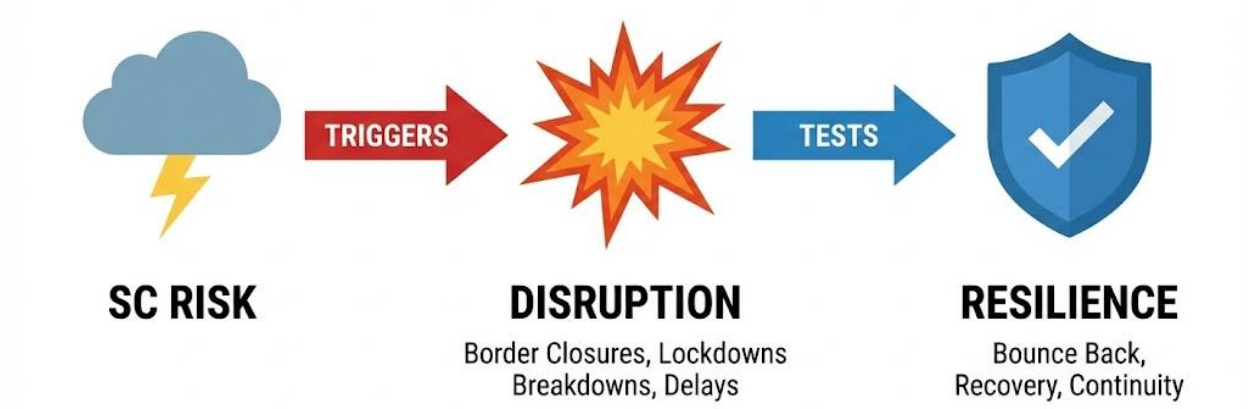
- The ripple effect refers to the propagation of disruptions from one node (i.e., a supplier) across other companies in the supply chain network.



Supply Chain Risks

- Disruptions caused by the ripple effect can often result in physical breakdowns, delays, material shortages, or increased costs.
  - A two-day delay at a chip manufacturer might lead to a two-week delay at a car assembly plant, eventually leading to a two-month backlog for the dealership.

- To reduce the impact of such disruption, companies need to maintain **supply chain resilience.**



Supply Chain Resilience

- **Supply chain resilience** refers to a supply chain's adaptive capacity to deal with disruptive events and swiftly regain previous performance levels.
- Resilience provides the capacity to predict and proactively monitor threats and disruptions.
- Resilience ensures a **continuous flow** of critical supplies and services even in turbulent environments by minimizing the consequences of disruptions.

Supply Chain Resilience – Principles

SUPPLY CHAIN REENGINEERING	SUPPLY CHAIN COLLABORATION	SUPPLY CHAIN AGILITY	RISK MANAGEMENT CULTURE
Definition: Radical redesign of structures & processes for resilience & performance.	**Definition:** Significant work with entities for mutual benefit.	**Definition:** Capacity to respond quickly to unpredictable changes.	**Definition:** Risk identification & management at all organizational levels.
Goal: Balance redundancy & efficiency; optimum resource utilization.	**Goal:** Mitigate risks via timely information & decision sharing.	**Goal:** React faster to mitigate disruption effects.	**Goal:** Sensor threats & reduce response time.
Drivers: Redesigning network structures, reducing complexity & length.	**Drivers:** Vertical & horizontal sharing of knowledge, risk, revenue.	**Drivers:** Improving visibility, maintaining flexible operations, increasing responsiveness.	**Drivers:** Top management support, specialized training, generalized risk awareness.

Reference: Belhadi, A., Kamble, S., Fosso Wamba, S., & Queiroz, M. M. (2022). Building supply-chain resilience: an artificial intelligence-based technique and decision-making framework. *International journal of production research*, *60*(14), 4487-4507.

Supply Chain Risk Management

- **Supply Chain Risk Management (SCRM)** is a proactive approach to maintain supply chain resilience.
- **Goal**: to identify and assess risks to help make informed decisions (e.g., targeted risk mitigation).
- A robust SCRM framework enables:
  - **Visibility** in not just from T1 suppliers, but also T2 and T3 for hidden vulnerabilities
  - Insights into **probability** and **impact** of disruptions (from the ripple effect)
- Managers can **prioritize** where to allocate the limited risk treatment budget.

Reference: Fan, Y., & Stevenson, M. (2018). A review of supply chain risk management: definition, theory, and research agenda. *International journal of physical distribution & logistics management*, 48(3), 205-230.

AI in Supply Chain Risk Management

- Effective SCRM requires incorporating **large volumes** of **qualitative** (e.g., reports) and **quantitative** data (e.g., financial indicators).
  - As supply chains grow more complex, uncertainty increases, necessitating a corresponding increase in data processing.

- Artificial intelligence has emerged as a potential tool due to its ability to process diverse formats and integrate multiple data sources

- The AI4BI development process can be applied to guide the AI development in SCRM.

Reference: Mithas, S., Chen, Z. L., Saldanha, T. J., & De Oliveira Silveira, A. (2022). How will artificial intelligence and Industry 4.0 emerging technologies transform operations management?. *Production and operations management*, *31*(12), 4475-4487.

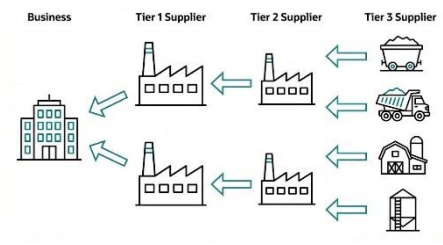
AI4BI Development Process in SCRM

SCRM Problem Identification

Visibility Gap

Risk Propagation

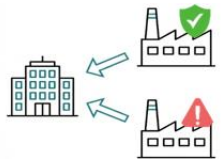
Data Collection and Extraction



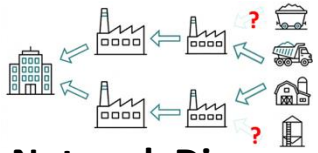
SC Network

Risk Signals

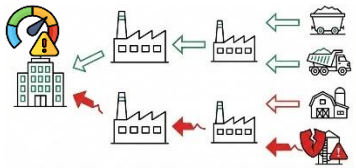
AI-enabled Analytics



Supplier Risk Profiling



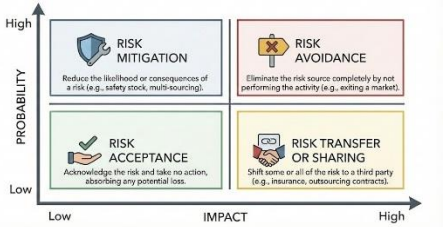
Network Discovery



Risk Propagation Analysis

Value Delivery

Visualization

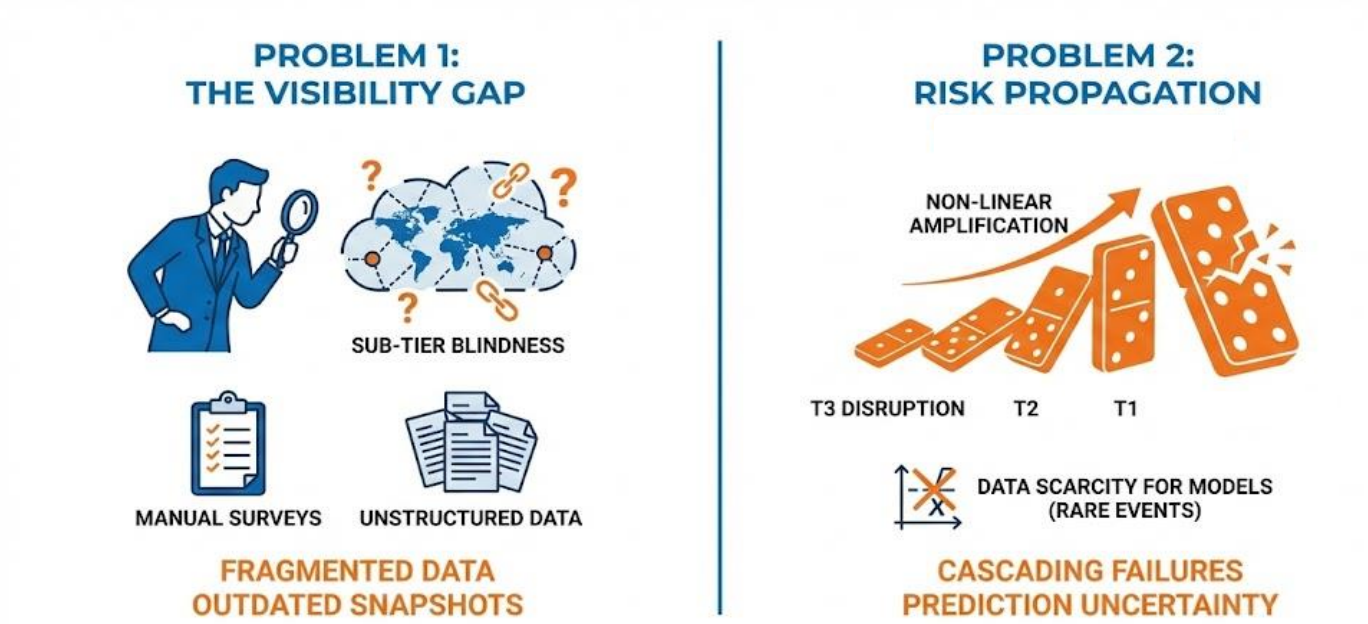


Risk Mitigation Decisions

Monitoring risks helps identify new SCRM business problems

Step 1: SCRM Problem Identification

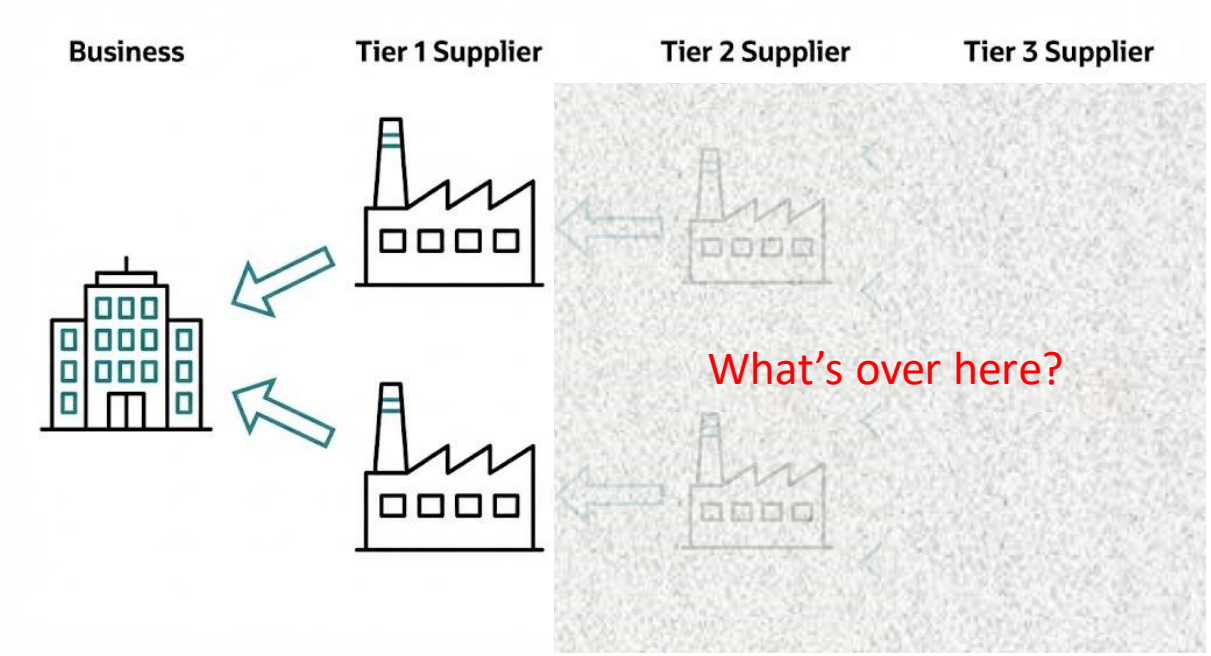
- To build a robust SCRM, supply chain risk managers aim to ensure they have:
  - Visibility into higher-tier suppliers by addressing the **visibility gap**
  - Insight into probability and impact by identifying **risk propagation**



Visibility Gap

- **Supply chain visibility gap** arises from a lack of transparency and information sharing across the supply chain network, particularly beyond direct (Tier 1) partners

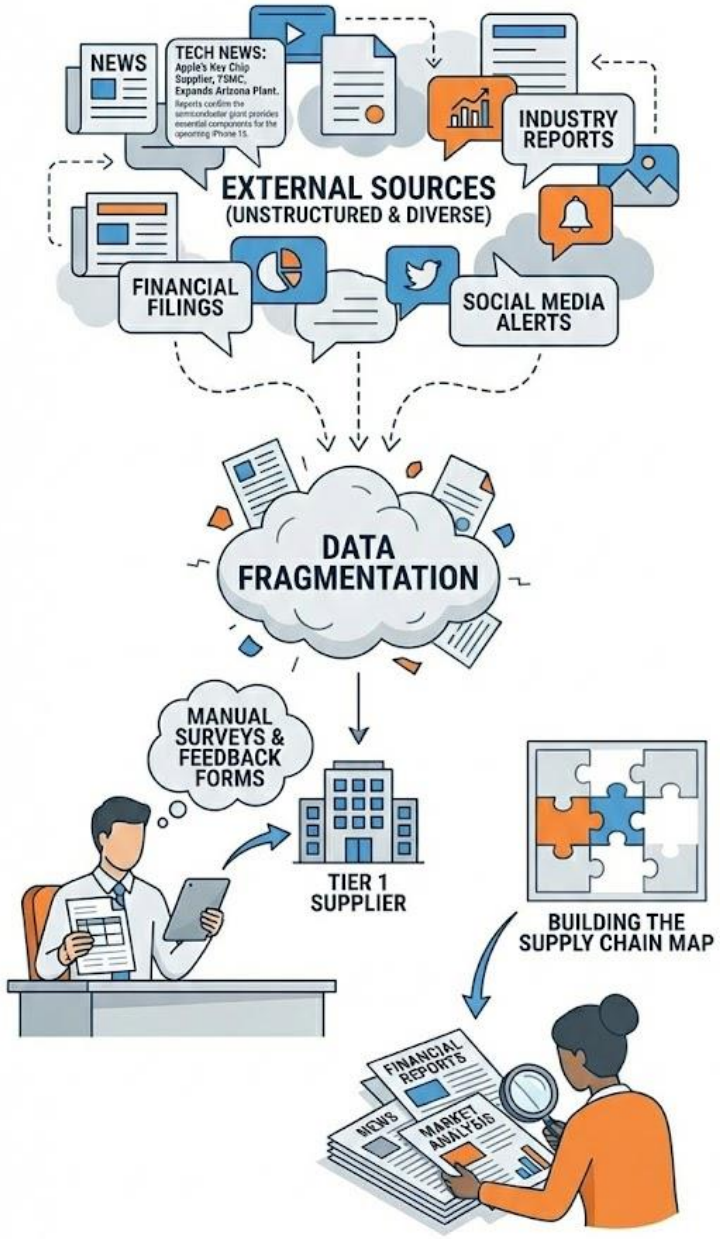
- Companies want to know beyond direct (Tier 1) suppliers and map the entire network (Tier 2, Tier 3, etc.) by uncovering suppliers and potential interdependencies.



Visibility Gap

- **Traditional methods**:
  - Sending **manual surveys** and risk **feedback forms** to Tier 1 suppliers to ask about their own suppliers.
  - Reading financial **filings, news, and reports** about suppliers to build the supply chain network.

- **Limitations**:
  - It is time-consuming to manually process to gather surveys and read from diverse sources.
  - Information often becomes outdated by the time manual processing is finished.



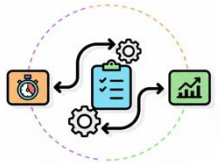
Visibility Gap – Summary

Stakeholder

- **Primary user**: Supply chain risk managers and practitioners
- **Responsibility**: Practice proactive risk management and ensure operational resilience.

Scenario

- **Task**: Identify suppliers across multiple tiers to provide visibility into the supply chain
- **Process**: Extract unknown supplying relationships from unstructured textual data



Current approach

- **Data source**: Survey, financial fillings, news, and reports from direct suppliers
- **Current method**: Conduct and read from various data sources to manually construct the SC network

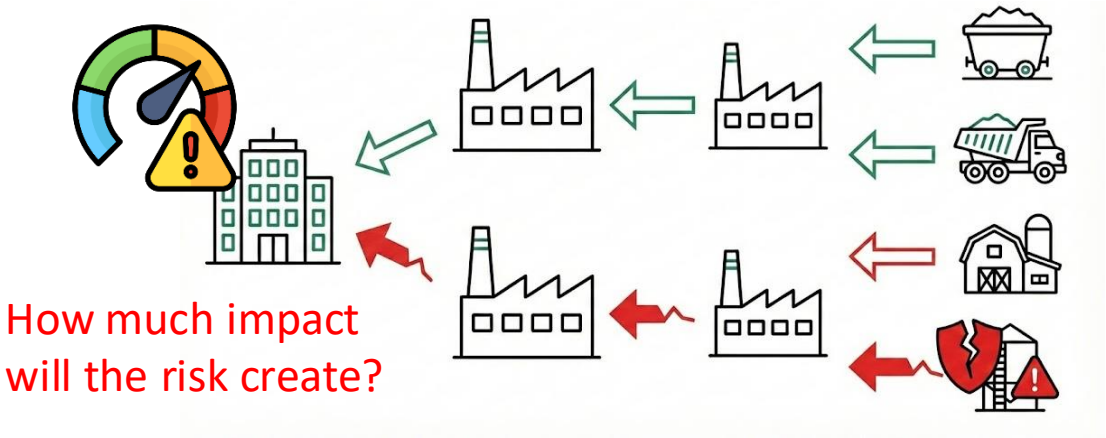
Limitation of this approach

- **Data-wise**: Collected data may become outdated after finishing the process
- **Process-wise**: Manual process to read and gather survey is inefficient.

Risk Propagation

- **Risk propagation** refers to the problem that a disruption at one node (supplier) can cascade through the network (the ripple effect).

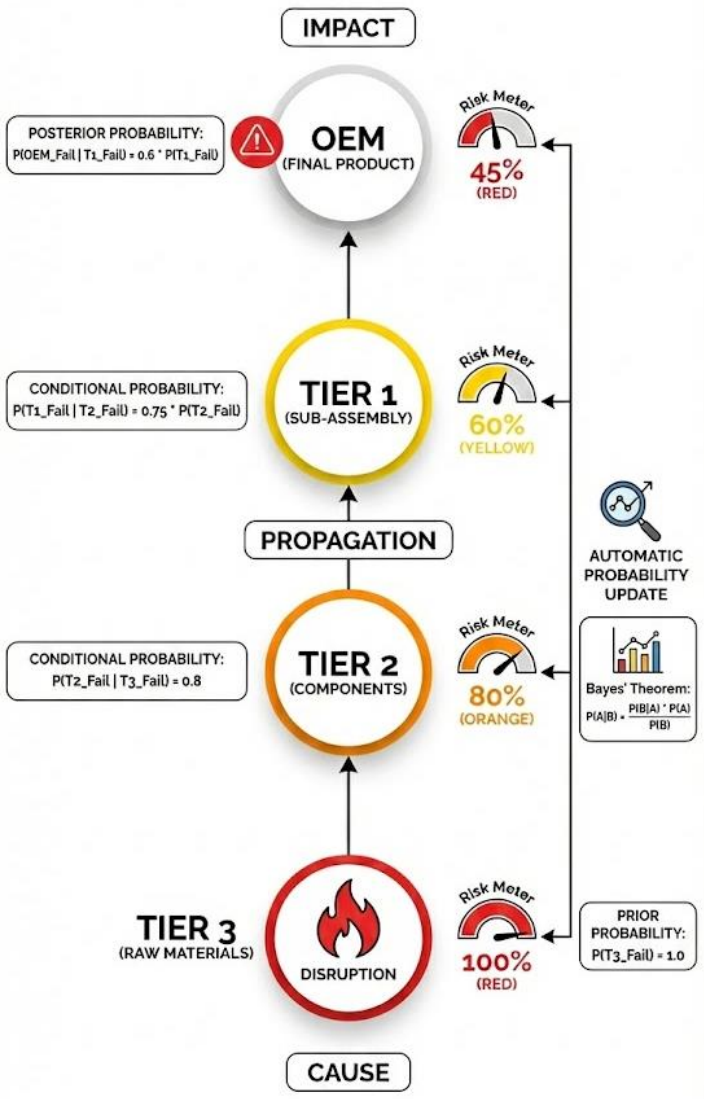
- Companies want to identify the potential **impact** and **probability** of disruptions.



Risk Propagation

- **Traditional methods**:
  - **Probability: Bayesian Networks** (BN) to calculate the probability of a disruption based on previous data.
  - **Impact**: Calculate potential revenue loss, lost sales, or total profit impact based on historical volumes with **expert judgement**.

- **Limitations**:
  - BNs require precise disruption probabilities (priors), which almost do not exist for rare events.
  - Expert judgment is not real-time and often focuses on a single node failing, overlooking the entire picture of propagation.



Bayesian network operations

Reference: Hosseini, S., & Ivanov, D. (2022). A new resilience measure for supply networks with the ripple effect considerations: A Bayesian network approach. *Annals of Operations Research*, *319*(1), 581-607.

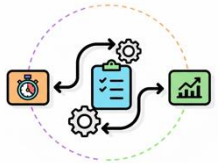
Risk Propagation – Summary

Stakeholder

- **Primary user**: Supply chain risk managers and practitioners
- **Responsibility**: Practice proactive risk management and ensure operational resilience

Scenario

- **Task**: Model the propagation to predict how a event/disruption to a supplier can affects the company
- **Process**: Estimate the probability and impact of the event



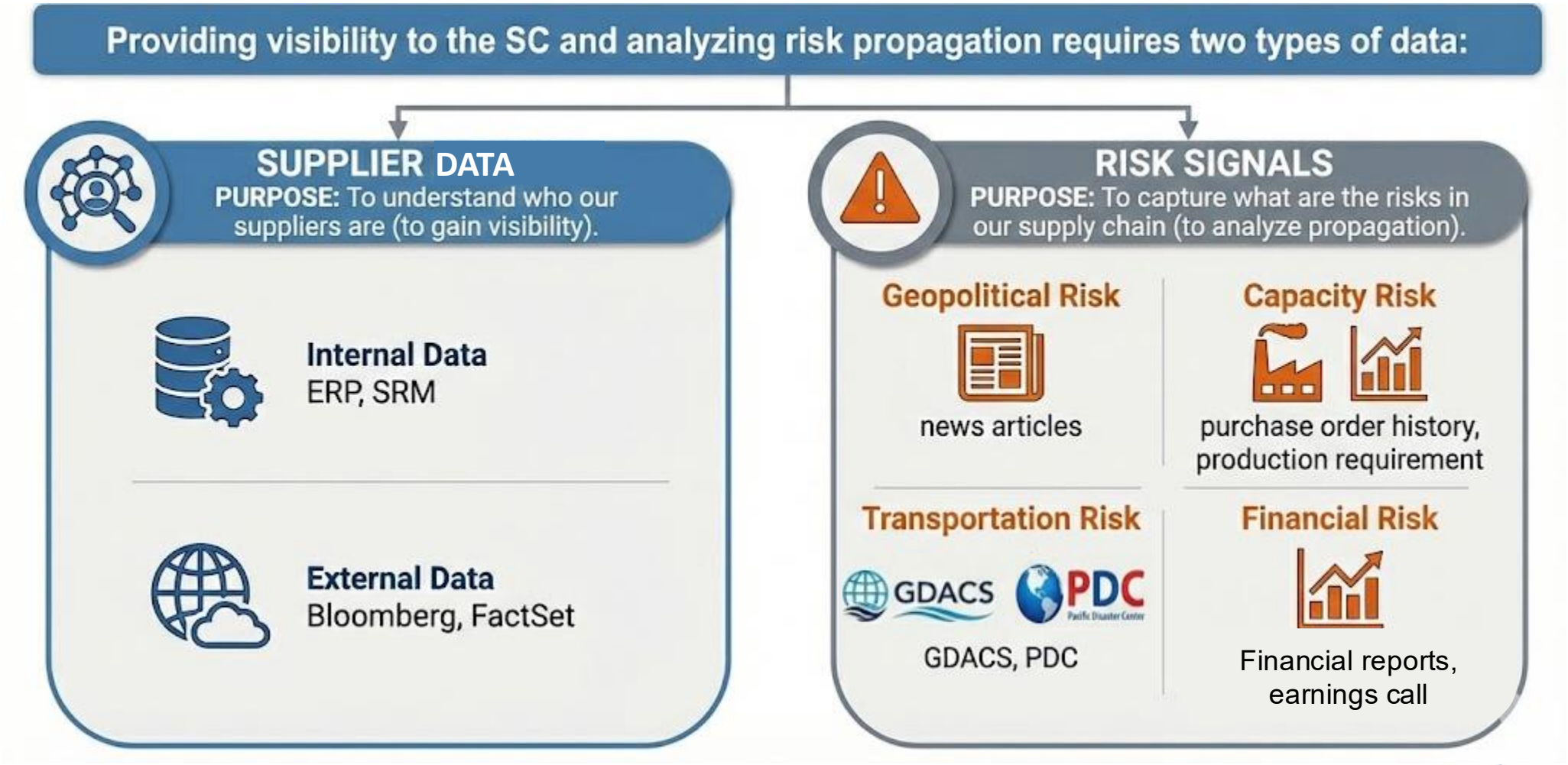
Current approach

- **Data source**: SC network, risk signals (news, disaster alert, financial report)
- **Current method**: Bayesian network and expert judgement

Limitation of this approach

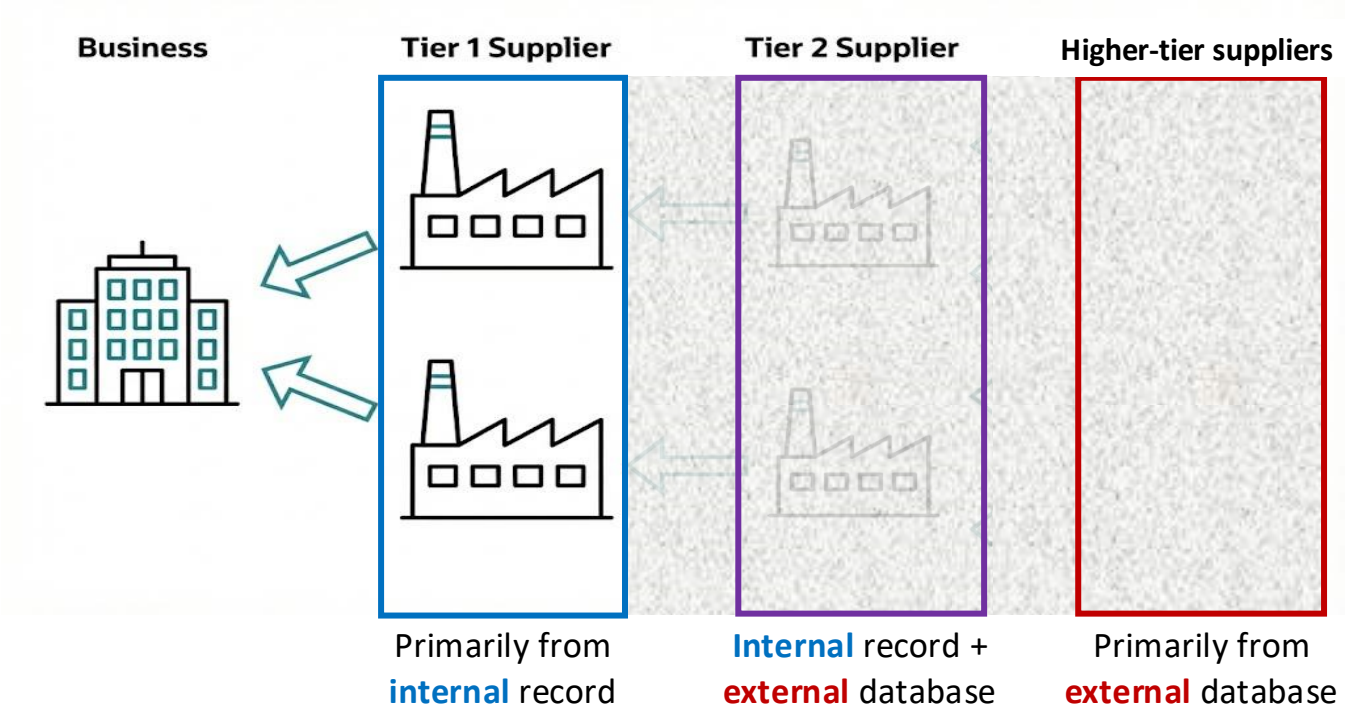
- **Data-wise**: Probability of rare event are unavailable for the Bayesian network.
- **Process-wise**: Expert judgement is not real-time and fail to holistically model the nature of proapgation.

Step 2: Data Collection and Extraction



Supplier Data

- Supplier data help map out a company's supply chain network.
  - It requires both **internal record** and **external databases**.

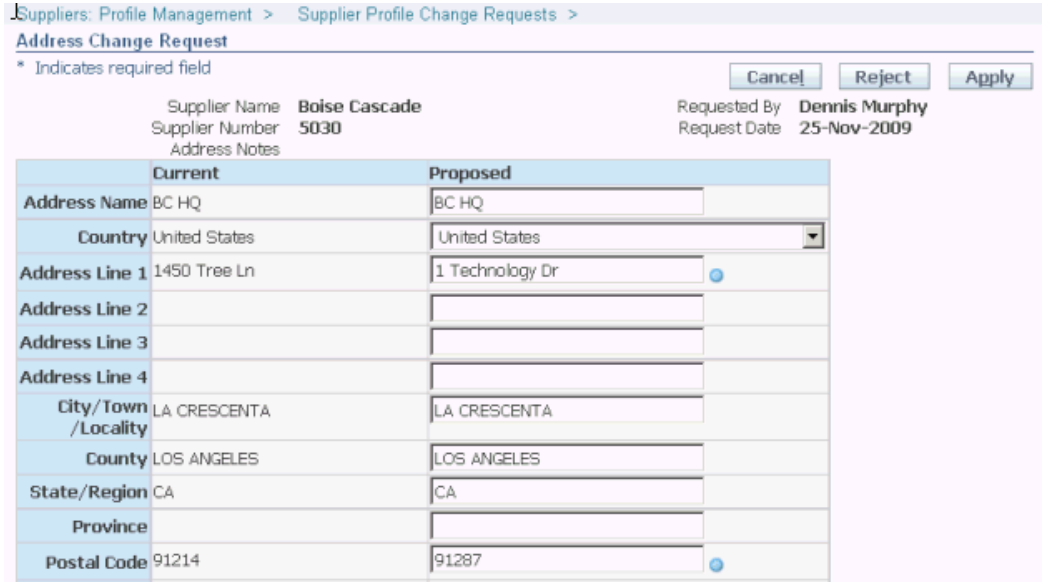


Supplier Data – Internal Records

- Internal records provide **profiles** of a company's direct suppliers, including
  - Name
  - HQ address
  - Manufacturing site
  - Product provided (category code)

- **Common sources**:
  - Enterprise resource planning (ERP) system
  - Supplier relationship management (SRM) system

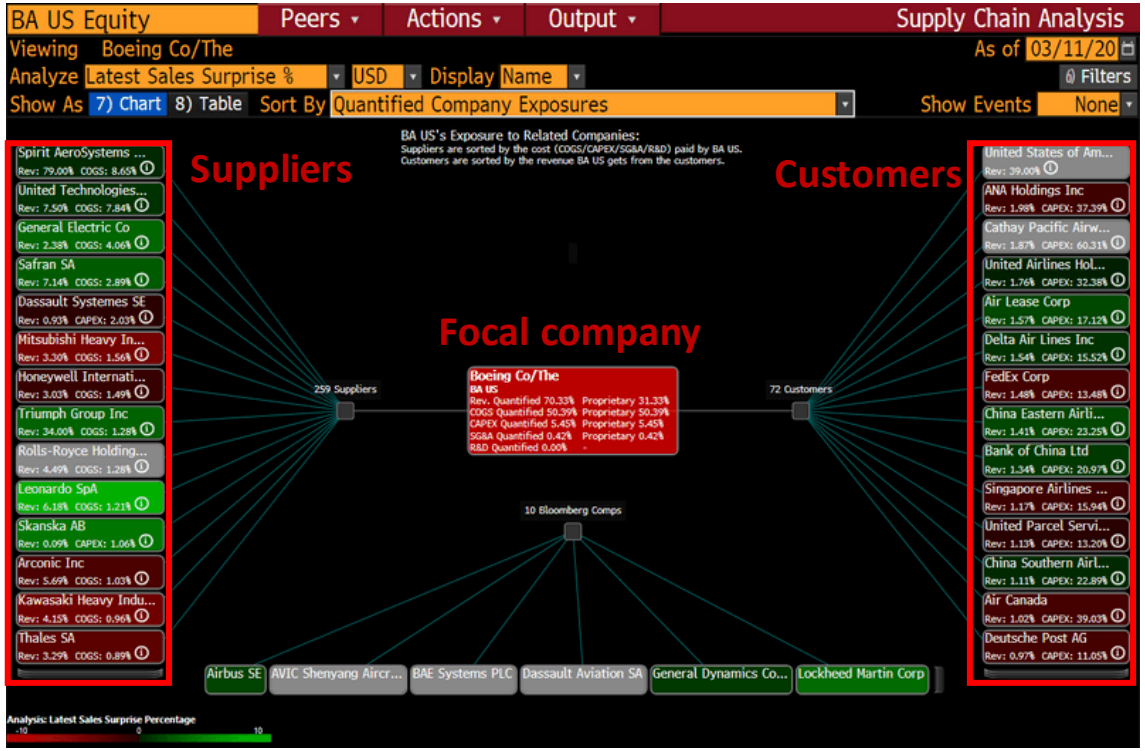
- **Collection methods**: direct database query, csv export



Sample supplier profile
From https://docs.oracle.com/cd/E18727-01/doc.121/e16534/T553530T553536.htm

Supplier Data – External Databases

- External databases provide **global supply chain networks** in a structured format by aggregating diverse data sources (e.g., public filings, annual reports, and news articles).
- Their network includes a supplier's
  - Name
  - Relationship type (e.g., materials or equipment provider)
  - % of COGS/Capex
- **Common sources**: Bloomberg SPLC, Factset
- **Collection methods**: Database API, csv exports

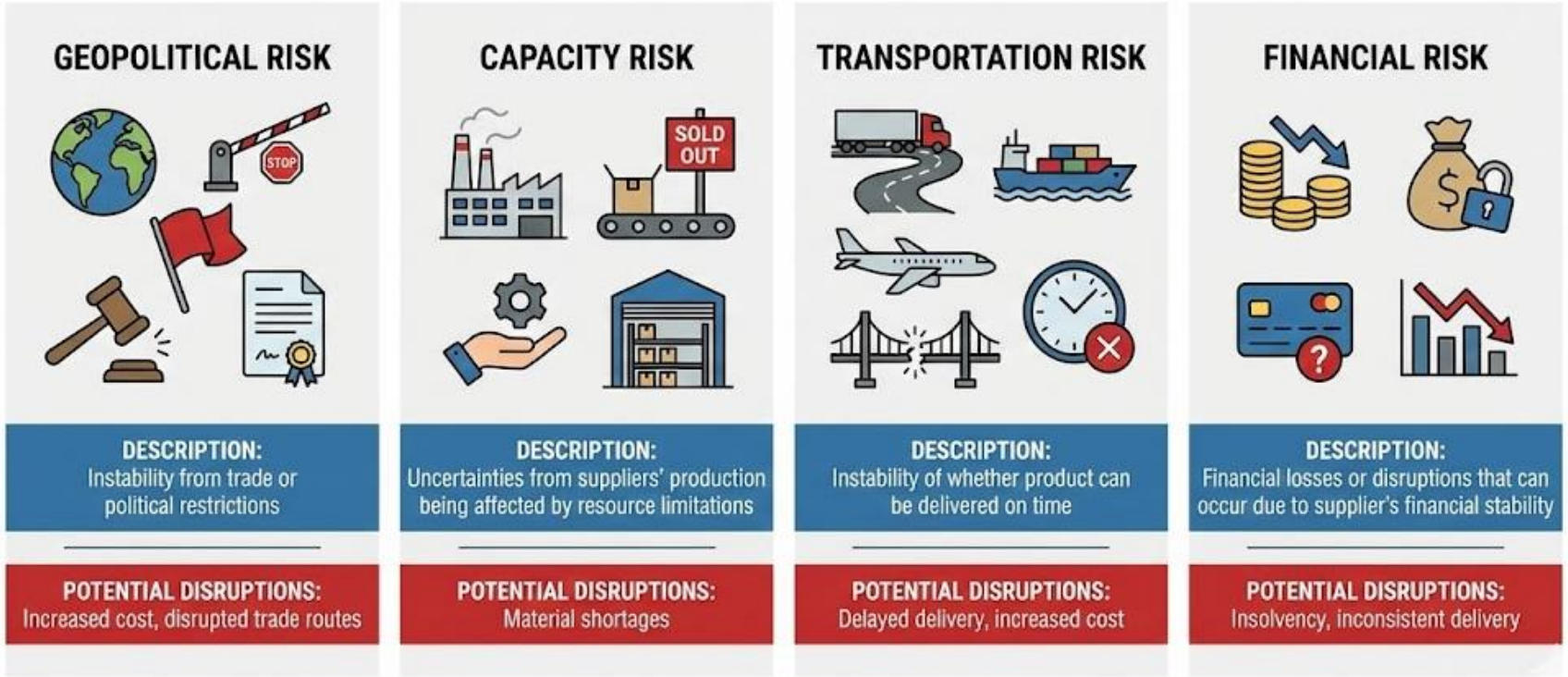


Bloomberg SPLC terminal (from Bloomberg.com)

Reference: Culot, G., Podrecca, M., Nassimbeni, G., Orzes, G., & Sartor, M. (2023). Using supply chain databases in academic research: A methodological critique. *Journal of Supply Chain Management*, *59*(1), 3-25.

Risk Signals

- Risk signals provide signs for potential disruptions.
  - They help identify four types of supply chain risks.



Reference: Li, X., Krivtsov, V., Pan, C., Nassehi, A., Gao, R. X., & Ivanov, D. (2025). End-to-end supply chain resilience management using deep learning, survival analysis, and explainable artificial intelligence. *International Journal of Production Research*, 63(3), 1174-1202.

Risk Signals for Geopolitical Risks

- Geopolitical risks comes from changes in government policies or international conflict.
  - **News articles** are the primary and credible source for documenting such events.

- **Key signals**: type of policy or conflict, countries or regions being affected

- **Collection methods**: API, web scraping

Maersk says Red Sea disruption could cut Asia-Europe capacity by 20%

"The risk zone has expanded, and attacks are reaching further offshore," Denmark's Maersk said.

"This has forced our vessels to lengthen their journey further, resulting in additional time and costs to get your cargo to its destination for the time being," it added in an updated advisory to customers.

Maersk's fuel costs on the affected routes between Asia and Europe are now 40% higher per journey, a spokesperson said.

Germany's Hapag-Lloyd (HLAG.DE), which has said it believes the crisis can be overcome before the end of 2024, is also rerouting vessels for the time being.

Reference: Caldara, D., & Iacoviello, M. (2022). Measuring geopolitical risk. *American economic review*, 112(4), 1194-1225.

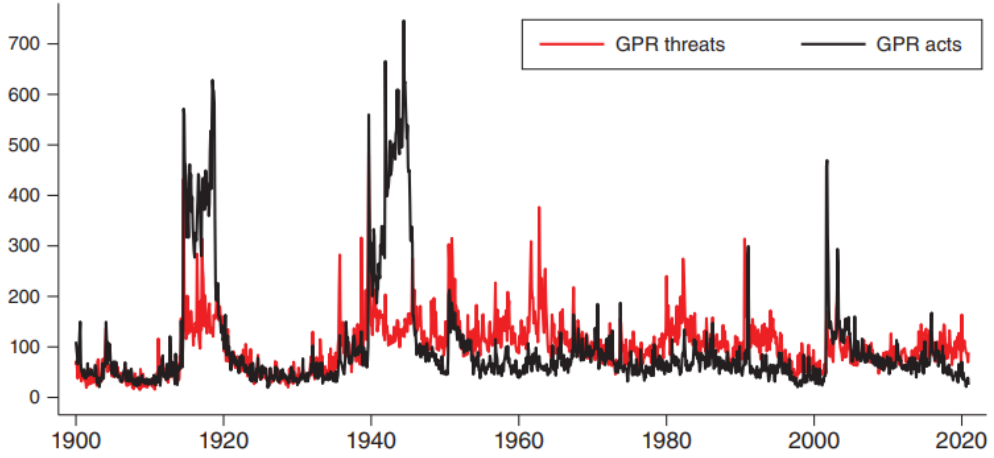
Risk Signals for Geopolitical Risks

- Static risk metric can help further identify the **severity** of each type of risk.
- The **Geopolitical Risk Index (GPR)** is measured based on the keyword occurrence from news articles.
- For each month t, the GPR score can be determined by:

$$GPR_t = \frac{\text{number of articles mentioning risk keywords}}{\text{Total number of articles}}$$

Topic sets	Phrases
War_words	**war OR conflict** OR hostilities OR revolution* OR insurrection OR uprising OR revolt OR coup OR geopolitical
Peace_words	**peace** OR truce OR armistice OR treaty OR parley
Military_words	**military OR troops** OR missile* OR "arms" OR weapon* OR bomb* OR warhead*
Nuclear_bigrams	**"nuclear war*"** OR "atomic war*" OR "nuclear missile*" OR "nuclear bomb*" **OR** "atomic bomb*" OR "h-bomb*" OR "hydrogen bomb*" OR "nuclear test" OR "nuclear weapon*"
Terrorism_words	**terror*** OR guerrilla* OR hostage*
Actor_words	**allie* OR enem* OR insurgen*** OR foe* OR army OR navy OR aerial OR troops OR rebels

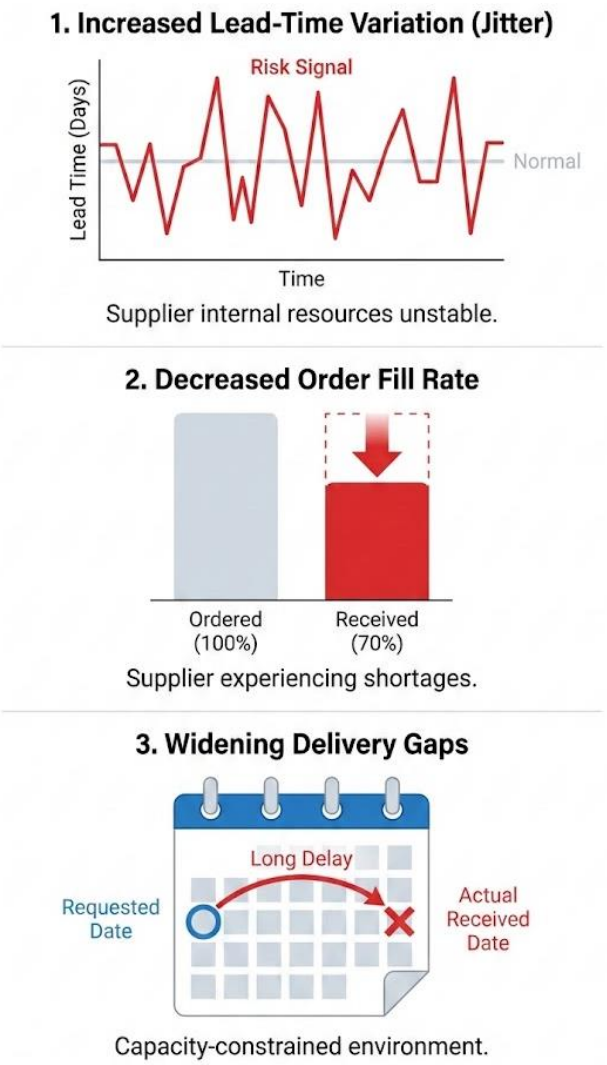
Threat/act sets	Phrases
Threat_words	**threat* OR warn* OR fear* OR risk* OR concern*** OR danger* OR doubt* OR crisis OR troubl* OR disput* OR tension* OR imminen* OR inevitable OR footing OR menace* OR brink OR scare OR peril*
Peace_disruption_words	**threat*** OR menace* OR reject* OR peril* OR boycott* OR disrupt*
Buildup_words	**buildup* OR build-up* OR sanction*** OR blockad* OR embargo OR quarantine OR ultimatum OR mobiliz*
War_begin_words	**begin* OR start* OR declar*** OR begun OR began OR outbreak OR "broke out" OR breakout OR proclamation OR launch*
Actor_fight_words	**advance* OR attack* OR strike*** OR drive* OR shell* OR offensive OR invasion OR invad* OR clash* OR raid* OR launch*
Terrorism_act_words	**attack** OR act OR bomb* OR kill* OR strike* OR hijack*



Reference: Caldara, D., & Iacoviello, M. (2022). Measuring geopolitical risk. *American economic review*, 112(4), 1194-1225.

Risk Signals for Capacity Risks

- Capacity risk arises when suppliers face **insufficient resources (e.g., facility, personnel)**
- Companies cannot directly access their suppliers' internal data.
  - They rely on **internal operational data** as a **proxy** to detect anomalies that signal potential delays.
- Capacity risk increases when a company observes the following internally:
  - Increase lead-time variation
  - Decreased order fill rate
  - Widening delivery gaps between requested delivery dates and the actual received date.
- They typically suggest that suppliers may be experiencing material or labor shortages.

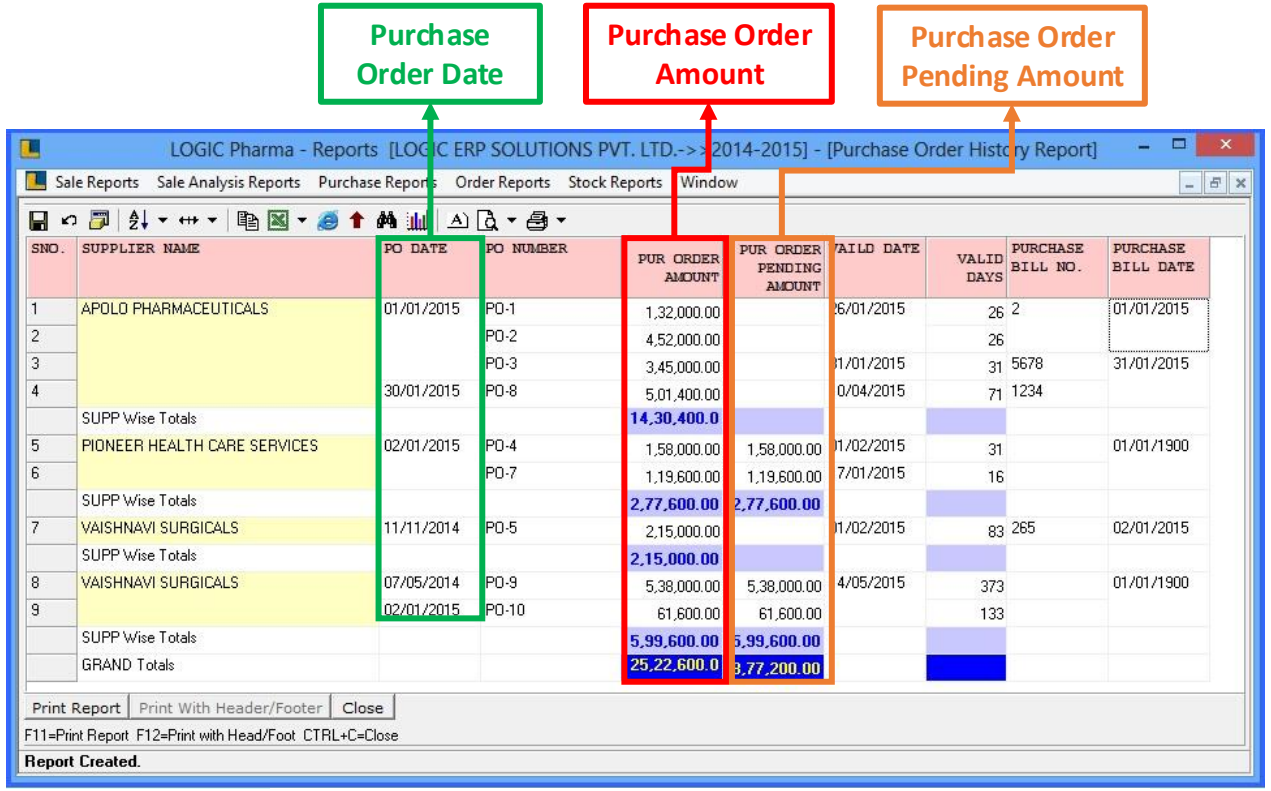


Risk Signals for Capacity Risks

- **Key data assets**:
  - **Purchase order history**: lead time and fill rate calculation
  - **Production requirement**: delivery gap calculation
- **Data sources**: ERP systems
- **Collection method**: direct database query, csv export

$$\textbf{lead time} = \text{Purchase receipt date} - \text{Purchase order date}$$

$$\textbf{fill rate} = \frac{\text{purchase order amount} - \text{purchase order pending amount}}{\text{purchase order amount}}$$



SNO.	SUPPLIER NAME	PO DATE	PO NUMBER	PUR ORDER AMOUNT	PUR ORDER PENDING AMOUNT	VAILD DATE	VALID DAYS	PURCHASE BILL NO.	PURCHASE BILL DATE
1	APOLO PHARMACEUTICALS	01/01/2015	PO-1	1,32,000.00		26/01/2015	26	2	01/01/2015
2			PO-2	4,52,000.00			26		
3			PO-3	3,45,000.00		1/01/2015	31	5678	31/01/2015
4		30/01/2015	PO-8	5,01,400.00		0/04/2015	71	1234	
	SUPP Wise Totals			14,30,400.0					
5	PIONEER HEALTH CARE SERVICES	02/01/2015	PO-4	1,58,000.00	1,58,000.00	1/02/2015	31		01/01/1900
6			PO-7	1,19,600.00	1,19,600.00	7/01/2015	16		
	SUPP Wise Totals			2,77,600.00	2,77,600.00				
7	VAISHNAVI SURGICALS	11/11/2014	PO-5	2,15,000.00		1/02/2015	83	265	02/01/2015
	SUPP Wise Totals			2,15,000.00					
8	VAISHNAVI SURGICALS	07/05/2014	PO-9	5,38,000.00	5,38,000.00	4/05/2015	373		01/01/1900
9		02/01/2015	PO-10	61,600.00	61,600.00		133		
	SUPP Wise Totals			5,99,600.00	5,99,600.00				
	GRAND Totals			25,22,600.0	8,77,200.00				

Sample purchase order history
https://www.logicerp.com/LOGICPharmaHelp/LogicERPPharmaUserGuide.html?purchase_order_history_report.htm

Risk Signals for Transportation Risks

- Transportation risks primarily result in delivery disruptions or delays from suppliers.
  - To mitigate them, companies monitor the weather and potential natural disasters.
- **Key signals:** Event type, severity, date, location, detailed description (news) for each weather or disaster event.
- **Common sources**: Global Disaster Alert and Coordination System (GDACS), PDC Disaster Aware
- **Collection methods**: API, RSS feed

From gdacs.org

Risk Signals for Financial Risks

- Financial risks come from suppliers' financial instability.
- To capture them, companies look at the report, earnings call, and stock price of their suppliers.

Data Asset	Description	Key metadata	Primary Data Source	Collection Methods
Report (10-K, 10-Q)	Comprehensive overview of financial health and operational performance.	Financial statement numbers, metrics, footnote description	Regulatory (e.g., SEC EDGAR)	API Integration
Earnings call	Management discussion on results, future guidance, and risk factors	Qualitative sentiment, executive disclosures	Market Analysis (e.g., Seeking Alpha)	API Integration or web scraping
Stock price	Real-time company valuation and indicator of sudden investor panic	Real-time Stock price	Financial Data Feeds (e.g., Yahoo Finance)	REST API, batch download

Reference: Wang, G., Chen, G., Zhao, H., Zhang, F., Yang, S., & Lu, T. (2021). Leveraging multisource heterogeneous data for financial risk prediction: A novel hybrid-strategy-based self-adaptive method. *MIS Quarterly*, *45*(4), 1949-1998.

Risk Signals for Financial Risks

- For example, in Lam Research's earnings call transcript and 10-Q report:
  - A. Slightly negative sentiment
    - May result in a risk in profit margin
  - B. R&D expenses increase by $159 millions for the six-month period.
    - Can create significant margin pressure if revenue growth slows
  - C. Income tax expense rose by **54%** this quarter
    - Significantly outstripping the 36% growth in pre-tax income

Supplier name

Lam Research Corporation (LRCX) Q2 2026 Earnings Call Transcript

Let's look to profitability. Gross margin in the December quarter was 49.7%, which exceeded the high end of our guided range on better-than-expected customer mix. Sequentially, gross margin was about 1 percentage point lower, reflecting a customer mix that was less favorable than what we saw in September. Operating expenses for December came in at $827 million, which is roughly flat sequentially. R&D accounted for 68% of the total operating expenses.

A.

Earning call transcript (from SeekingAlpha)

Supplier name

EDGAR | Company Search Results

FAQ EDGAR search tools Feedback Classic version

Home » Company Search

LAM RESEARCH CORP LRCX on Nasdaq

Investor Toolkit: On

[+] Company Information

Latest Filings (excluding insider transactions)

- February 6, 2026 - 144: Report of proposed sale of securities Filing
- February 4, 2026 - 8-K/A: Current report - *amendment* Filing
  - **5.02** - Departure of Directors or Certain Officers Election of Directo...
  - **9.01** - Financial Statements and Exhibits
- February 3, 2026 - 8-K: Current report Filing
  - **5.02** - Departure of Directors or Certain Officers Election of Directo...
  - **9.01** - Financial Statements and Exhibits
- January 29, 2026 - 10-Q: Quarterly report for quarter ending December 28, 2025 Filing
- January 28, 2026 - 8-K: Current report Filing **Earnings release**
  - **2.02** - Results of Operations and Financial Condition
  - **9.01** - Financial Statements and Exhibits

View filings

Selected Filings

[+] 8-K (current reports)

[-] 10-K (annual reports) and 10-Q (quarterly reports)

- January 29, 2026 - 10-Q: Quarterly report for quarter ending December 28, 2025 Filing
- October 24, 2025 - 10-Q: Quarterly report for quarter ending September 28, 2025 Filing
- August 11, 2025 - 10-K: Annual report for year ending June 29, 2025 Filing
- April 25, 2025 - 10-Q: Quarterly report for quarter ending March 30, 2025 Filing

View all 10-Ks and 10-Qs | How to read a 10-K/10-Q

Reports (8-K, 10-K, 10-Q) available to download

Financial statement section of 10-Q report

LAM RESEARCH CORPORATION
CONDENSED CONSOLIDATED STATEMENTS OF OPERATIONS
(in thousands, except per share data)
(unaudited)

	Three Months Ended		Six Months Ended	
	December 28, 2025	December 29, 2024	December 28, 2025	December 29, 2024
Revenue	$ 5,344,791	$ 4,376,047	$ 10,668,964	$ 8,544,023
Cost of goods sold	2,693,629	2,303,066	5,332,923	4,468,359
Gross margin	2,651,162	2,072,981	5,336,041	4,075,664
Research and development	573,305	494,947	1,149,751	990,305
Selling, general, and administrative	267,654	244,150	546,999	487,278
Total operating expenses	840,959	739,097	1,696,750	1,477,583
Operating income	1,810,203	1,333,884	3,639,291	2,598,081
Other income (expense), net	26,410	14,262	56,484	44,343
Income before income taxes	1,836,613	1,348,146	3,695,775	2,642,424
Income tax expense	(242,619)	(157,128)	(533,121)	(334,962)
Net income	$ 1,593,994	$ 1,191,018	$ 3,162,654	$ 2,307,462
Net income per share:				
Basic	$ 1.27	$ 0.93	$ 2.51	$ 1.78
Diluted	$ 1.26	$ 0.92	$ 2.50	$ 1.78
Number of shares used in per share calculations:				
Basic	1,254,856	1,287,109	1,259,651	1,293,173
Diluted	1,261,739	1,291,469	1,265,526	1,297,767

B.

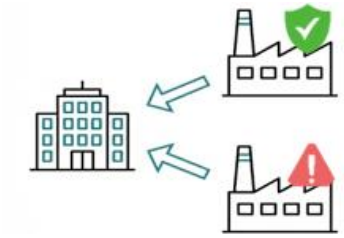
C.

Sample 10-Q Report (from EDGAR)

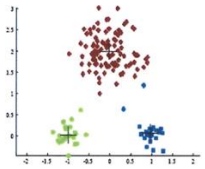
Step 3: AI-Enabled Analytics

- AI-enabled analytics are designed to provide supply chain visibility and analyze risk propagation based on the collected data.

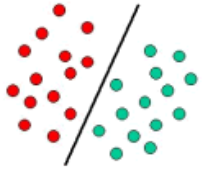
1. Supplier Risk Profling



How risky is our direct supplier?

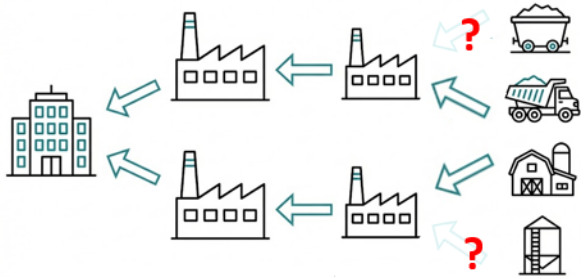


Clustering

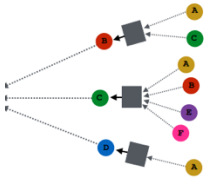


Classification

2. Network Discovery



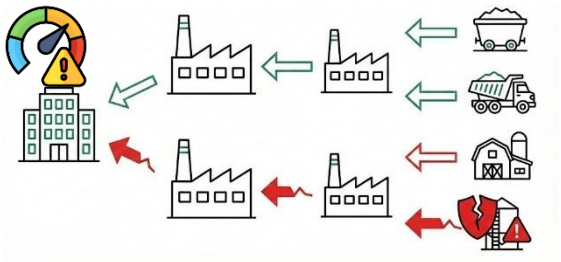
How does our SC look like?



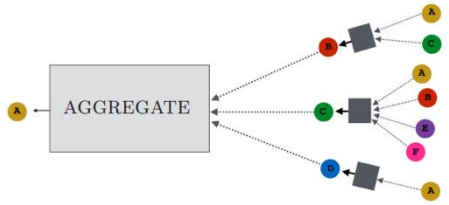
GNN

LLM

3. Risk Propgation Analysis



How's the impact of risk propagation



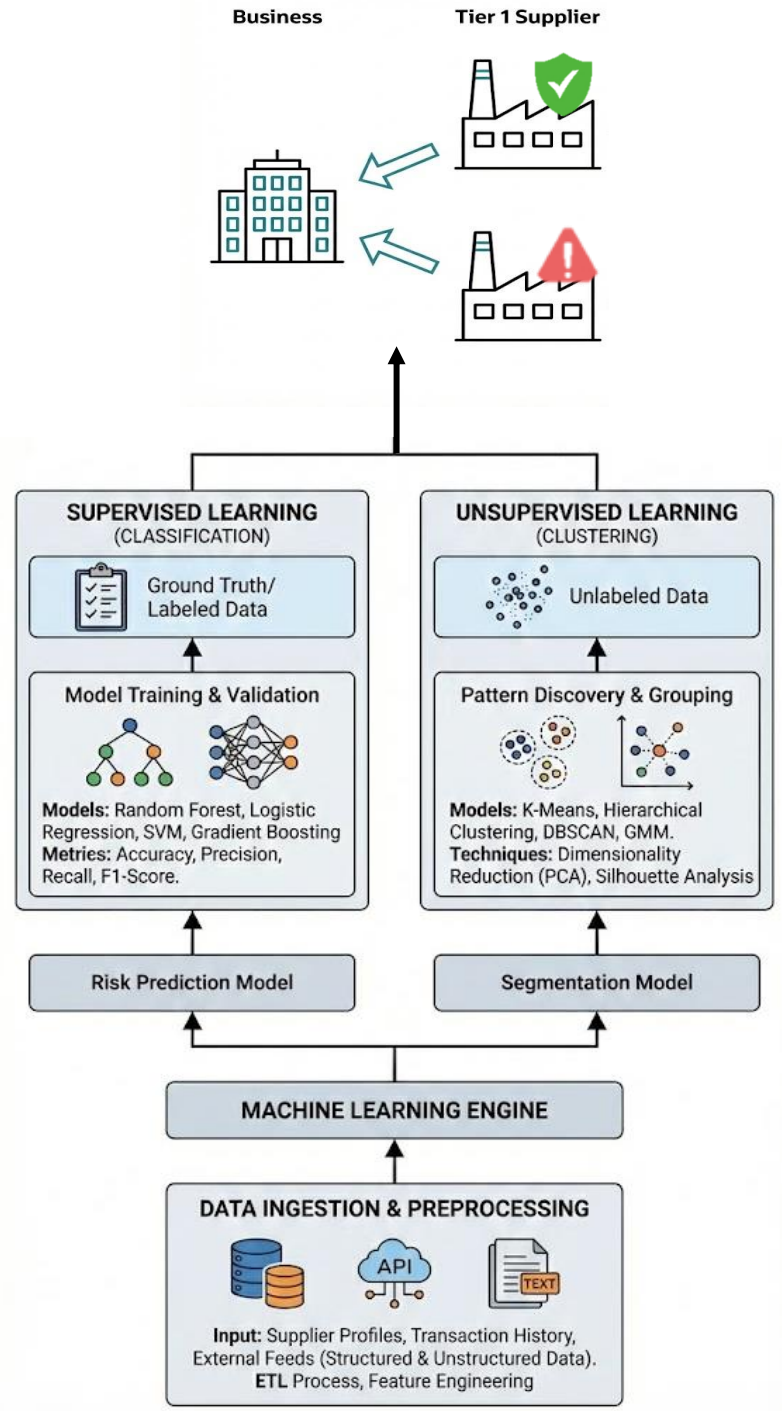
GNN

Supplier Risk Profiling

- Before looking outward, organizations focus on the data they already own regarding their immediate suppliers (T1 suppliers).

- **Goal**: Characterize and segment known suppliers based on their specific risk profiles
  - **Input**: suppliers and their profiles
  - **Output**: risk level for each supplier (e.g., low, medium, high)

- **AI methods:**
  - Classification (when ground truth is available)
  - Clustering (no ground truth)



Supplier Risk Profiling (Example)

- **Goal**: characterize and group suppliers based on their risk profiles (in a company's internal ERP systems)
- **Data:** 72 suppliers and with 17 risk criteria such as**,**
  - **Financial:** Price variance, financial condition
  - **Capacity:** Lead time variability, shipping quality, late deliveries
- **Key data characteristics**:
  - No predefined risk levels (no ground truth risk level)
  - Large amount of feature (17 performance criteria)
- **Design**:
  - **Dimensionality reduction** with factor analysis
  - **K-means clustering** to identify three clusters of suppliers based on risk levels

	Cluster 1	Cluster 2	Cluster 3
Previous supplier assessment score (c_1)	2.39	2.09	2.29
Commodity price variance (c_2)	4.63	6.82	7.31
Financial condition of the supplier (c_3)	4.54	3.91	4.91
Percentage of subcontracted work (c_4)	0.13	0.34	0.54
Manufacturing capability (c_5)	4.93	4.16	5.13
Flexibility (c_6)	4.84	4.27	5.07
Technological capability (c_7)	4.85	4.12	5.20
Defect rate (c_8)	0.12	0.26	0.13
Quality management effort (c_9)	4.93	3.51	4.83
Late delivery date (c_{10})	0.11	0.32	0.15
Lead time variability (c_{11})	0.10	0.35	0.17
Packaging and shipping quality (c_{12})	5.38	4.91	5.92
Ease of communication (c_{13})	3.95	3.21	4.62
Reliability (c_{14})	4.79	3.64	4.80
Problem solving performance (c_{15})	4.54	4.33	5.43
Warranty policy and after sales service (c_{16})	4.52	4.35	5.45
Disaster recovery plans (c_{17})	4.44	4.36	5.35

Highest risk score | Medium risk score | Lowest risk score

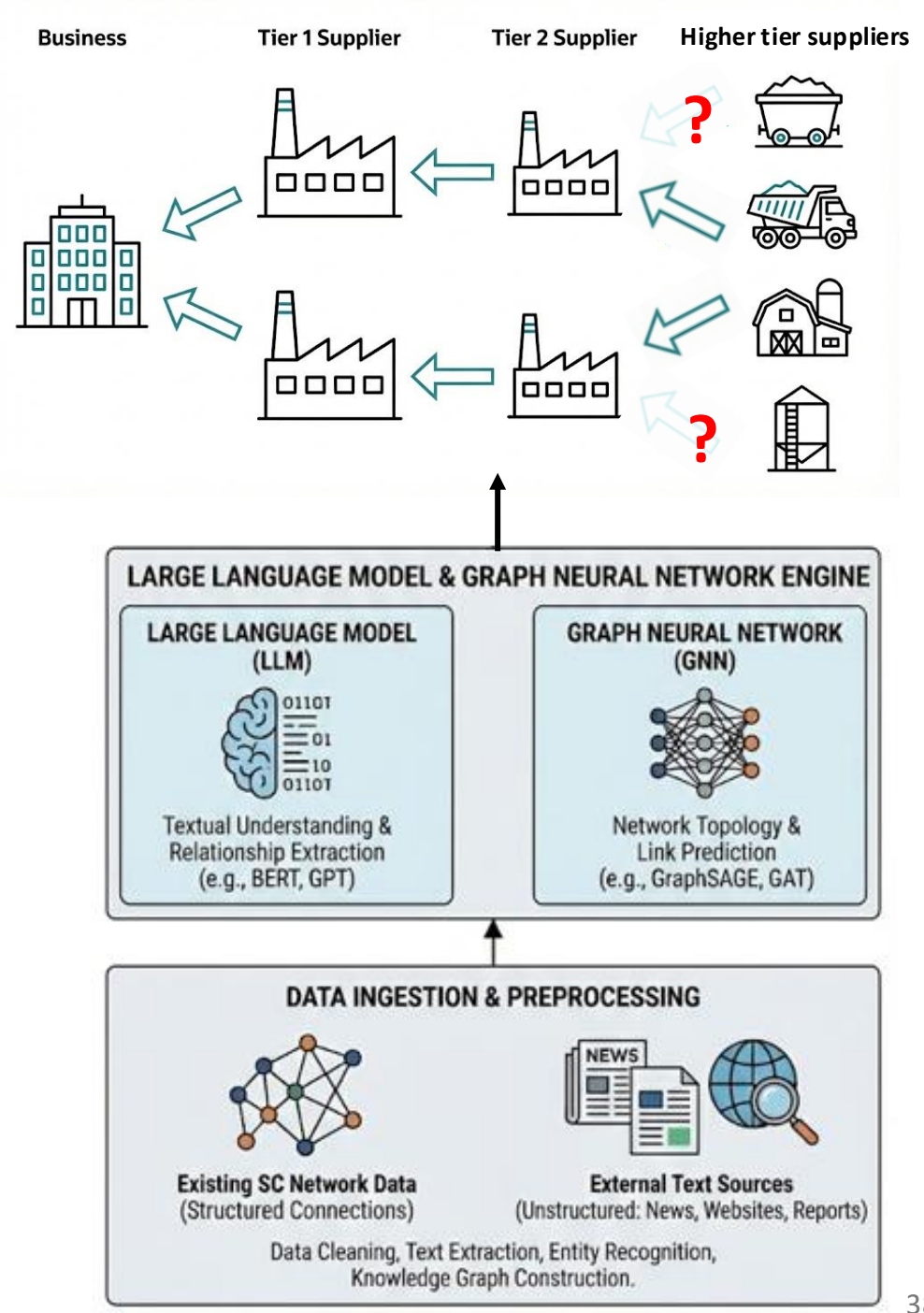
Reference: Kara, M. E., Fırat, S. Ü. O., & Ghadge, A. (2020). A data mining-based framework for supply chain risk management. *Computers & Industrial Engineering*, *139*, 105570.

Netowrok Discovery

- Once we know our T1 suppliers, we look into the entire picture of the supply chain if the existing network is incomplete.

- **Goal**: map out the suppliers for higher-tier suppliers to address the “visibility gap”.
  - **Input**: existing SC network connections, external text sources (e.g., news, company websites, and reports)
  - **Output**: new supplying relationship (e.g., company A provides product X to company B)

- **AI methods**: large language models or GNN to capture both the existing supply chain network and external textual data.



Netowrok Discovery (LLM Example)

- **Goal**: enhance supply chain visibility by automatically extracting interdependencies from textual sources
- **Data**: news articles, company websites, Wikipedia entries, and industrial reports
- **Data characteristics and design**:
  - Unstructured text with no labels (e.g., whether A is B's supplier)
  - Domain-specific wordings (e.g., acquires, subsidiary)
- **Design**: Zero-shot named entity extraction using LLMs by crafting prompt to have:
  - A. Task description
  - B. Definition (with domain-specific examples)
  - C. Data integrity instructions (e.g., syntactic formatting, coreference resolution)

Prompt 1 (RE)

A. Task Description

Relation Extraction
You are tasked with extracting relationships between different nodes (entities defined earlier). Follow these instructions:

B.

Definition 1

Example

Definition 2

Example

Definition 3

Example

T9. A relationship is the link that represents the connection between 2 nodes.
T10. Extract ONLY the following relationships, strictly complying with these definitions:

produces: Captures production or manufacturing relationships.
Examples:
- "Apple manufactures iPhones"
- "Toyota produces hybrid vehicles"
- "Samsung Electronics fabricates semiconductors"

** In this context, manufactures, produces and fabricates all semantically represent the same relationship which is "produces"

locatedIn: Identifies geographical associations. This relationship should always link to a location node.
Examples:
- "Volkswagen is headquartered in Wolfsburg, Germany"
- "Foxconn operates a factory in Zhengzhou, China"
- "Amazon's main offices are situated in Seattle, Washington"

** Here, headquartered, in, are situated in all represent the same relationship "locatedIn"

suppliesTo: Represents supplier-buyer relationships.
Examples:
- "TSMC supplies chips to Qualcomm"
- "LG Display provides OLED panels to Sony"
- "Bosch delivers automotive parts to Ford"

** In this context, supplies, provides and delivers all represent the same relationship "suppliesTo"

T9-T10 Provide contextual information and simple examples on different ways of writing the same relationship

C. Data integrity instructions

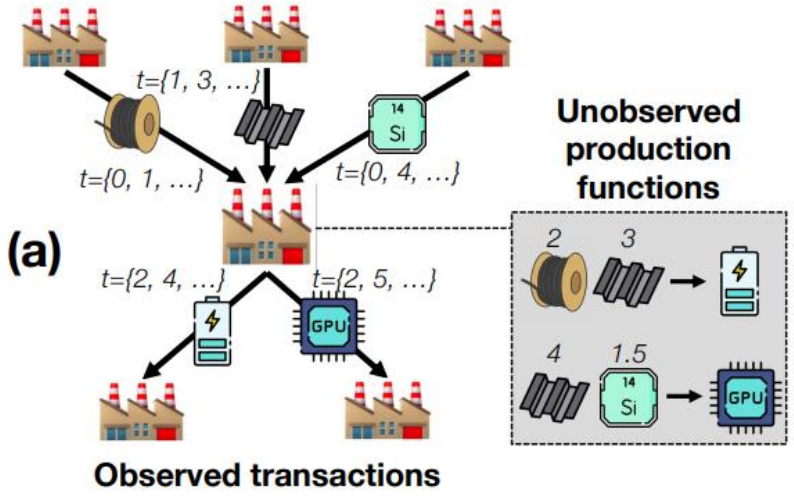
T11. Use camelCase format for all labels of all relationships extracted.
T12. Extract ONLY the defined relationships above (produces, locatedIn, suppliesTo).
Coreference Resolution
T13. Maintain Entity Consistency: When extracting entities, ensure consistency if an entity is mentioned multiple times using different names or pronouns.
T14. Always use the most complete identifier for that entity throughout the knowledge graph.
Example: If "Microsoft Corporation" is also referred to as "Microsoft" or "the tech giant", use "Microsoft Corporation" consistently.
T15. The knowledge graph should be coherent and easily understandable, so maintaining consistency in entity references is crucial.
T16. Adhere strictly to these rules. Non-compliance will result in termination.

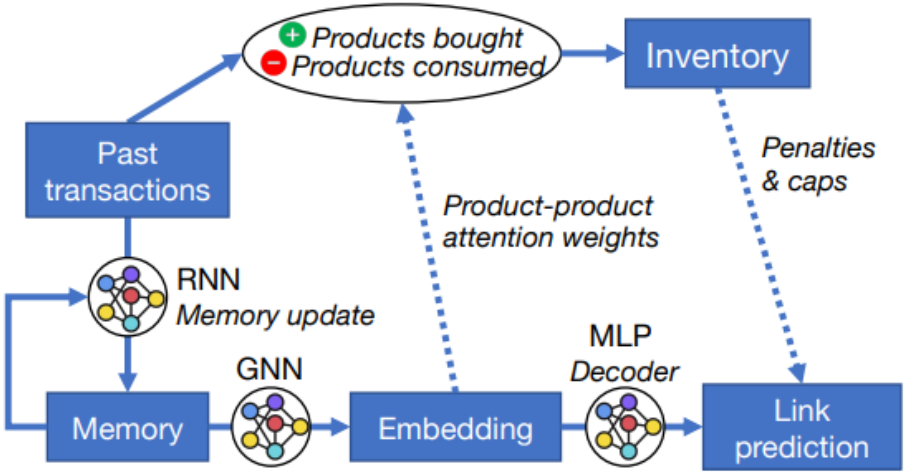
T11-T16 Instruction on formatting output data, coreference resolution and strict compliance

Reference: AlMahri, S., Xu, L., & Brintrup, A. (2025). Enhancing supply chain visibility with knowledge graphs and large language models. *International Journal of Production Research*, 1-32.

Netowrok Discovery (GNN Example)

- **Goal**: Predict the existence and weights of future transactions between companies (link prediction).
- **Data**:
  - SC network from SupplySim (open-source SC data)
  - Transactions from TradeSparq (each includes supplier, buyer, and product)
- **Key data characteristics**:
  - Time-varying transactions with three distinct entities: a supplier, a buyer, and a specific product
- **Design**: Extended temporal GNNs capable of message passing over multiple entities.





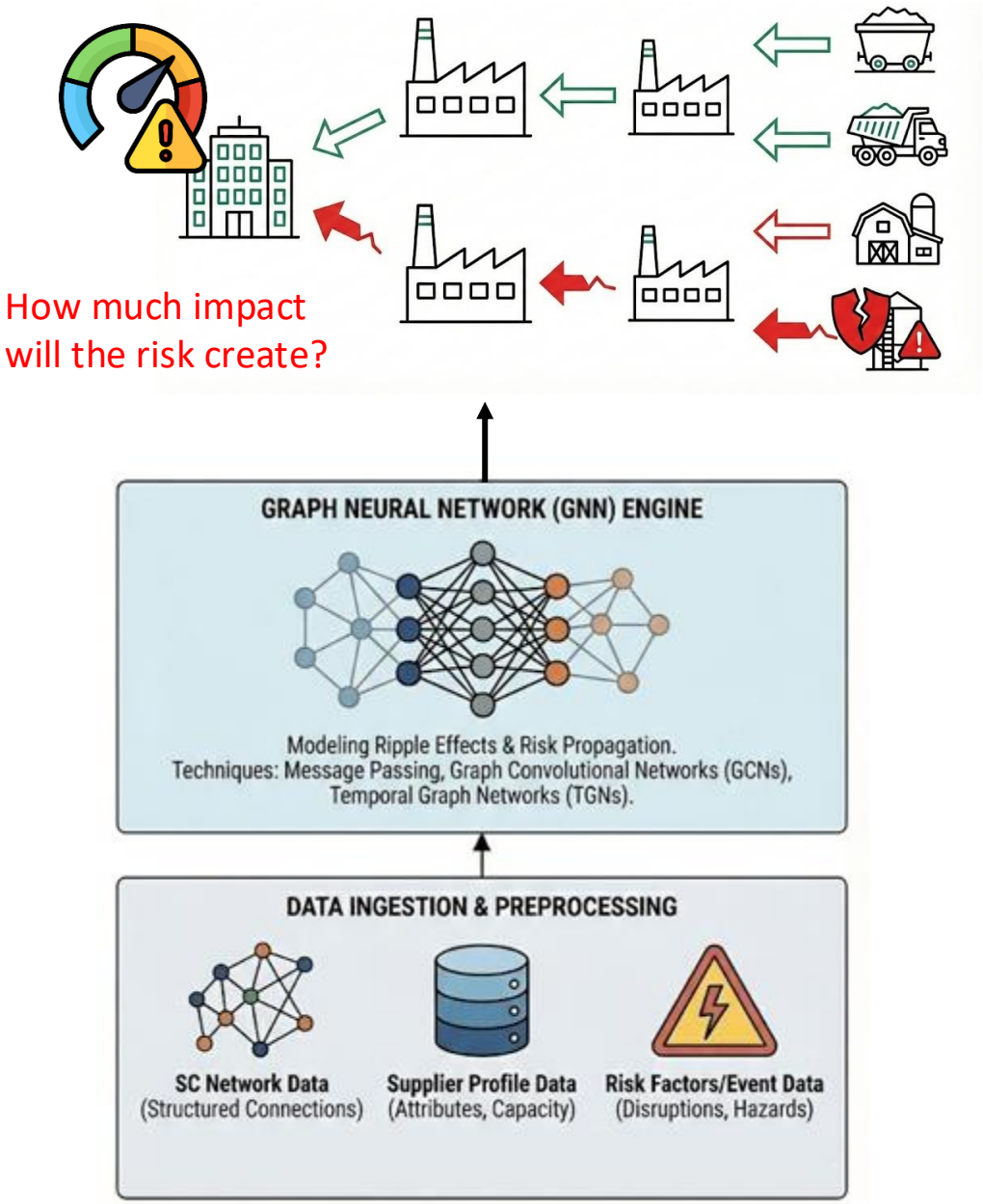
Reference: Chang, S., Lin, Z., Yan, B., Bembde, S., Xiu, Q., Wong, C. H. & Leskovec, J. (2025). Learning production functions for supply chains with graph neural networks. In *Proceedings of the AAAI Conference on Artificial Intelligence* (Vol. 39, No. 27, pp. 27878-27886).

Risk Propagation Analysis

- With a comprehensive map of the supply chain network, the company can assess how risks propagate over it.

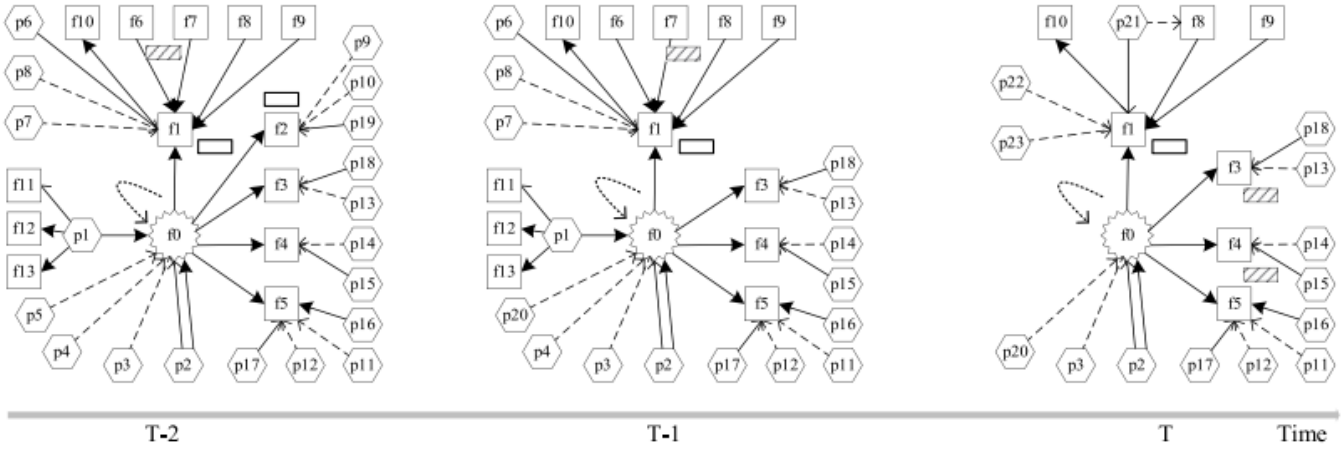
- **Goal**: identify the impact of SC risk under the ripple effect
  - **Input**: supply chain network, supplier profile, risk factors/event
  - **Output**: predict potential propagation pattern or impact

- **AI methods**: GNN



Risk Propagation Analysis (Example)

- **Goal**: predict financial risk by capturing how they propagate through the SC network.
- **Data**: 26 financial indicators for 3000+ companies with different types of relationship (e.g., suppliers, partners) from FactSet ➔ form a network (node = company, edge = relationship).
- **Data Characteristics**:
  - Financial distress can spread via multi-relational links
  - Corporate relationships are dynamic and evolve year-over-year
- **Design**: A spatial temporal graph neural network with time-variant attention weights.



Reference: Wang, J., Zhou, L., Jiang, C., & Wang, Z. (2025). Modeling and Interpreting the Propagation Influence of Neighbor Information in Time-Variant Networks with Exemplification by Financial Risk Prediction. *Journal of Management Information Systems*, *42*(1), 105-142.

Step 4: Value Delivery

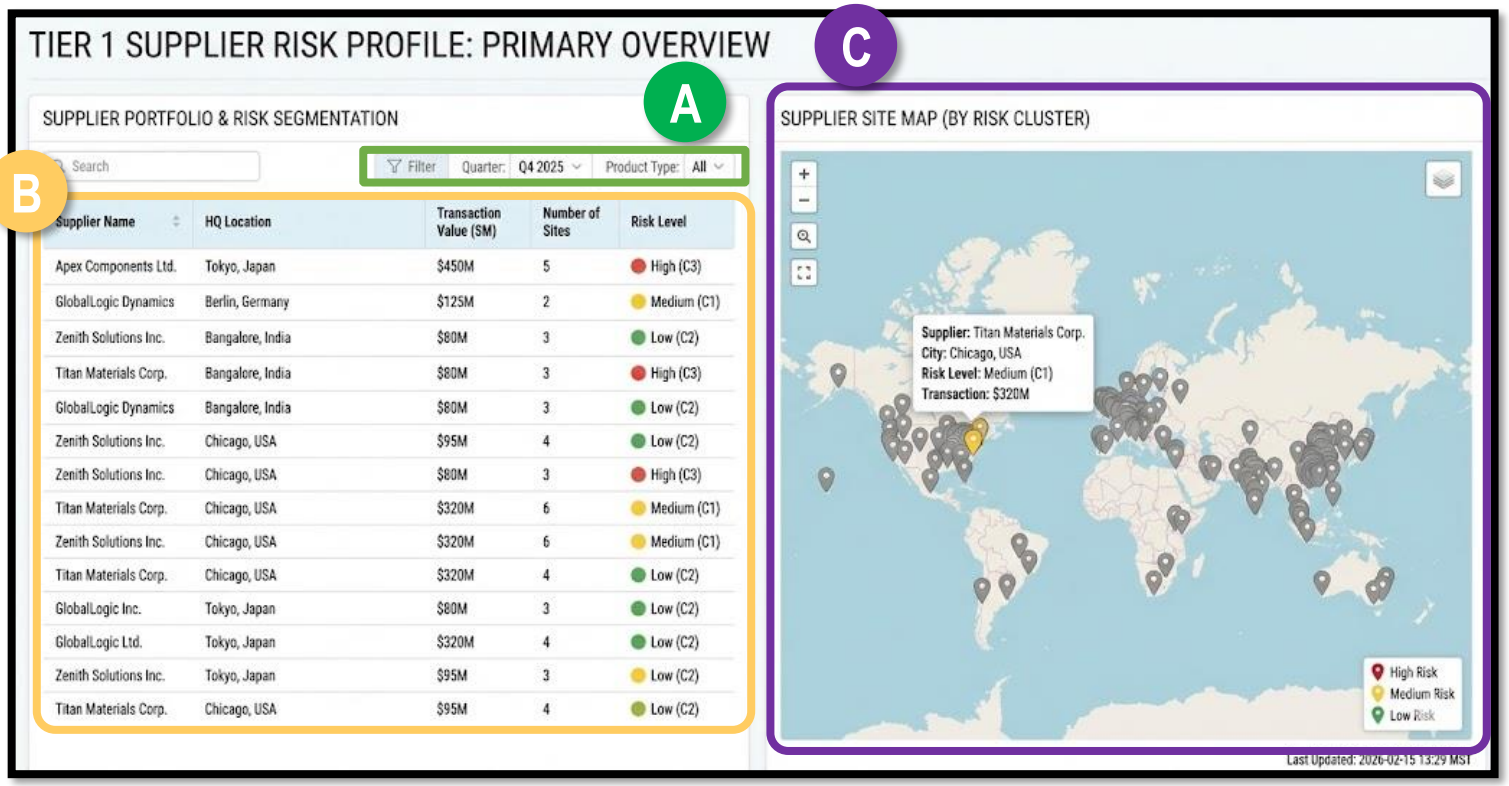
- **Visualization**: dashboards can be designed based on the AI-enabled analytic results.

Analytic	Key Analytic Output	Other Relevant Infromation	Chart/Exhibit	Dashboard
Supplier Risk Profiling	Risk level for each direct supplier	Supplier location, financial status	Supplier profile table, site maps, financial summary	**Supplier risk profile** (and drilldown)
Network Discovery	A complete SC network	-	Network visualization	**Risk Analysis Overview**
Risk Propagation Analysis	Risk propagation and impact	Risk signals, disruptive events	Map and news for events	

- The visualization supports **risk treatment decisions**.

Visualization – Supplier Risk Profile

- A dashboard can be built based on the **supplier risk profiling** analytic result.



A. **Quarter and product type selection** for suppliers display

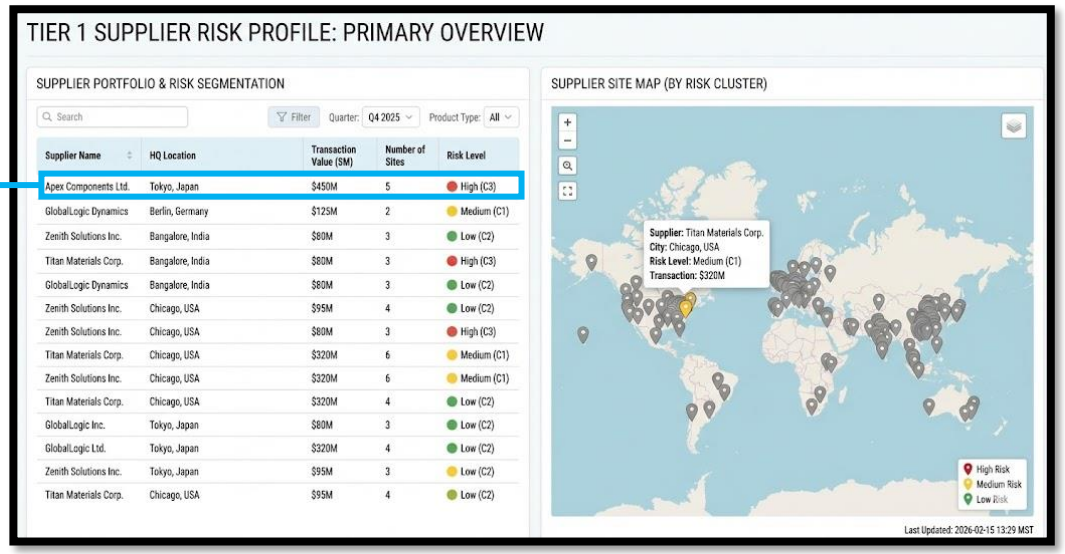
B. **Supplier profile with risk level:** Help quickly identify suppliers that requires attention

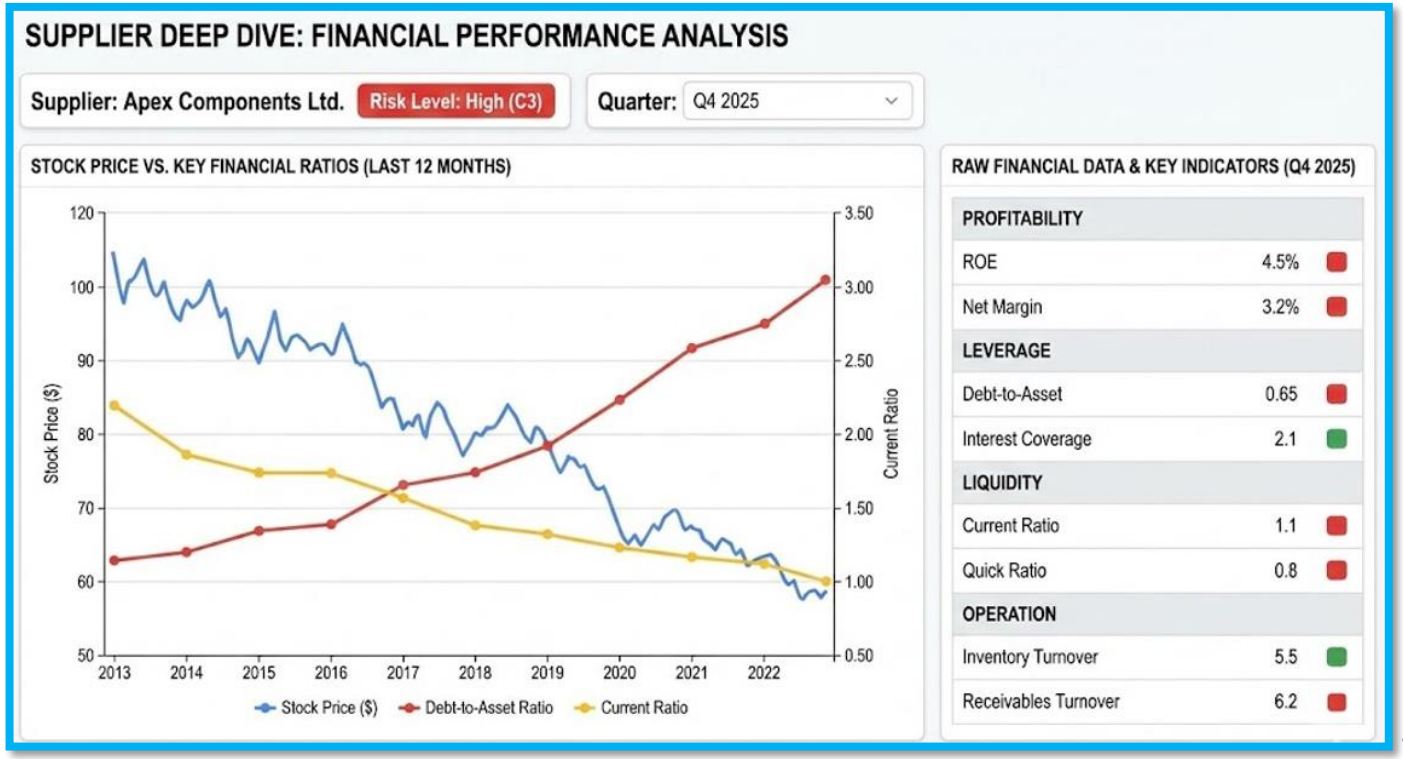
C. **Supplier site map**: overview of suppliers' site location

Visualization – Supplier Risk Profile

- This dashboard can also provide detailed information about a supplier through a drilldown:
  - key financial ratios
  - stock price trend
  - financial performance

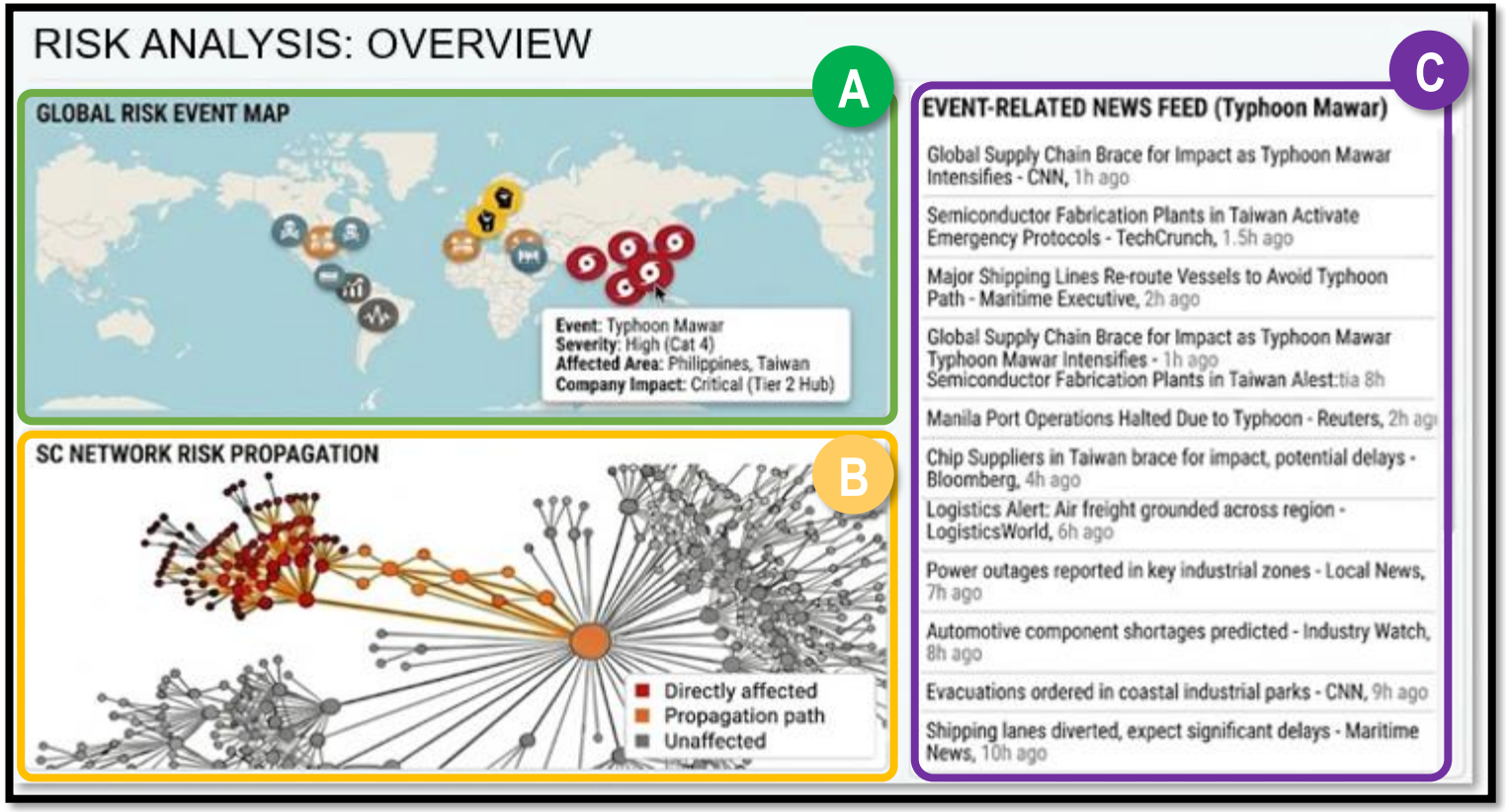
- This helps understand the **financial risks** of suppliers.





Visualization – Risk Analysis Overview

- A **risk analysis overview** dashboard can be built based on the collected **risk signal** and **risk propagation analysis** result.



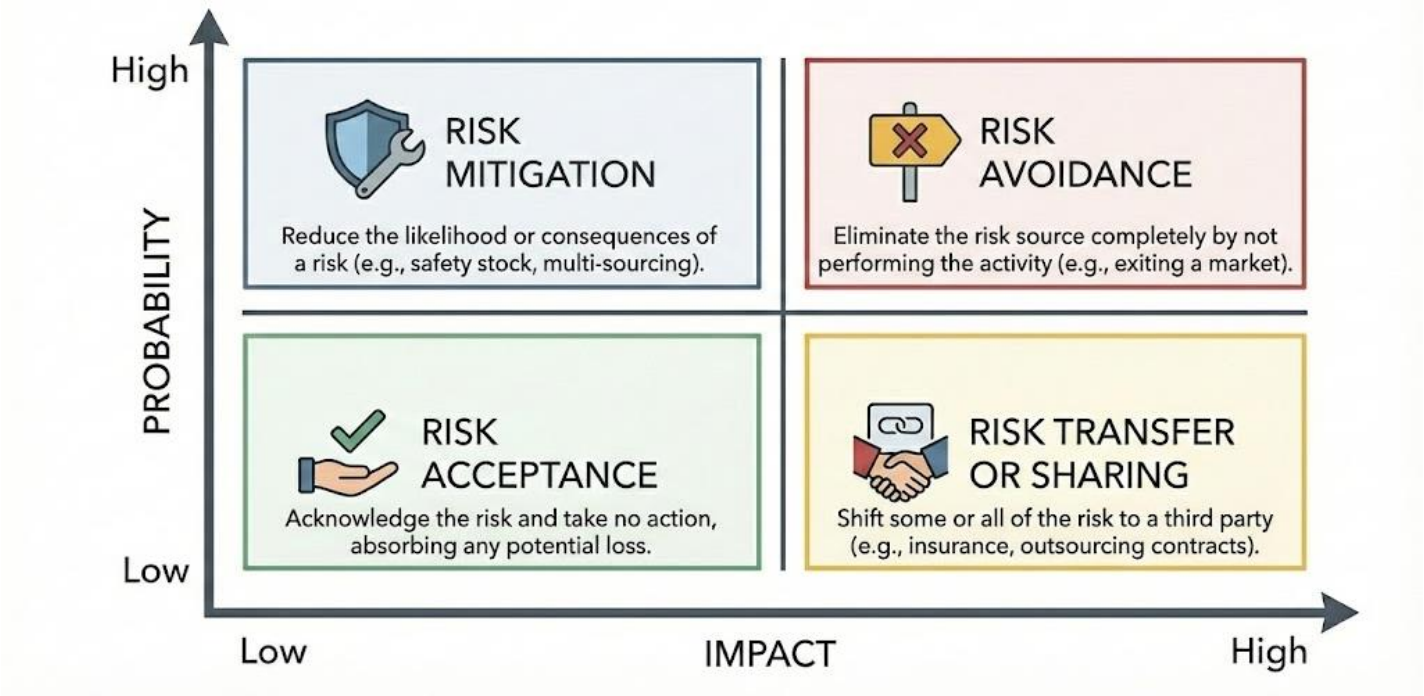
A. **Global risk event map** (geopolitical event + disasters)

B. **Risk propagation over the SC network:** Help identify where the risk comes from

C. **News relevant to the selected risk event:** Help understand the detail of a risk event for geopolitical risks and transportation risks

Risk Mitigation Decisions

- Decisions around supply chain risks are based on the **probability** and **impact** of supply chain risks to be cost-effective.
  - Is it worth the cost of holding 20% more safety stock to avoid a 5% chance of a delay?



Reference: Fan, Y., & Stevenson, M. (2018). A review of supply chain risk management: definition, theory, and research agenda. *International journal of physical distribution & logistics management*, 48(3), 205-230.

Review Questions

- What are the principles to build a good supply chain resilience?
- Why do we need external databases to help map out the supply chain network?
- What are the goals and common AI methods for the three major supply chain analytics?
- What are the key charts and exhibits in the dashboard that help deliver business value for supply chain analytics?