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For Supply Chain
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Supply
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Management



In collaboration with



MIT and PwC Research Study

Supply Chain and Risk Management

*Making the right decisions to strengthen
operations performance.*

Study by MIT Forum for Supply Chain Innovation and
PwC

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Supply Chain and Risk Management

Introduction

This study analyses the supply chain operations and risk management approaches of large companies and looks at their operations and financial performance in the face of supply chain disruptions.

It proposes a framework and a set of principles to help companies manage today's risk challenges and prepare for future opportunities. Using the framework, a company's leaders can increase their awareness of where they and their competition stand.

Executive Summary

The MIT Forum for Supply Chain Innovation and PwC Global Supply Chain and Risk Management Survey is a study of the supply chain operations and risk management approaches of **209 companies with a global footprint**. As globally operating organisations, they are exposed to high-risk scenarios ranging from controllable risks, such as raw material price fluctuation, currency fluctuation, market changes or fuel price volatility, to uncontrollable ones such as natural disasters.

The findings validate **five key principles** that companies can learn from to better manage today's risk challenges to their supply chains and prepare for future opportunities:

- 1. Supply chain disruptions have significant impact on company business and financial performance.*
- 2. Companies with mature supply chain and risk management capabilities are more resilient to supply chain disruptions. They are impacted less and they recover faster than companies with immature capabilities.*
- 3. Mature companies investing in supply chain flexibility are more resilient to disruptions than mature companies that do not invest in supply chain flexibility.*
- 4. Mature companies investing in risk segmentation are more resilient to disruptions than mature companies that do not invest in risk segmentation.*
- 5. Companies with mature capabilities in supply chain and risk management do better along all surveyed dimensions of operational and financial performance than immature companies.*

In the past twelve months, **more than 60%** of the companies surveyed said that their performance indicators had dropped by 3% or more as a result of supply chain disruptions.

“Capability maturity” referred to in the above five principles was determined using our **supply chain and risk management capability maturity framework**. This framework assesses the degree to which companies are applying the most effective enablers of supply chain risk reduction (e.g., flexibility, risk governance, alignment, integration, information sharing, data, models and analytics, and rationalisation) and their associated processes. The model depicts where a company stands in relation to its competition and the rest of the industry.

According to the survey results, as many as 60% of the companies pay only marginal attention to risk reduction processes. These companies are categorised as having *immature* risk processes. They mitigate risk by either increasing capacity or strategically positioning additional inventory. This is not a surprise as the survey also shows that most of these companies are focused either on maximising profit, minimising costs or maintaining service levels.

The remaining 40% do invest in developing advanced risk reduction enabler capability and are classified as having *mature* processes. Our research validated that companies with mature risk processes perform operationally and financially better – something for CEOs and CFOs to note. Indeed, managing supply chain risk is good for all parts of the business - product design, development, operations and sales. Using the capability maturity model, companies can benchmark their ability to respond to risks, and then increase their capability maturity to gain competitive advantage.

When mature risk management and operational resilience pay off

On March 11, 2011¹, Nissan Motor Company Ltd and its suppliers experienced a 9.0-magnitude earthquake as it struck off the East coast of Japan. The quake was among the 5 most powerful earthquakes on record. Tsunami waves in excess of 40 meters travelled up to 10km inland causing a “Level 7” meltdown at three nuclear reactors at Fukushima Daiichi. The impact of this multi-headed disaster was devastating. 25,000 people died, went missing or were injured. 125,000 buildings were damaged and economic losses were estimated at \$200 billion.

In the weeks following the catastrophic earthquake, 80% of the automotive plants in Japan suspended production. Nissan’s production capacity was perceived to have suffered most from the disaster compared to its competitors. Six production facilities and fifty of the firm’s critical suppliers suffered severe damage. The result was a loss of production capacity equivalent to approximately 270,000 automobiles.

Despite this devastation, Nissan’s recovery was remarkable. During the next six months, Nissan’s production in Japan decreased by only 3.8% compared to an industry wide decrease of 24.8%. Nissan ended 2011 with an *increase* in production of 9.3% compared to a reduction of 9.3% industry wide.

How was Nissan able to successfully navigate a disruption of this magnitude so successfully?

1. To begin with, Nissan responded by adhering to the principles of its risk management philosophy. It focused on identifying risks as early as possible, actively analysing these risks, planning countermeasures and rapidly implementing them.
2. The company had prepared a continuous readiness plan encompassing its suppliers including: an earthquake emergency response plan; a business continuity plan; and disaster simulation training. Nissan deployed these advanced capabilities throughout risk management and along the supply chain.
3. Management was empowered to make decisions locally without lengthy analysis.
4. The supply chain model structure was flexible, meaning there was decentralisation with strong central control when required. This was combined with simplified product lines.
5. There was visibility across the extended enterprise and good coordination between internal and external business functions.

¹ Nissan Motor Company Ltd: Building Operational Resiliency: William Schmidt, David Simchi-Levi, MIT Sloan Management: Case Number 13-150

These capabilities allowed the company to share information globally, allocate component part supplies on higher margin products and adjust production in a cost-efficient way.

Objectives of Study

Counter-intuitive stories such as the Nissan story are at the heart of this study. It illustrates that companies such as Nissan with highly mature capabilities in both supply chain management and risk management will be able to effectively address risks, outperform the market and even gain competitive advantage.

We believe that linking the customer value proposition, sound supply chain operations, and robust risk management is key to success. Moreover, there are supply chain and risk management principles, frameworks, and processes that enable companies to address complex market challenges and achieve superior performance.

The MIT Forum for Supply Chain Innovation and PwC launched the Supply Chain Risk Management Survey to assess how global organisations address these challenges and their impact on business operations. The survey was distributed to members of the MIT Forum for Supply Chain Innovation and world-wide clients of PwC.

In total, 209 companies completed the survey. Appendix A characterizes the participant population.

The challenges of an extended global supply chain

When a company expands from a local or regional presence to a more global one, the operations strategy needs to be adjusted to align with the changes. The economic crisis in Europe is a good example of this. Due to the decrease in demand for many products and services in the continent, companies are changing strategies, seeking alternate global markets. That's when operations become more complex. Transportation and logistics become more challenging, lead times lengthen, costs increase and end customer service can suffer. With a more a global footprint, different products are directed to more diverse customers via different distribution channels, which require different supply chains.

To address the challenge successfully, there are a number of questions companies need to consider as their operations globalise:

1. What are the drivers of supply chain complexity for a company with global operations and how have they evolved over the recent past?
2. What are the sources of supply chain risk?
3. How can vulnerability and exposure to high impact supply chain disruptions be properly assessed and managed?
4. How can supply chain resilience be improved?
5. What supply chain operations and risk principles will guide the improvement of the company's bottom line: the operations and financial performance?

Through this research, we aim to provide valuable insight in response to these questions.

What are the drivers of supply chain operations complexity?

Supply chains are exposed to both domestic and international risks. The more complex the supply chain, the less predictable the likelihood and the impact of disruption. In other words, exposure to risk is potentially higher. We asked survey participants their views on how certain key supply chain complexity drivers have evolved over the past three years. The responses are shown in **Figure 1**.

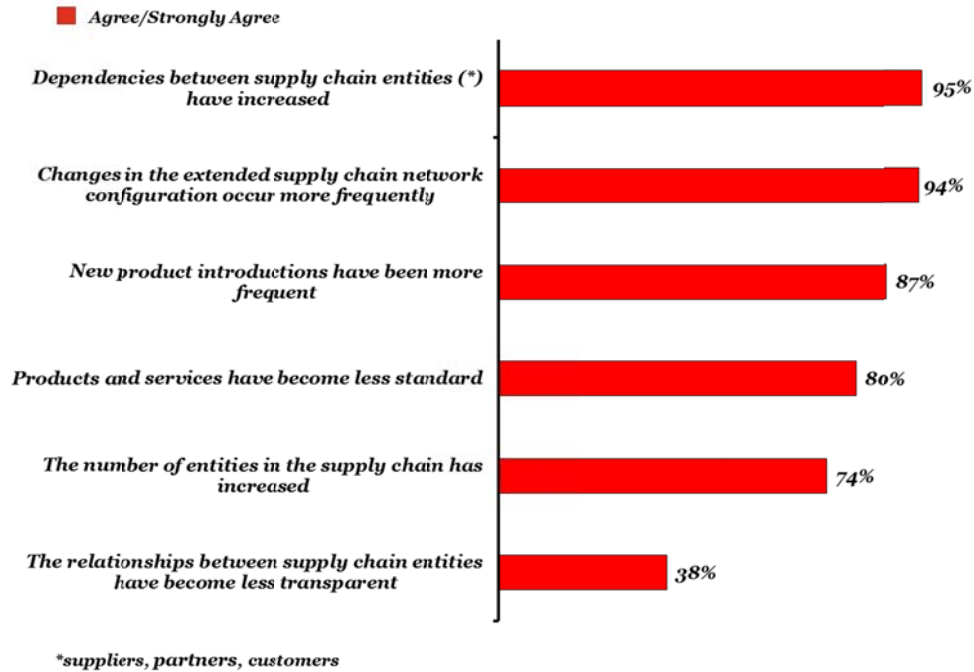


Figure 1. Evolution of supply chain complexity over the past three years

Over recent years, the size of the supply chain network has increased, dependencies between entities and between functions have shifted, the speed of change has accelerated and the level of transparency has decreased.

Overall, developing a product and getting it to the market requires more complex supply chains needing a higher degree of coordination.

What are the sources of supply chain risk?

Risks to global supply chains vary from known-unknowns and controllable, to unknown-unknowns and uncontrollable ones². In the Nissan Case, the devastating natural disasters were unknown-unknowns (difficult to quantify the likelihood of occurrence) and uncontrollable (you cannot manage the expected risk and its impact).

To understand the level of exposure to diverse and broad ranging sources of risk, we asked survey participants to identify the sources of risks faced by their supply chain. The results are shown in **Figure 2**.

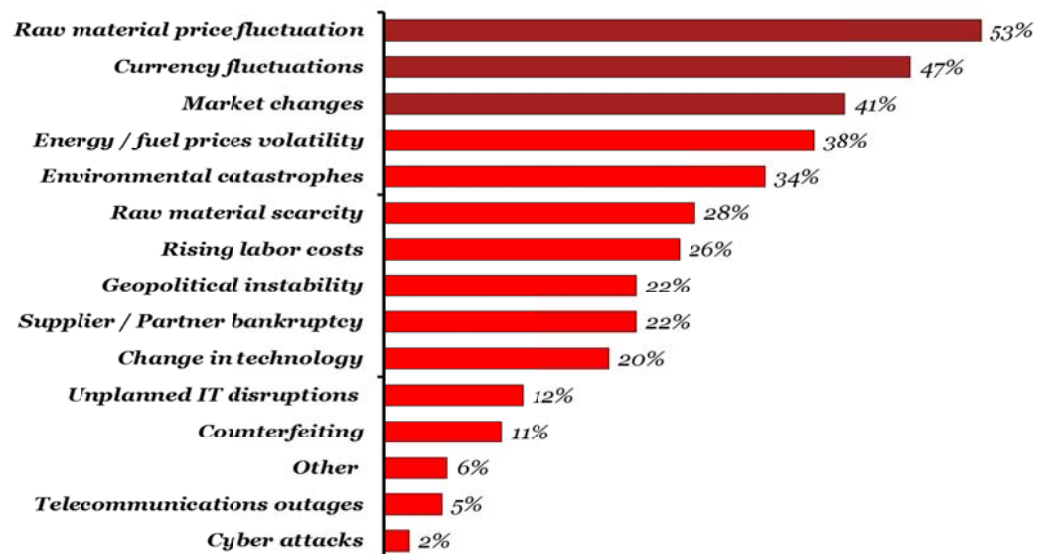


Figure 2. Survey participants' view on sources of risks faced by their supply chain

Interestingly, all the top six risks, with the exception of environmental catastrophes, are known-unknowns and controllable to some degree.

² Operations Rules: Delivering Value Through Flexible Operations, David Simchi-Levi, 2010, The MIT Press.

What parameters are supply chain operations most sensitive to?

Respondents replied that their supply chain operations were most sensitive to skill set and expertise (31%), price of commodities (29%), energy and oil (28%), see **Figure 3**.

As an example of the energy and oil parameter, according to the Department of Energy Information Administration, U.S. diesel prices rose 9.5 cents per gallon in February 2012. Cognizant of the sensitivity and impact diesel prices can have on their financial bottom line, shippers adjust their budgets in order to offset the increased costs higher fuel prices produce.



Figure 3. Parameters to which survey participants' supply chain operations are most sensitive

How do companies mitigate against disruptions?

What kind of actions do our survey respondents currently take to reduce the exposure of their supply chain to potential disruptions or to mitigate the impact? Nissan had a well-thought out and exercised business continuity plan ready to kick into action to facilitate a quick recovery. And indeed 82% of responders said they had business continuity plans ready. See **Figure 4**.

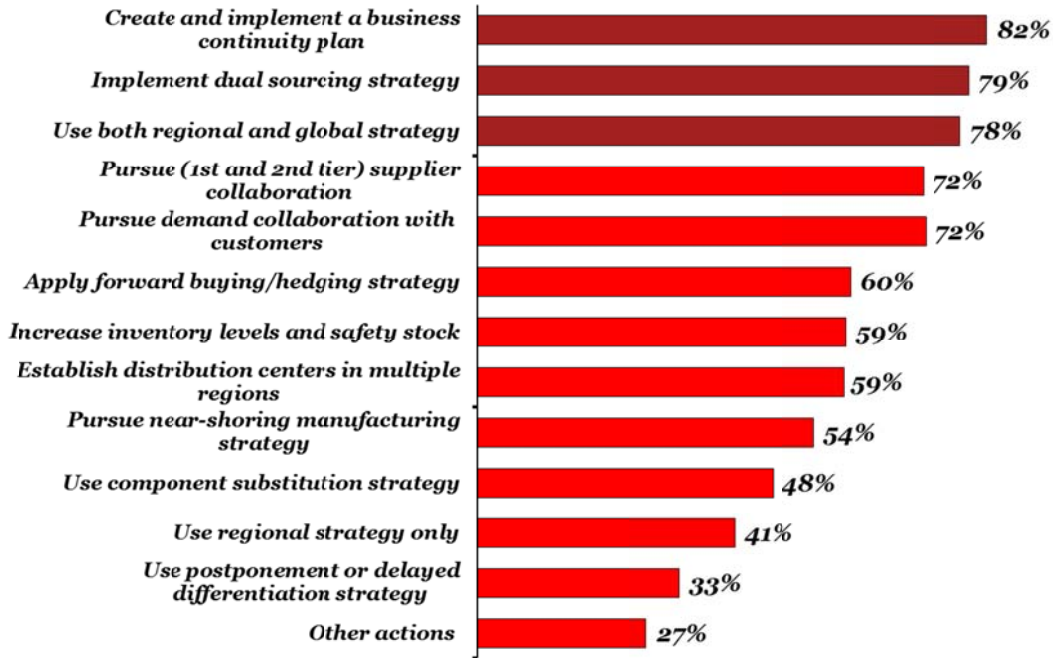


Figure 4. Actions companies take to mitigate supply chain risk

The supply chain and risk management maturity framework

Strengthen supply chain and risk management

As Nissan illustrated, to reduce vulnerability and exposure to high impact supply chain disruptions, companies need advanced capabilities along two dimensions: supply chain management and risk management. But how can they understand the maturity level of their capabilities in these areas before designing ways to strengthen them?

The seven supply chain and risk enablers of maturity

There are seven factors that enable stronger capabilities in both supply chain management and risk management. By matching their practices against these seven “enablers” companies can assess how mature or immature their capabilities are. This is the basis of our Supply Chain and Risk Management Maturity Model – an empirical framework that applies set questions across the seven enablers.

For each of the seven enabling areas, we asked survey respondents to answer questions concerning the extent to which they have implemented gradually advancing practices. The more developed the practices are, the more advanced the capabilities.

The seven enablers are:

1. **Risk Governance** - the presence of appropriate risk management structures, processes and culture.
2. **Flexibility and redundancy in product, network and process architectures** – having the right levels of flexibility and redundancy across the value chain to be able to absorb disruptions and adapt to change.
3. **Alignment between partners in the supply chain** – strategic alignment on key value dimensions, identification of emerging patterns and advancement towards higher value propositions.
4. **Upstream and downstream supply chain integration** – information sharing, visibility and collaboration with upstream and downstream supply chain partners.
5. **Alignment between internal business functions** – alignment and the integration of activities between company value chain functions on a strategic, tactical and operational level.
6. **Complexity management/rationalisation** – ability to standardise and simplify networks and processes, interfaces, product architectures and product portfolios and operating models.
7. **Data, models and analytics** – development and use of intelligence and analytical capabilities to support supply chain and risk management functions.

According to our survey, companies consider alignment between partners in the supply chain as the most important factor in enabling risk reduction (60%), see **Figure 5**.

Internal and external process integration is also very important (49%) and (47%). Risk governance (44%) and network flexibility and redundancy (37%) are also being included in the mix. Finally, despite recent advances, data, models and analytics (28%) and complexity management / rationalisation (26%) are low on the priority list. As analytics continue to mature, this may change.

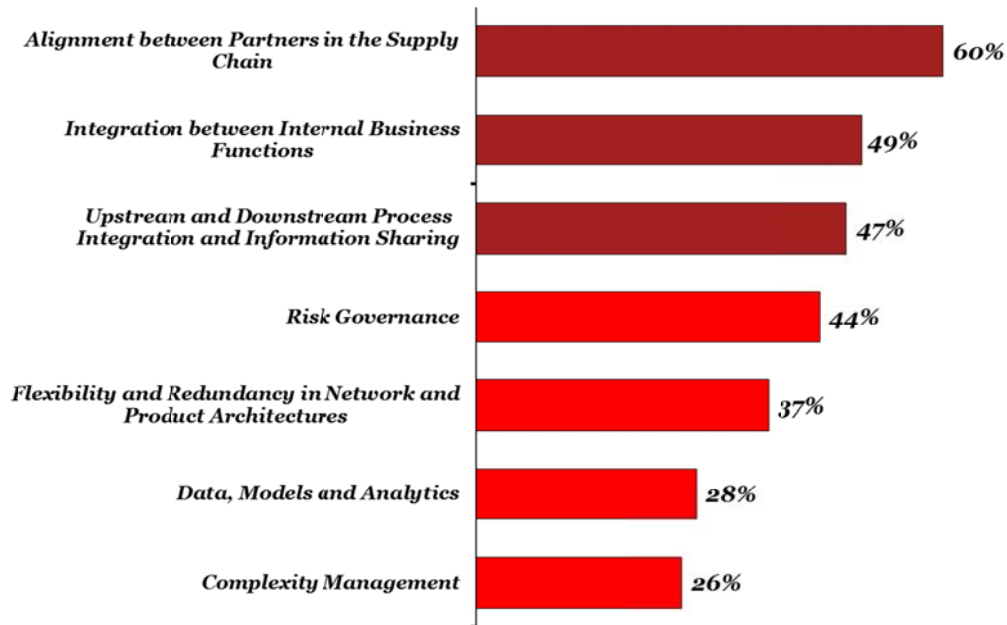


Figure 5. Survey participants' view on which capability enabler they consider the most important

Four levels of maturity in supply chain operations and risk management

Supply chain operations and risk management processes go hand-in-hand and complement one another. At lower maturity levels the processes are decoupled and stand-alone but at high maturity levels they are fully intertwined. For developing and deploying capabilities to manage supply chain risk effectively, a high level of supply chain sophistication is an absolute pre-requisite.

There are four levels of supply chain and risk management process maturity:

Level I: Functional supply chain management and ad-hoc management of risk. Supply chains are organised functionally with a very low degree of integration. They are characterised by high duplication of activities, internally and externally disconnected processes and an absence of coordinated efforts with suppliers and partners. Product design is performed independently and there is little visibility into partners/suppliers operations. Inventory and capacity levels are unbalanced leading to poor customer service and high total costs. There is no risk governance structure and poor visibility into sources of supply chain risk. Only very limited vulnerability or threat analysis is performed. Risk is managed in an *ad-hoc* way with no prior anticipation or positioning of response mechanisms.

Level II: Internal supply chain integration and positioning of planned buffers to absorb disruptions. Supply chains are cross-functionally organized. Internal processes are integrated, information is shared and visibility is provided between functions in a structured way. Resources are jointly managed and there is a higher level of alignment between performance objectives. Integrated planning is performed at strategic, tactical and operational levels – that leads to a single company plan. Risk management processes are documented and internally integrated. Basic threats and vulnerabilities are analysed. Scenarios concerning the base integrated plan are conducted to position targeted buffers of capacity and inventory to absorb disruptions. Postponement or delayed differentiation product design principles are explored to improve response to changing demand patterns. There is minimum visibility, however, into emerging changes and patterns outside the company.

Level III: External supply chain collaboration and proactive risk response. Supply chains feature collaboration across the extended enterprise. Information sharing is extensive and visibility is high. Key activities such as product design or inventory management are integrated between supply chain partners. External input is incorporated into internal planning activities. Interfaces are standardised and products and processes are rationalised to reduce complexity. Information sharing and visibility outside the company domain is exploited to set up sensors and predictors of change and variability to proactively position response mechanisms. Formal quantitative methodologies for risk management are introduced and sensitivity analysis is conducted. Suppliers and partners are monitored for resilience levels and business continuity plans are created.

Level IV: Dynamic supply chain adaptation and fully flexible response to risk. Companies are fully aligned with their supply chain partners on the key value dimensions across the extended enterprise. Their individual strategies and operations are guided by common objectives and fitness schemas. Their supply chain is fully flexible to interact and adapt to complex dynamic environments. Emerging value chain patterns resulting from this interaction are probed and identified and higher value equilibrium points are achieved. At this level, the supply chain is often segmented to match multiple customer value propositions. Risk sensors and predictors are supported by real-time monitoring and analytics. Risk governance is formal but flexible. Full flexibility in the supply chain product, network and process architecture and short supply chain transformation lead-times allow quick response and adaptability. Supplier segmentation is performed. Risk strategies are segmented based on supplier profiles and market-product combination characteristics.

Table 1 summarizes the criteria used as a basis for the questions and the maturity levels.

| | Supply chain management | Risk management | |
|------------------|---|---|--------------------|
| Level I | Functional <ul style="list-style-type: none"> Internally and externally disconnected plans and processes Lack of visibility into supplier/partner operations and business data Resources are locally owned and managed Performance is measured separately based on functional key performance parameter (KPIs) | Ad-hoc <ul style="list-style-type: none"> Ad-hoc risk management processes Product design is performed independently Absence of common standards and processes No planning of redundancy buffers towards potential disruptions Can absorb only limited volatility around standard functional input parameters | Less mature |
| Level II | Integrated <ul style="list-style-type: none"> Internally aligned and integrated functions Information sharing and planning activities between internal functions Postponement strategy used Supply chain performance measured | Buffer planning <ul style="list-style-type: none"> Anticipatory risk planning Build capacity/invest in inventory Position redundancy buffers based on a common cross-functional plan Basic risk governance processes | |
| Level III | Collaborative <ul style="list-style-type: none"> External and internal collaboration Visibility and information sharing between supply chain partners Full integration of key functions Incorporation of external input into internal planning activities Supply chain rationalisation Performance measured and forecasted | Proactive <ul style="list-style-type: none"> Proactive risk management Quantitative risk management Business continuity plans – Partner resilience monitoring Use of sensors and predictors to proactively position response mechanisms | More mature |
| Level IV | Dynamic <ul style="list-style-type: none"> Dynamic supply chain adaptation to value chain change Full enterprise integration Full upstream and downstream visibility Complete alignment on key customer value dimensions across the enterprise Sophisticated operations models in use Supply chain segmentation matches multiple customer value propositions | Flexible <ul style="list-style-type: none"> Invest in flexibility (processes, products, plants, capacity) Manage risk pressure away from weak suppliers Common standards and processes Timely supply chain bottlenecks management | |

Table 1. Capability maturity classification model

How mature are company capabilities?

The framework is a useful tool in evaluating each company's capabilities. Importantly, according to our study, it shows that the majority of the companies have immature supply chain operations and risk management processes in place. See **Figure 6**.

Specifically, of the companies surveyed, only 41% were classified as having mature processes, based on their responses. 59% of companies have immature processes in place to effectively address incidents. Only a minority of companies (9%) are fully prepared to address potential challenges from supply chain disruptions in increasingly complex environments.

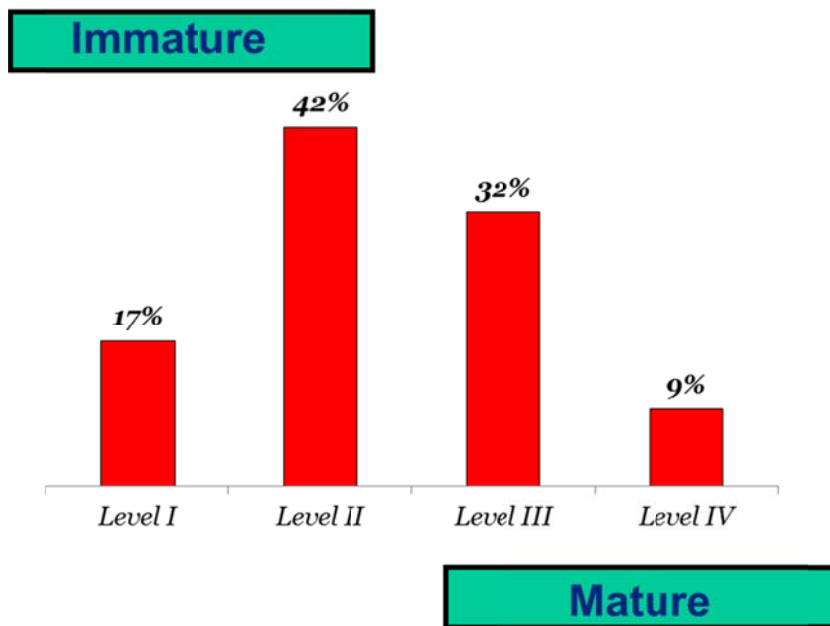


Figure 6. Capability level company classification profile

Key insights - More mature capabilities lead to better operational performance

Having assessed the maturity levels of the 209 companies in the survey, we then analysed their business and operational performance indicators over the last 12 months. Our aim was to understand the impact of disruptions on mature vs. immature companies.

The indicators cover a wide spectrum of company performance including profitability, efficiency and service. Both the scale of the impact, and the time it took to recover to prior or improved levels of performance, were measured.

These are the key insights from the 209 companies surveyed:

1. Supply chain disruptions have a significant impact on company business and financial performance

To better understand the impact of disruptions³, we assessed the performance of companies that faced at least three disruptive incidents over the last twelve months. If performance indicators were negatively affected by 3% or higher, this was considered “significant impact.” As **Figure 7** illustrates, 54% said that sales revenue was negatively affected and 64% suffered a decline in their customer service levels. Across all the operational KPIs examined, at least 60% reported a 3% or higher loss of value.

The importance of having mature capabilities in place to deal with supply chain disruptions is clear.

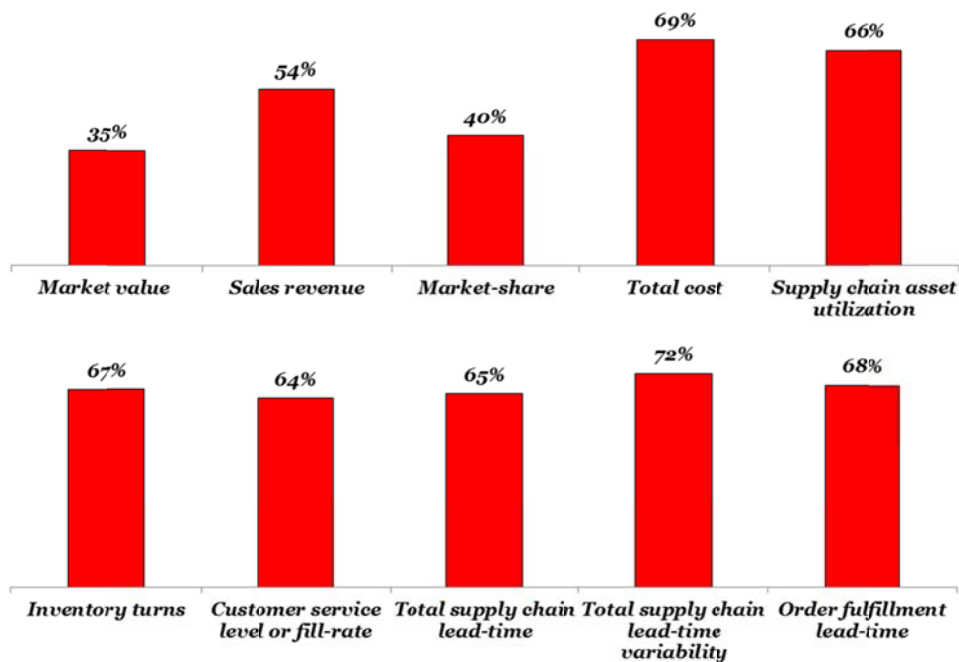


Figure 7. Percentage of companies that suffered a 3% or higher impact on their performance indicators as a result of supply chain disruptions in the past twelve months.

³ Information about disruption impacts is self-reported by survey participants.

2. Companies with mature supply chain and risk management processes are more resilient to disruptions than those with immature processes

According to the survey results, companies with mature (maturity levels III & IV) supply chain and risk management processes are more resilient to disruptions than companies with immature (maturity levels I & II) processes. The more mature companies suffer lower impact and enjoy faster recovery.

Figure 8 shows the percentage of companies with more than 3 incidents that suffered an impact of 3% or higher on their performance as a result of supply chain disruptions in the last twelve months.

Only 44% of the companies with mature processes suffered a 3% or more decline in their revenue compared to 57% with immature processes. The higher resilience trend for mature companies is common for all the KPIs examined. The difference is striking in key areas such as total supply chain cost, order fulfilment lead times and lead-time variability. These KPIs are among those most heavily impacted by supply chain disruptions, so mature companies gain a distinct advantage by investing in the proposed set of capabilities.

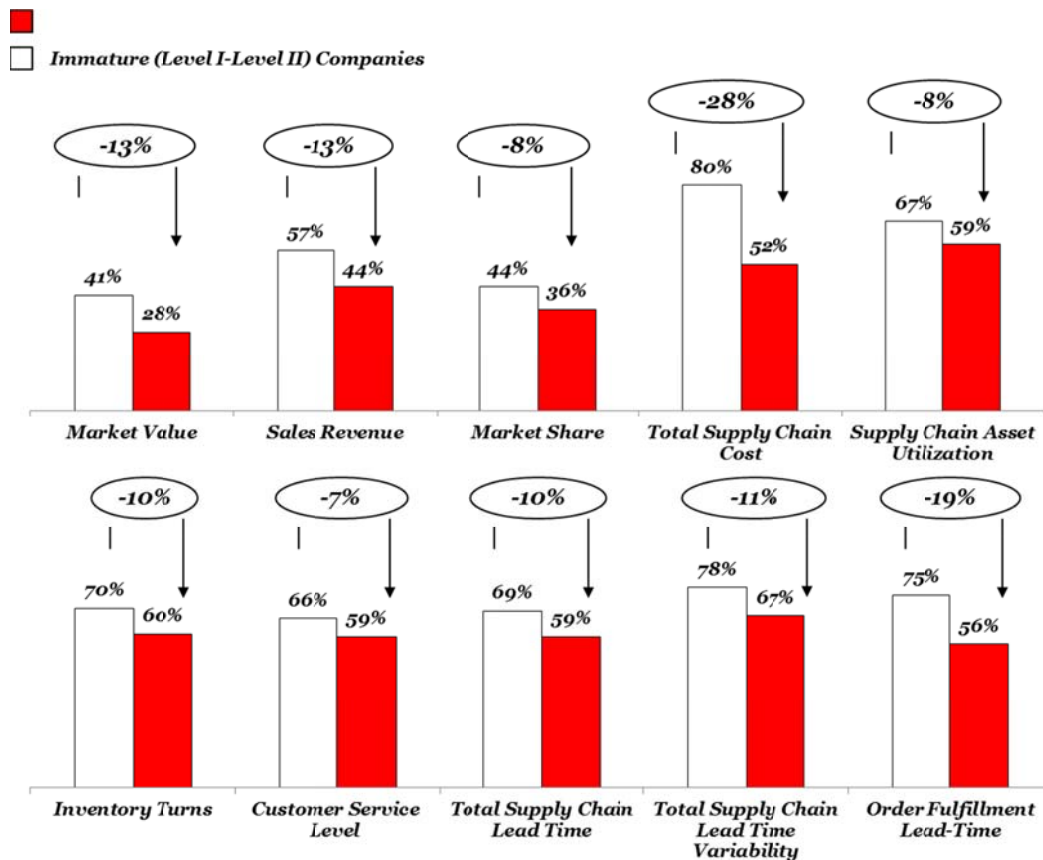


Figure 8. Performance KPI resilience to disruptions between more mature and less maturity levels

3. Mature companies that invest in supply chain flexibility are more resilient to disruption than mature companies that don't

Flexibility is critical to a company's ability to adapt to change. A greater degree of flexibility in their businesses will allow companies to better respond to demand changes, labour strikes, technology changes, currency volatility, volatile energy and oil prices. However, flexibility does not come free and the higher the level of flexibility the more expensive it is to achieve. Similarly, achieving a higher level of service can be costly. It's a difficult trade-off between the desire to minimise costs vs. investing in flexibility or increasing customer service levels.

We asked the respondents to identify the key supply chain value drivers for their leading customer value proposition. High customer service level (34%) and flexibility (27%) were cited as the top two drivers followed by cost minimisation (22%) and efficient use of inventory (14%). See **Figure 9**.

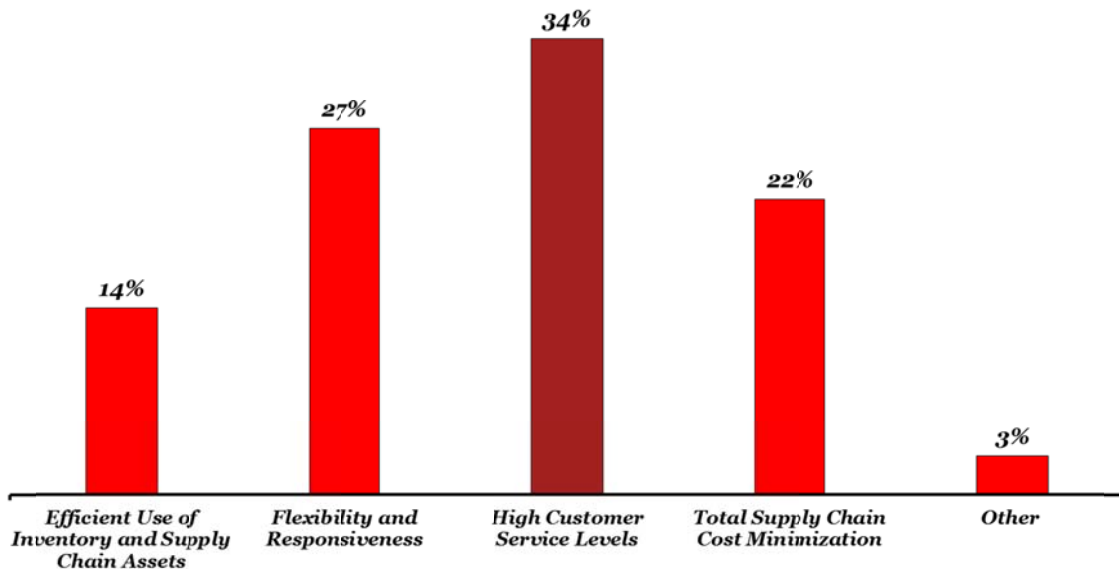


Figure 9. Key supply chain value driver to match customer value proposition

Two distinctive groups emerge from this response:

- The cost-efficient group - mature companies that selected cost or efficiency as their key supply chain value driver.
- The flexible-response group - mature companies that selected flexibility or customer service levels as their key supply chain value driver.

When we compared the performance resilience of these two groups, we learned that the flexible-response group fared significantly better. The performance of cost-efficient companies suffered more from the changes and disruptions in their supply chain even though they possess mature capabilities in deploying their strategy. Mature companies investing in flexibility, responsiveness and customer service, demonstrate higher performance resilience compared to companies whose strategies emphasise cost and efficiency,

Figure 10 highlights the major differences.

■ Mature (L3-L4) Flexible Response Companies
 Immature (L3-L4) Cost Efficient Companies

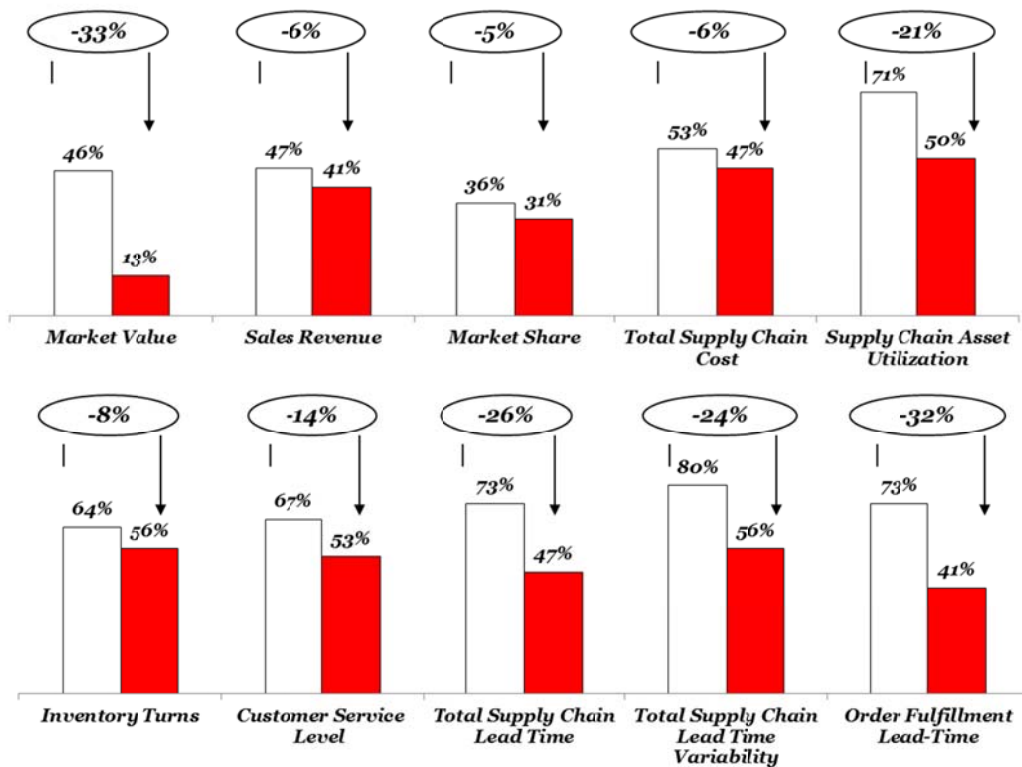


Figure 10. Difference in performance resilience between mature cost-efficient and mature flexible-response companies.

Figure 10 also illustrates that the largest majority of cost-efficient companies (80%) face high variability in their supply chain lead times once a supply chain disruption takes place. This is interesting given that low variability is one of the key drivers of an efficient operating strategy.

4. Mature companies that invest in risk segmentation are more resilient to disruptions than mature companies that don't

Companies with different market value propositions prioritise different value dimensions in their supply chains. Today, companies often target different market segments and therefore have several customer value propositions. For example, one part of the product portfolio may emphasise price as key differentiator while another emphasises product innovation or product selection and availability.

We asked our survey respondents to identify the key value dimension of their leading customer value proposition.

The top three choices were: Quality (23%), Innovation (14%) and Price (14%). See **Figure 11**.

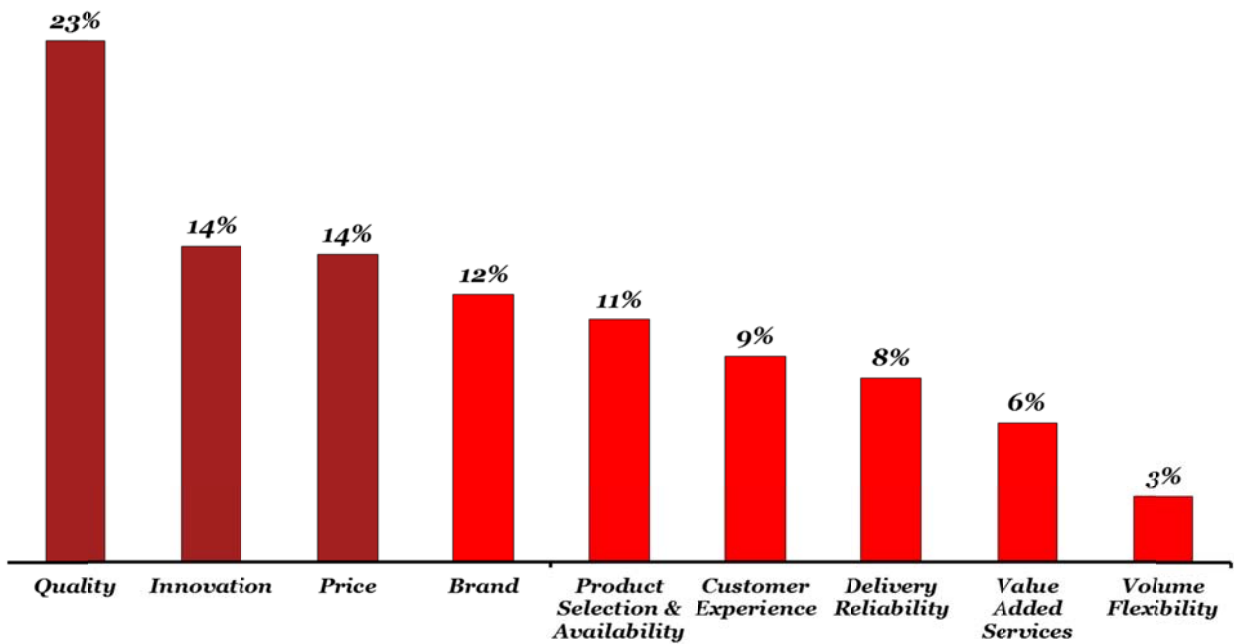


Figure 11. The key value dimension of the leading customer value proposition of survey participants.

Different value propositions – and the corresponding operating strategies - do not necessarily have the same risk profile. Value dimensions are not exposed to the same threats and vulnerabilities. As a result, the management of supply chain risk – exposure reduction and mitigation strategies – may need to vary significantly based on the value dimension. Consider a value proposition emphasising product innovation. The high speed of innovation, the corresponding lower forecast accuracy, the higher price risk and the higher supply risk will essentially determine the type of strategy the company deploys with its supplier. If the price risk or supply risk is higher as a result of the speed of innovation then it is more likely that flexible risk-sharing contracts, rather than a build-up of inventory buffers is appropriate. Thus, risk strategies needs to be segmented according to the value driver.

We asked survey respondents whether they actively pursued risk strategy segmentation. Almost 60% do and 40% don't. See **Figure 12**.

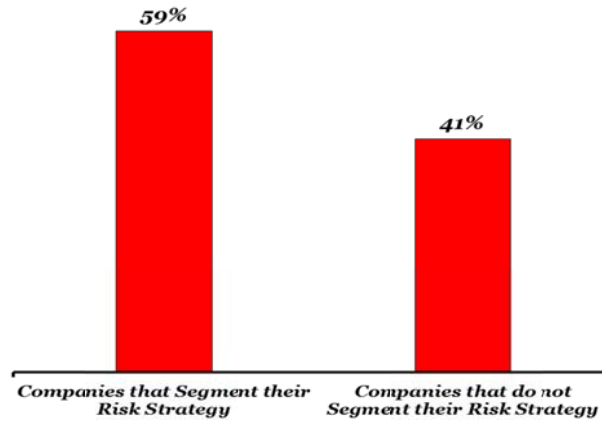


Figure 12. Percentage of companies that perform risk strategy segmentation.

We asked the 59% of companies that pursued risk segmentation, “What product differentiators do you use as a basis for risk strategy segmentation?” The top three choices were: strategic importance (56%), demand volatility (52%) and sales volume (45%). See **Figure 13**.

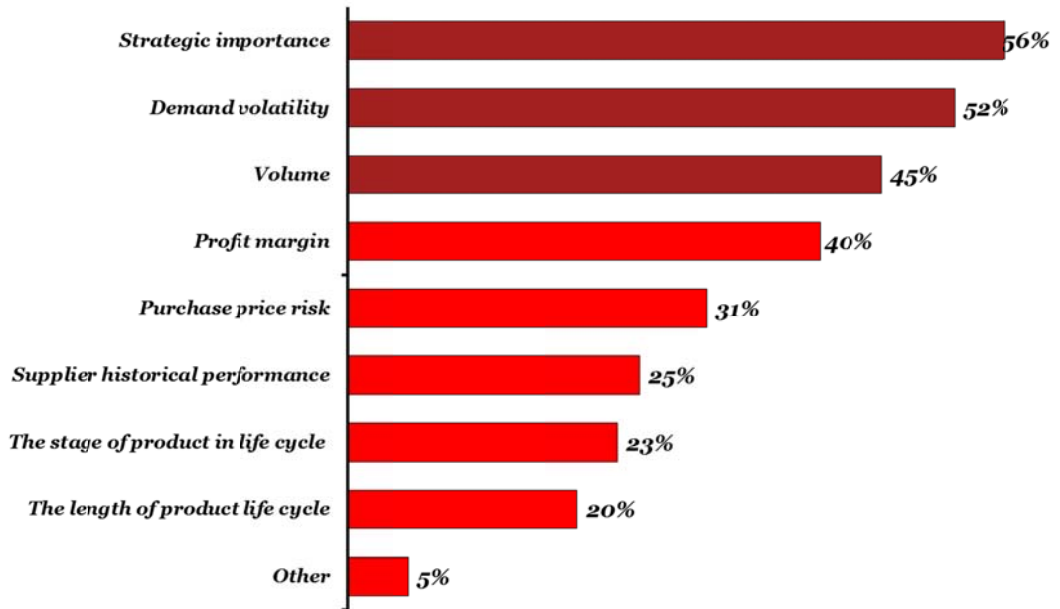


Figure 13. Key product differentiators for risk strategy segmentation

Companies with mature capabilities were clustered into two main groups: those that perform risk strategy segmentation and those that don't. We then compared the performance resilience to supply chain disruptions for both groups.

We observed that mature companies investing in risk segmentation based on different value proposition demonstrate higher performance resilience than companies that do not invest in risk segmentation.

Figure 14 highlights the major difference between the two groups across operations and financial performance indicators. Of particular note is in the sales revenue category. Only 32% of the mature companies that segment their risk management strategy were significantly impacted as a result of incidents that occurred. This compares to 70% of mature companies that don't segment - a 38% difference!

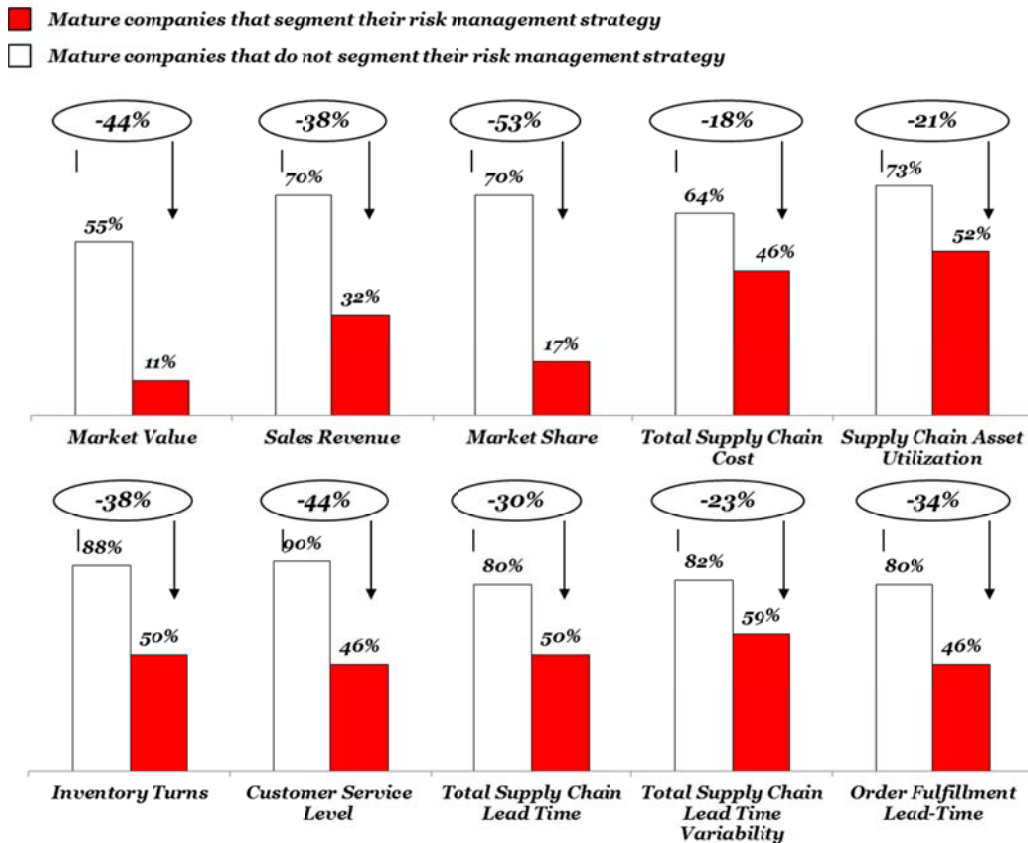


Figure 14. Difference in performance resilience based on risk strategy segmentation.

5. Companies with mature capabilities in supply chain management and risk management do better along all surveyed dimensions of operational and financial performance than immature companies

We compared how company operations and financial performance differed between the mature and immature companies over the prior 12 months. As **Figure 15** highlights, companies with mature capabilities in supply chain and risk management do better along all surveyed dimensions of operational and financial performance.

This finding suggests that there is a direct link between having mature supply chain and risk management capabilities and higher overall performance.

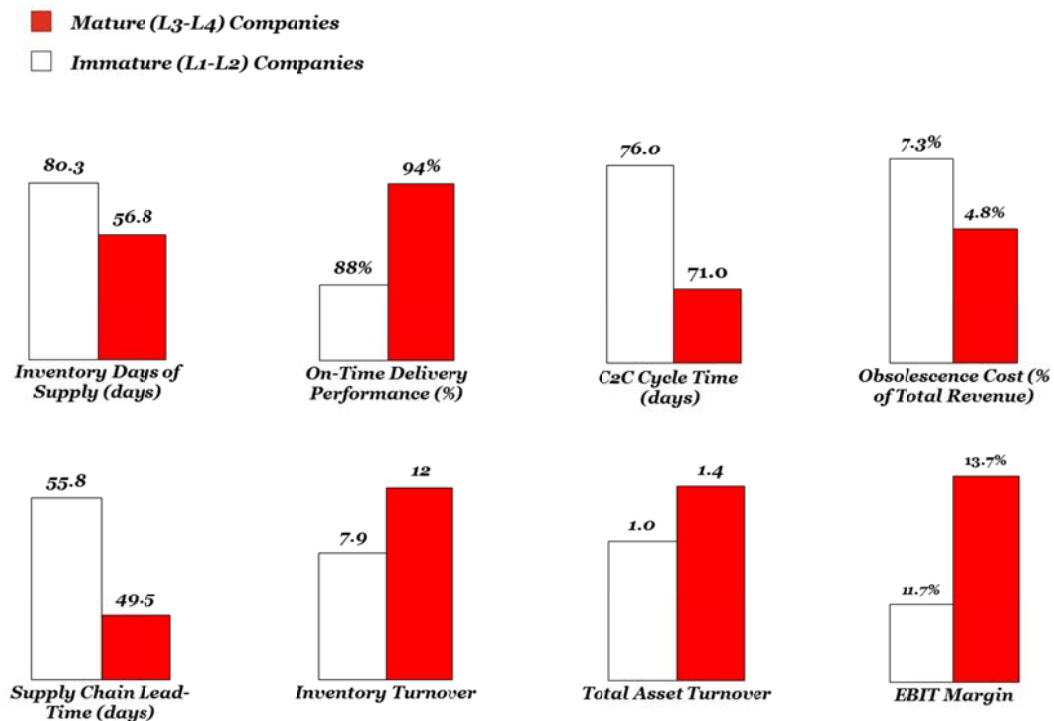


Figure 15. Business and financial performance difference between mature and immature companies

The capability maturity evaluation will enable company executives to gain insight into the risk position and maturity of the company measured in terms of their operations and financial performance.

Appendix A: Survey demographics and trends

The majority of the 209 survey participants are from Europe. **Figure 16** illustrates the geographical distribution of survey participants according to where their headquarters are based.

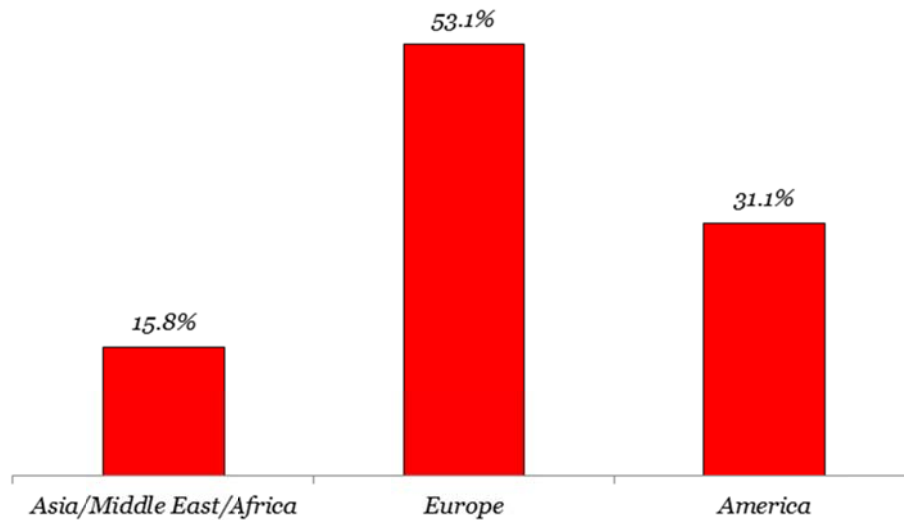


Figure 16. Distribution of survey participants' headquarters by region

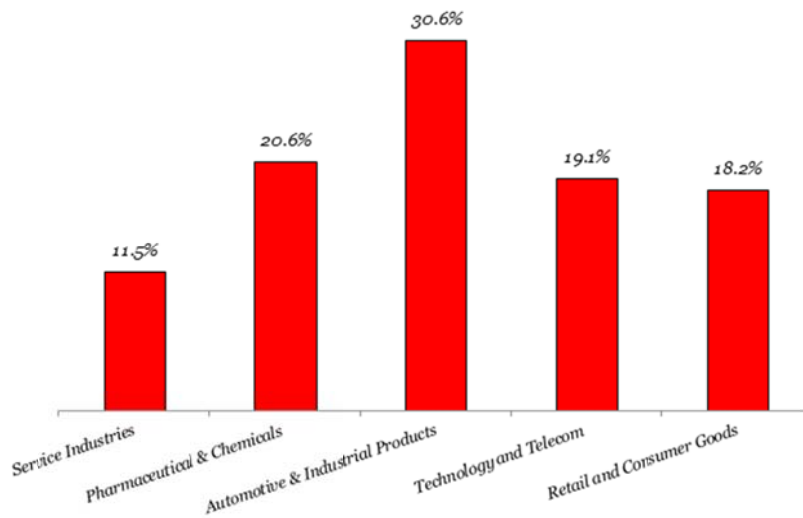


Figure 17. Distribution of survey participants by industry

Distribution of all participating companies based on their 2011 reported sales revenues.

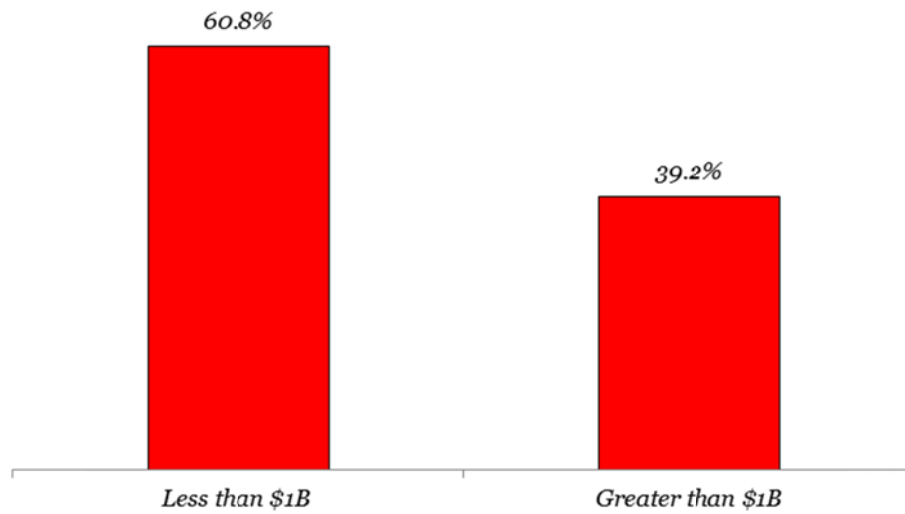


Figure 18. Distribution of survey participants by annual sales revenue

The majority of survey participants (64%) are manufacturing companies.

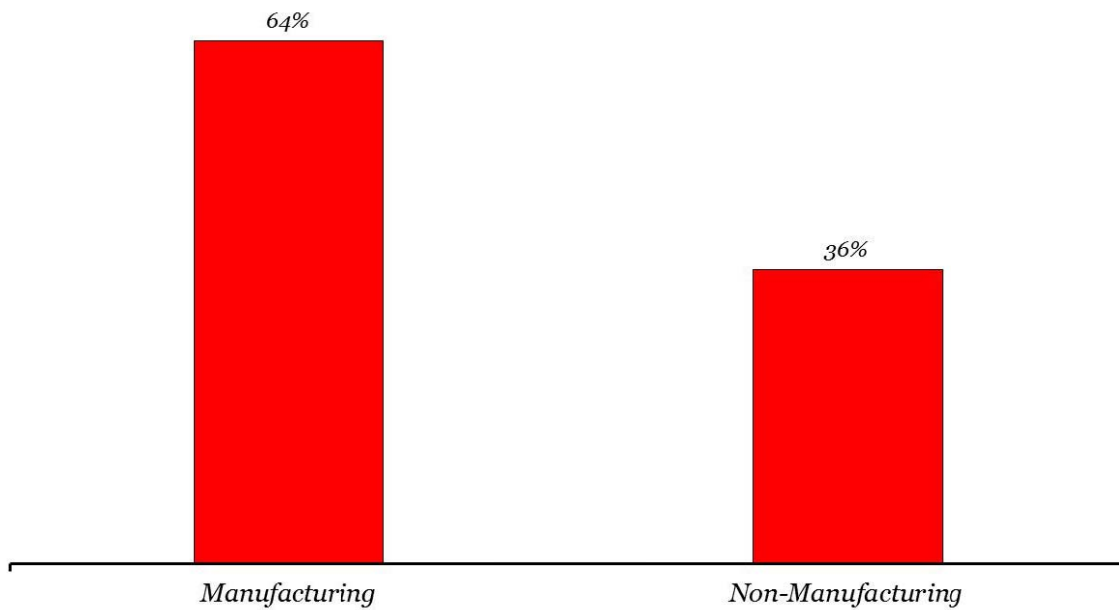


Figure 19. Percentage of manufacturing vs. non-manufacturing survey companies

83% of the participating companies have their manufacturing operations dispersed in multiple geographic regions while only 17% have them in the same region as their headquarters.

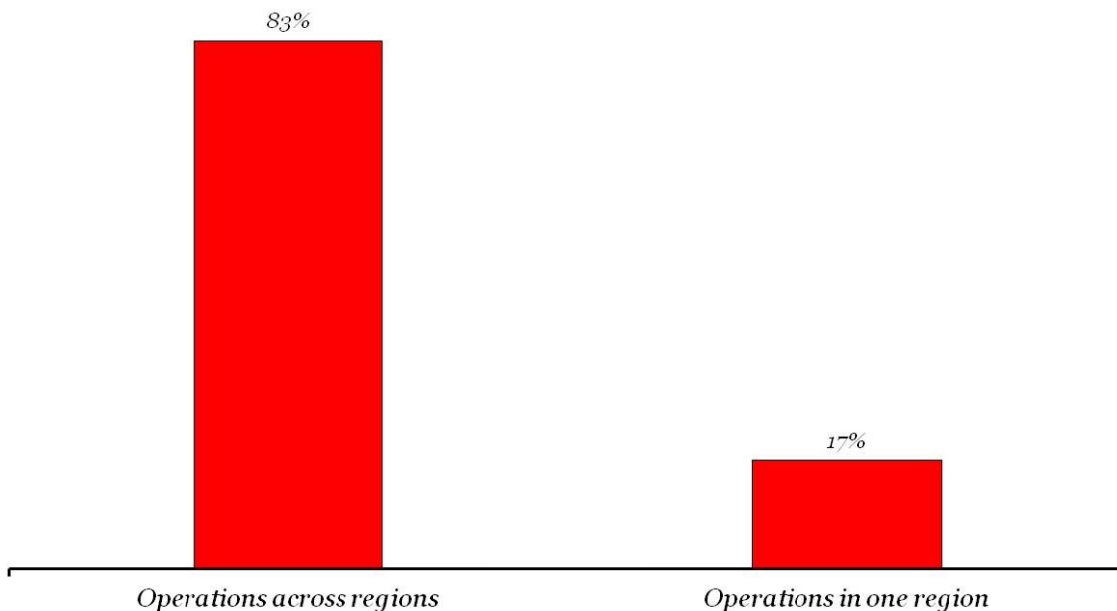


Figure 20. Distribution of Companies by scale of operations globalization

With 83% of the companies having operations across regions we examined how the split of operations volume by regions compares with the split of their sales volume by region to get an indication for the use of regional vs. global operations strategies to meet demand. For the last 12 months, we observe that sales vs. operation volumes per region are mostly aligned indicating use of regional strategies by survey participants.

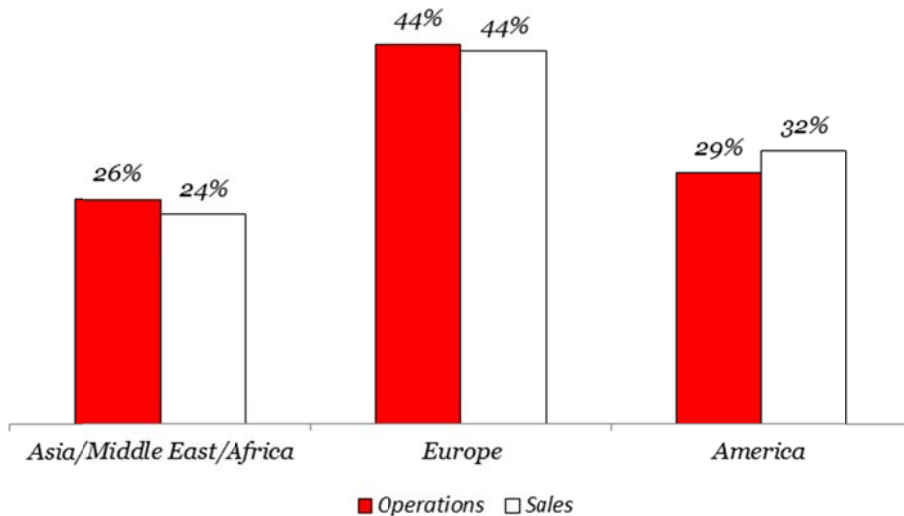


Figure 21. Comparison between manufacturing operations volume and sales volume by region

This is a comparison between the current and the future expected operations volume in 2015 by region based on the expectation of survey participants. America operations remain constant.

A 3 percent growth is shown for Asia and a corresponding 2 percent decline for Europe indicating a shift of operations from Europe to Asia.

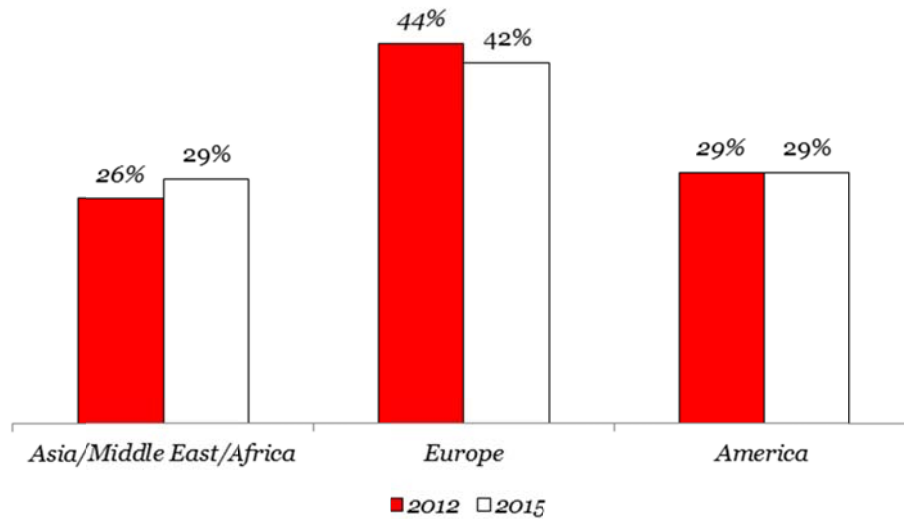


Figure 22. Comparison between current vs. future expected operations by volume

The current vs. future expected sales volumes in 2015 by region based on the expectation of survey participants are compared in **Figure 23**.

Survey participants expect a drop in their sales volume in Europe by 2015 and increase in sales volumes in most of the other world regions with Asia, Middle East & Africa contributing the biggest part.

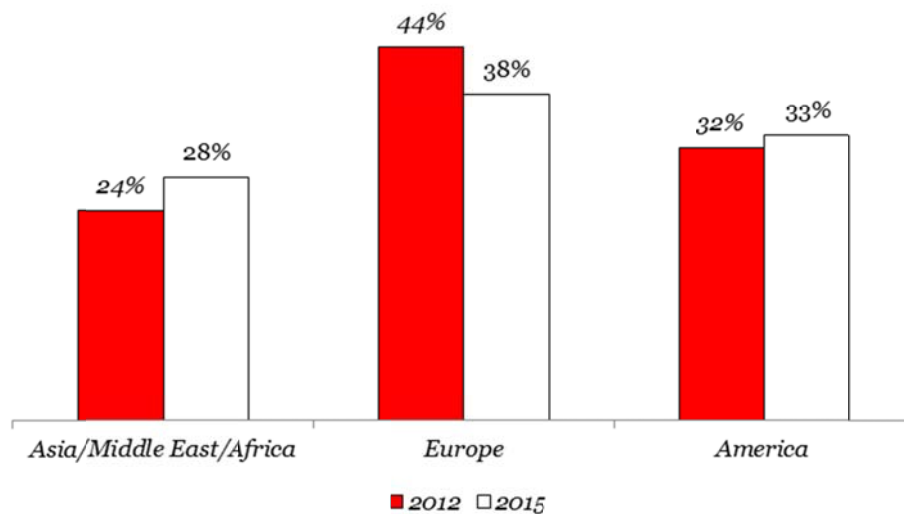


Figure 23. Comparison between current vs. future expected sales volumes by region

Appendix B: Key performance indicator definitions

The key operations ⁴ and financial performance indicators used in this study are described below:

Market value:

The current market value of a company is the total number of shares outstanding multiplied by the current price of its shares. Recent research has shown that shareholder value can be significantly impacted by severe supply chain disruptions. An example is Mattel, the world's largest toymaker, who had to issue a major product recall due to quality issues. Mattel's stock-price suffered a steep fall when the recall was announced in Q3 2007 and did not recover for many months after.

Sales revenue:

The revenues a company makes after the sale of its products. Supply chain disruptions or structural market shifts can impact a company's ability to deliver the value proposition and lead to loss of sales volume and sales revenue.

Market share:

The company's sales over the period divided by the total sales of the industry over the same period. Loss of delivery capability or damaged brand image can lead to market-share loss, especially, when the impact of a supply chain disruption is long-lasting.

Earnings before income and taxes (EBIT) margin

The earnings before interest and tax (EBIT) divided by total revenue. EBIT margin can provide an investor with a clearer view of a company's core profitability

Total supply chain cost:

The sum of fixed and variable costs to perform the plan, source, make and deliver functions for company products. Supply chain disruptions have an impact on total supply chain cost as a number of activities need to be expedited or redesigned across the various functions.

Supply chain asset utilisation:

Supply chain asset utilisation is a measure of actual use of supply chain assets divided by the available use of these assets. Assets include both fixed and moving assets. Fixed assets enable direct product development, transformation, and delivery of a company's products or services, as well as indirect support, and, typically, have greater than one year of service life. A disruption can directly impact the usability of assets and resources or cause their re-positioning in order to recover. As a result, the utilisation of key assets and resources may deviate significantly from the set targets.

Inventory turns:

Inventory turnover ratio measures the efficiency of inventory management. It reflects how many times average inventory was produced and sold during the period. A disruption or change may impact inventory efficiency either by introducing increased obsolescence or by changing inventory positioning and consumption plans.

⁴ David Simchi-Levi, Phil Kminsky, Edith Simchi-Levi (2008). *Designing and Managing The Supply Chain: Concepts, Strategies and Case Studies, 3rd Edition*. McGraw-Hill Irwin

Customer service levels:

The probability that a customer demand is met. The loss of delivery, customer communication or customer service capability due to a supply chain disruption can impact customer service levels.

Order fulfilment lead-time:

The average actual lead times consistently achieved, from order receipt to order entry complete, order entry complete to start build, start build to order ready for shipment, order ready for shipment to customer receipt of order.

Total supply chain lead-time:

Total supply chain lead-time in supply chain management is the time from the moment the customer places an order (the moment you learn of the requirement) to the moment it is received by the customer. In the absence of finished goods or intermediate (work in progress) inventory, it is the time it takes to actually manufacture the order without any inventory other than raw materials. Supply chain disruptions can introduce significant delays across all stages of the supply chain.

Total supply chain lead-time variability:

Total supply chain lead-time variability is the time variation around the total supply chain lead time mean. Exposure to incident disruptions introduces variability and fluctuations in the standard lead-time levels within the supply chain.

About the Project Team

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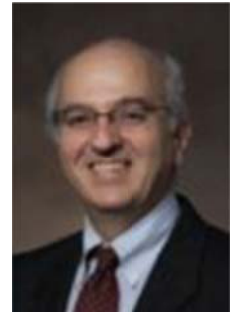
Prof. Simchi-Levi is considered to be one of the thought leaders in supply chain management. Prof. Simchi-Levi holds a Ph.D. from Tel Aviv University. His research currently focuses on developing and implementing robust and efficient techniques for logistics and manufacturing systems. He has published widely in professional journals on both practical and theoretical aspects of logistics and supply chain management. He is also the editor-in-chief of Operations Research, the flag-ship journal of INFORMS, the Institute for Operations Research and the Management Sciences.



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About The MIT Forum for Supply Chain Innovation

MIT Forum for Supply Chain Innovation

The MIT Forum for Supply Chain Innovation is a community composed of academics and industry members whose support allows forum researchers to provide customer-focused solutions to design and manage the new supply chain. The Forum has pioneered a deeper understanding of the supply chain and its relationship to corporate strategy and has broad support from a wide cross-section of industry.

<http://supplychain.mit.edu/>

MIT Forum Manufacturing Technology Advisory Board

In June 2012, the MIT Forum launched the **Manufacturing Technology Advisory Board** in response to Forum members' request for technology transformation guidance. The board consists of MIT academic and research leaders with major technology providers and industry leaders to collaborate on key issues around U.S. manufacturing.

<http://supplychain.mit.edu/news-events>

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