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An Empirical Analysis of Manufacturing Re-shoring and Supply Chain Risk

by

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Abstract

After an exodus of jobs in the last few years, the U.S. is committed to improving its manufacturing competitiveness by investing in manufacturing innovation and increasing its labor force productivity. With rising labor costs in China and the current economic recession in Europe the timing could not be better for the U.S. to surge forward to gain back its competitive edge. These advantages along with the expected U.S. shale oil energy boom create an attractive opportunity for U.S. companies to re-shore their operations. This empirical manufacturing study analyzes the survey responses from a large number of companies with global manufacturing footprint and examines whether U.S. companies consider re-shoring their operations. The results show that a significant proportion, 33.6 percent of the U.S. companies are “considering” bringing manufacturing back to the U.S., while 15 percent of U.S. companies are “definitely” planning to re-shore to the U.S. This is a very insightful finding and it shows that the re-shoring trend is picking up speed. We used the survey data to identify what drives this trend and whether this trend has made an impact.

Competition in the manufacturing industry is instigating companies to reduce their supply chain costs. To retain their competitiveness, companies are responding by implementing strategies such as lean manufacturing, outsourcing and offshoring. However, these strategies have significantly increased the company’s exposure to supply chain risks. For example, lean manufacturing means lower inventory levels, and a high risk incident can cause a major disruption in operations. Similarly, as outsourcing and offshoring operations grow, supply chains become geographically dispersed and exposed to various types of risks. As a result, many companies are concerned about their supply chain resilience but only a few are effectively managing risk. Therefore, companies need to plan their supply chain strategy to effectively respond to various risks. This empirical study develops a framework to characterize the supply chain risk maturity level of each company. We then apply the maturity model to examine resiliency and operational effectiveness. The results offer a number of important insights: For example, companies with mature supply chain and risk management processes are more resilient than immature ones. The operational
insights gained by this research can help companies manage today’s challenges and prepare for tomorrow’s opportunities.

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1. An Empirical Analysis of Manufacturing Re-shoring

1.1 Introduction

In the 1970 and 1980's companies based their operations and sales in US or Western Europe to serve home and neighboring countries. In the 90's and 00's rising labor costs and government regulations forced a number of companies to start looking to outsource their manufacturing operations elsewhere. Far East Asia nations, like China, India and Taiwan, were offering better manufacturing operations opportunities with subsidies, low-wage labor, stable economic environment, lax regulations and monetary rigging. Further, rapid growth in emerging and untapped economies like China's was offering higher returns and benefits. With this strategy they were successful in luring US companies to relocate their manufacturing operations there. Large scale industrial manufacturing parks, such as the Tianjin Economic Development Area (TEDA) and Shanghai Fengpu were built to host and attract foreign business. Shanghai Fengpu is one of China's top cheap labor manufacturing centers. About an hour west of Sichuan's capital Chengdu, is Foxconn Technology Group, one of Apple's biggest manufacturing partners. Foxconn employs hundreds of thousands as they help build electronics products for Apple and many other global brand names, such as Amazon's Kindle and Microsoft's Xbox. [1]

These parks were built with the sole purpose to attract foreign capital. Pretty soon, after manufacturing, research and development (R&D) moved abroad and then, product development (PD) followed course. TEDA is one China's top high-tech innovation centers attracting such global R&D and product development investments. So this is not only about manufacturing. In the meantime, over the past-ten years, millions of US jobs moved abroad. Manufacturing had become the foundational cornerstone of China's economic growth and global market presence.

In 2013, rising Chinese labor costs, concerns over Intellectual Capital (IP) theft and, longer supply chain lead times, high fuel costs are causing companies, with more than $1B in sales revenues, to consider regionalizing their manufacturing operations. Google recently announced that its Nexus Q streaming media player would be manufactured in the US. Apple also announced a limited manufacturing of their products in the US. General Electric and Ford start moving some of their manufacturing back in the US. Caterpillar is moving assembly of its largest excavators from Japan to Texas. The question that is being posed is: Based on this information,
is there a trend that US reached a turning point and has become an attractive place for re-shoring manufacturing?"

The U.S. Bureau of Labor Statistics, in their Current Employment Statistics Highlights [2] states that in the month of February 2013 +14,000 manufacturing jobs were added in the economy. Fabricated metal products added 6,000 out of the 14,000 while employment in motor vehicles and parts manufacturing was essentially unchanged. The manufacturing industry has recovered 178,000 since January 2010. US president Obama, in his 2013 State of the Union Address mentioned that 500,000 jobs were added over the three years. The next question is: Is there a real trend that manufacturing jobs are "coming back?"

U.S. manufacturing has been one of the pillars of American prosperity. Today, more than ever, it is essential that the U.S. continues its leadership in manufacturing—to sustain the foundations of the Nation’s economic prosperity and national security and to meet new challenges in the domains of technology innovation, energy, transportation, health care, and education. If U.S. wants to maintain its technological innovation, scientific R&D, product development and manufacturing leadership then these areas become central priorities of the US Government policy makers. A few studies [3] address some of the policy questions, but “What are the manufacturing policy initiatives and incentive actions that the US Government policy makers can take to support bringing manufacturing back and create new jobs?” U.S. economic growth can be based on rethinking about the next manufacturing shift.

1.2 Survey Need Statement

To receive responses to the questions posted in the previous section the Massachusetts Institute of Technology (MIT) Forum for Supply Chain Innovation and Supply Chain Digest (SCDigest) publication launched the “2012 Re-shoring Survey.” The discussion above has given rise to three manufacturing hypotheses:

1. U.S. manufacturing reached a turning point and has become an attractive place for re-shoring manufacturing operations.

2. Time has reached for U.S. companies to change their manufacturing strategy and move back to U.S.

3. U.S. Government is applying the right government policies to bring manufacturing back
The survey was distributed to members of the MIT Forum for Supply Chain Innovation and Supply Chain Digest. In total, 340 participants completed the survey, providing the input for this thesis study and the Annual Re-shoring Report [4]

1.3 **Survey Data Characterization Summary**

Decision makers and executives from 340 companies across a wide range of primary industries participated in the survey, which MIT Forum and SCDigest conducted in July and August of 2012. From the 340 participated industries, 198 were manufacturing industries. The list of industry types and the selection of the subset of 19 manufacturing industries is based upon the North American Industrial Classification [5], which is a United States Government Department of Labor Bureau of Labor Statistics classification system. A U.S. headquarter company is defined as the company that has their headquarters in the U.S. Table 1 below summarizes the survey characteristics.

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<tr>
<td>1</td>
<td>Survey Closure Date</td>
<td>9 Sep 2012</td>
</tr>
<tr>
<td>2</td>
<td>No. of Participants</td>
<td>340</td>
</tr>
<tr>
<td>3</td>
<td>No. of Manufacturing Companies Only</td>
<td>198</td>
</tr>
<tr>
<td>4</td>
<td>No. of US companies (defined as HQ in US)</td>
<td>156</td>
</tr>
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*Table 1. Survey Data Summary*

1.3.1 **Manufacturing Company Distribution by Industry Type**

The distribution of manufacturing only companies by industry type is shown in Figure 1 and Figure 2. Based on the company's businesses we have a good cross section of industries from 19 U.S. Government manufacturing categories.
Based on the sample size of 198 manufacturing only companies, the top industries responding to the survey were:

1. Computer and Electronic Product Manufacturing, 19.2 percent
2. Food & Beverage Product Manufacturing, 10.6 percent
3. Chemicals, 8.1 percent
4. Electrical Equipment, Appliance and Component Manufacturing, 7.6 percent
5. Pharmaceutical and Medicine, 7.1 percent

There is a miscellaneous manufacturing category that includes all other manufacturing categories that has received the largest share of 27.8 percent. Further decomposition of this category reveals a list of assorted manufacturing industries such as:

1. Personal Care Products
2. Golf Equipment manufacturing
3. Other types of manufacturing industries represented by 1 percent by proportion

Figure 1. Pie Chart of Manufacturing only Companies by Industry
1.3.2 Manufacturing Companies Distribution by Revenue Size

The distribution of manufacturing only companies by revenue size is shown in Figure 2. The largest category of companies is the $1B - $10B range with 22.5 percent and the smallest category is $20M - $50M with 2.2 percent.

![Company Size](image)

**Figure 2. Distribution of Manufacturing only Companies—by Revenue Size**

Figure 3 shows the segmentation and distribution of companies using only three size categories: by proportion 52.5 percent of the companies are less than $1B in sales revenue, 22.2 percent are between $1B and $10B and 25.3 percent is greater than $25B.

![Company Size](image)

**Figure 3. Distribution of Manufacturing Companies by Consolidated Revenue Size**

1.3.3 US HQ Manufacturing Companies Distribution by Manufacturing Operations

The first question is: *Where is your manufacturing operations footprint?* The question introduces one of the two interrelated concepts that we will examine later – manufacturing operations footprint and the revenue sales footprint. The distribution of manufacturing operations for all US HQ manufacturing companies is shown in Figure 4. 119 out of the 156 US
manufacturing companies provided data on their current distribution of their manufacturing operations. A U.S. manufacturing company is defined as the one that has its Headquarters in the U.S. Thirty seven companies chose not to reveal any information about their distributions of operations strategy. In terms of revenue size, we have a good representation of the manufacturing companies that are operating globally.

Figure 4. US Manufacturing Companies--Distribution of Manufacturing Operations

The survey responses reveal that about 52.6 percent of the U.S. Companies have their manufacturing operations in the U.S. and 21.1 percent in China. We also note, 61.8 percent of the manufacturing operations are based in North America, 7.6 percent in Europe, and 28.6 percent in SouthEast Asia. Hence, despite the common preception that most of U.S. manufacturing has moved overseas, the survey data show that U.S. companies have their main manufacturing thrust in the U.S. and North America region, closer to the market demand.

1.4 Survey Data Analysis

In the following sections we perform an analysis of the static and dynamic characteristics of manufacturing sector and examine any emerging trends or shifts in the landscape. From Figure 4, the analysis provides results at the aggregate level and does not distinguish the footprint of the
companies in terms of industry type or revenue size. This type of revenue size segmentation analysis is performed in the next section.

1.4.1 Distribution of Manufacturing Activities, by Company Size
To facilitate analysis of the survey results we will segment the Revenue (Sales) Size into three categories (see Figure 3):

1. Small size companies with revenue less than $1 billion (Rev < $1B)
2. Mid size companies with revenue between $1 billion and $10 billion ($1B < Rev < $10B)
3. Large size companies with revenue greater that $10 Billion (Rev > $10B)

Let us focus in the blue-colored section of the pie chart for each of the A, B and C graphs of Figure 5. The blue area sector indicates the portion of the manufacturing operations performed in the US. We note that as the company’s revenue increases, the proportion of U.S. manufacturing operations in the U.S. decreases. The percentage values decline from 60 percent for small companies, to 50.4 percent for mid-size and, to 35.3 percent for large size companies.

Figure 5. Distribution of Manufacturing Activities, by Company Size
The **downward trend** in the U.S.-based manufacturing operations vs. US company size is also illustrated in Figure 6 below. Figure 6 shows a bar chart with a polynomial trend-line of the 60-50-35 percentage values shown in Figure 5. The survey data for China-based manufacturing operations vs. US company size is also shown in the same graph. Based on the data trends with respect to China, we cannot draw any conclusion.

![Proportion of MFG Activities in US vs Company Revenue Size](image)

**Figure 6. US-Based Manufacturing Operations Trend vs US HQ Company Revenue Size**

### 1.5 U.S. Manufacturing Companies Distribution by Market Demand (Sales)

The second question is: *From what region is most of you market demand and revenue sales coming from?* The answer to this question is important. In the previous section we addressed regional distribution of manufacturing operations by company size. In this section we will address regional distribution of sales by company size. Only 83 companies provided information about their Sales Strategy.
Figure 7. Distribution of Sales by Company Size

Figure 7 shows the distribution of sales by company size. Let us again focus in the blue-colored section of the three pie charts. The blue area sector indicates the portion of the sales revenues coming from the U.S. vs. other regions. There is another important insight: as the company’s revenues size increases, US sales proportion decreases. U.S. companies with revenues less than $1B have 69.4 percent of their sales coming from U.S., while the ones with revenues sales between $1B and $10B have 55.6% percent of their sales coming from the U.S. Large companies with more than $10B in revenues have 43.9 percent of their revenue come from U.S.

In summary, it is not surprising why these large companies are moving their operations outside the U.S. More than 56 percent of their sales revenues come outside of U.S. and from emerging markets such as Latin America, Western Europe and Middle East. Thus a regional supply chain operations strategy will be more suitable for this scenario.

1.6 Manufacturing Operations vs. Company Sales Correlation

Now that we understand the downward trend patterns of manufacturing operations vs. company size and sales per region vs. company size the next interesting questions is: what is the
correlation of the manufacturing footprint to sales per region footprint for different company sizes?

The response to this question is addressed in Figure 8. The insight is that *manufacturing footprint and sales footprint in the regions are highly correlated (with a coefficient of correlation closer to -0.8) indicating a high linear relationship*. This insight is intuitive: companies like General Electric or Intel may have 70 percent of their revenue come from outside the US so a lot of their manufacturing activities and sales are outside the U.S.

![Distribution of manufacturing and Sales vs Company Size](image)

**Insight: As Revenue Size Increases the Proportion of Manufacturing Activities and Sales in US Decreases**

**Figure 8. Distribution of Manufacturing and Sales vs. Company Size**

1.7 **Manufacturing Operations vs. Sales Comparison for Different Regions**

If we examine the distribution of manufacturing operations by region in the upper-left corner of Figure 9 we notice that for US companies:

1. A large concentration of manufacturing operations is in the US
2. A large size of sales comes from US

If we look at the pair of manufacturing operations plus sales across regions, at the aggregate level we observe the following **important insights**: 

1. Sales exceeds manufacturing operations for developed countries by 20 percent
2. Manufacturing operations exceeds sales revenue by proportion for emerging markets by 20 percent.

The **Emerging Model** on the right side of Figure 9 provides an insight for U.S. companies on: where the revenues are coming from and where their manufacturing operations are located.

![Percentage of Manufacturing Operations and Sales for Different Regions (US companies)](chart)

**Insights – The Emerging Market Model**
- Sales exceeds Manufacturing for developed countries
- Manufacturing exceeds sales for emerging markets

*Figure 9. Percentage of Manufacturing and Sales Comparison for Different Regions*
2. Re-shoring Survey: Hypothesis

2.1 Hypothesis Testing

For this survey research we will use the deductive approach to develop the hypotheses and then test it through empirical survey observations. Now, based on the reasoning provided in Section 1 it is hypothesized that:

\[ H_0: \text{There is no trend that manufacturing is moving back (aka re-shoring) to US} \]

\[ H_A: \text{There is a positive trend that manufacturing is moving back to US} \]

We will use the survey results to qualitatively and quantitatively test the hypothesis.

2.1.1 Considering vs Definitively Planning to Moving Back Decision

In the survey we have asked the companies “whether they are considering bringing manufacturing back to the U.S. in the next three years (2012-2015).” In order to explore their realistic intentions we have asked a second back-to-back reinforcing question:

**Is Your Company Definitively Planning To Bring Manufacturing Back to The U.S. In The Next Three Years (2012-2015)?**

As addressed in Figure 10 in our Survey, about 33.6 percent of the companies reported that they are considering moving manufacturing operations back in the U.S. (left chart). But when we ask them whether they are definitively planning to get back (right chart) we get a much smaller number, 15.3 percent. This is a comparison between Consideration vs Definitively Planning to move manufacturing back to the U.S. at the aggregate. We observe the following:

1. **1\textsuperscript{st} Observation:** There is a big difference between those that are discussing and those that have made the decision to move back in the US. But even 15.6 percent it is an enormous number. **That is a change in manufacturing operations footprint.**

2. **2\textsuperscript{nd} Observation:** If we look closely at the green sector of the pie-chart – about 1/3 of the companies refused to discuss their strategy. This is one part of the survey: the companies are willing to tell us everything else but in this question they were not willing to tell us.
All US Companies: Consider to Bring MFG Back

Key Insights: For US manufacturing companies:
- Big difference between those considering and those planning to move manufacturing to the US
- About one third of the companies refused to discuss the topic
- Not clear what type of activities are moved to the US

Figure 10. Comparison of Considering vs Definite Planning to Move Back to U.S. by Aggregate

This second observation is an important observation to a sensitive question even though we said at the survey that we are not going to disclose any information (the survey data are kept confidential). A set of companies considered that this may too sensitive to report and they have not responded. The green color sector consists primarily of large size companies.

In Figure 11 we segmented the Considering vs. Definite Planning to Move Back decision by size in order to understand the breakdown:

1. Small size companies go down from 34% → 12%
2. Mid-size goes down from 32 → 20%
3. Larger size does down from 27% → 8%

The largest drop is observed in small size companies but the biggest manufacturing operations impact is from large size companies.
Consider to Bring MNFG Back
Rev < $1B

- No Consideration: 37.6%
- No Response: 31.0%
- Consider to Bring MNFG Back: 31.4%

Consider to Bring MNFG Back
$1B < Rev < $10B

- No Consideration: 31.1%
- No Response: 33.8%
- Consider to Bring MNFG Back: 31.6%

Consider to Bring MNFG Rev > $10B

- No Consideration: 33.0%
- No Response: 58.1%
- Consider to Bring MNFG Back: 31.0%

Definitively Plan to Bring
MNFG Back: Rev < $1B

- No Definitively Planning: 59.8%
- No Response: 25.9%
- Definitively Planning: 14.3%

Definitively Plan to Bring
MNFG Back: $1B < Rev < $10B

- No Definitively Planning: 43.8%
- No Response: 31.8%
- Definitively Planning: 24.4%

Definitively Plan to Bring
MFG Rev > $10B

- No Definitively Planning: 56.0%
- No Response: 31.1%
- Definitively Planning: 15.9%

Figure 11. Comparison of Considering vs. Definite Planning to Move Back to US by Size

2.1.2 2012-2015 Re-distribution of Manufacturing Operations

Two more interesting questions arise. The first question is: "From the U.S. companies that are considering to re-shore what is the re-distribution of their manufacturing operations from 2012 to 2015?" Figure 12 provides an illustrative answer. U.S. and Mexico are gaining +4.5 and +1.8 percent respectively. This data may indicate a shift into a more regional strategy as Mexico is emerging as the new North America manufacturing alternative due its proximity to the U.S. markets. Note also from where the shifts are coming from: China and Western Europe are losing -4.8 and -1.8 percent of their manufacturing capacity.

Insights:
- US is gaining manufacturing (+4.5%) along with Mexico (1.8%) and Other Asia Regions (0.8%)
- China (-4.8%) and W. Europe (-1.8%) are losing manufacturing

Figure 12. Re-distribution of Mfg. Operations for Companies Considering to Re-shore

The 2nd question is: From the U.S. companies that are considering to re-shore what is their distribution of their sales? Figure 13 indicates that the companies that are considering moving back their manufacturing operations back to US have the bulk of their sales, 62 percent, in the U.S. Now wonder why they want they change to regional strategy: the shift in demand is expected to pull manufacturing operations and supply chains back to U.S. to move closer to their primary market. The main drivers cited in the survey are better control, faster time-to market and higher quality.

But what are the 2012-2015 manufacturing operation trends of all U.S. companies? In the previous paragraphs we examined only the U.S. companies that are considering re-shoring. What are expected global manufacturing operation shifts in the period 2012-2015?
US companies considering to re-shore their manufacturing operations have the bulk of their sales, 62%, in the US.

Figure 13. Distribution of Sales per Region for U.S. Companies Considering to Move

Figure 14. Changes in the Distribution of Manufacturing Operations 2012-2015

Insights
- US, China, Europe, Japan are losing manufacturing
- Canada, Other Asia, Mexico, South America and Middle East Regions are gaining manufacturing
Figure 14 (blue indicate gain and red indicate loss) answers that question. U.S. and China, by proportion, are experiencing a reduction in manufacturing operations at -1.8 percent and -0.8 percent respectively while Mexico and Other Asia Regions are gaining +1.0. We can also observe the flows from where the changes are coming from. For example, U.S. manufacturing operations are shifting to Mexico while China operations are shifting primarily to other Asia regions. China is not gaining but the numbers on U.S. are important. The results are indicative of a trend. Business analysts may have thought that China would develop its market internally. That maybe the case but the data are only about U.S. companies strategic decisions. We also see a low cost to low cost movements (there is a movement from within developing countries) from China to Vietnam, Malaysia and Myanmar. Note that this is the delta for 3-years differences. We do not expect a big change in the three years.

When we asked the questions on “what are the leading industries that are moving their manufacturing operations back to the U.S.?” Figure 15 shows that the top industries are:

1. Food and Beverage Products manufacturing (75 percent)
2. Motor Vehicle Products and Parts Manufacturing (60 percent)
3. Electrical Equipment, Appliances and Component Manufacturing (57.1 percent)
4. Aerospace Products and Parts Manufacturing (50 percent)
5. Pharmaceutical and Medicine (42.9 percent)
6. Chemicals (37.5 percent)
2.1.3 Hypotheses Testing
Analyzing the data we observe a positive trend from 2012-2015, that a good percentage, +4.5 percent (Figure 12), is considering to move operations back into the U.S. and an even stronger +6.5 percent from those that are definitively planning to move operations back. Further, as we mentioned earlier, 31.0 percent of the companies with greater than $10B are considering moving back but only 11.9 percent are definitively planning. This is a big difference! But we cannot draw conclusions analyzing one side of the story. By referencing Figure 14, the aggregate empirical results of all companies for the period 2012-2015, indicate -1.8 percent reduction, by proportion, in moving manufacturing operations back in the U.S. This antithesis in how company executives are really thinking vs. 2015 sales and operations trends leads to a stipulation that companies that have invested heavily ashore are considering rescoring in a longer than 3-year horizon. We do not have a strong evidence of a positive relation between manufacturing operations re-shoring to the U.S. Therefore we cannot say that there is a strong trend that manufacturing is definitely moving back to US in the near future. There is a good percentage of companies that are considering moving back to US, thus creating an opportunity for re-shoring. In the next section we will analyze the drivers that lead to the decision for re-shoring.

2.2 Drivers and Government Action to Support Re-shoring

2.2.1 Decision Drivers to Consider Re-shoring
We asked the companies if they are considering moving manufacturing back to the US then what the main decision drivers? The answers to this survey question are shown in Figure 16. The companies identified the following reasons:

1. Time to market (73.7 percent) – this driver motivates a regional manufacturing strategy. For companies with a customer value proposition such as Zara’s “High fashion content at a reasonable price” then “time-to-market” is the key operations driver.

2. Cost Reductions/Total Landed Cost Calculations (63.9 percent). The total landed costs includes the total costs of purchasing and delivering the product to its final retail destination.
3. Product Quality (62.2 percent). There have been concerns about product quality from low-wage labor countries due to low-quality of supplier components made overseas, longer waiting times, lack of quality specifications and consumer safety issues.

4. More Control (56.8 percent). A number of companies want to have control over materials, labor costs, intellectual property rights, and technology partners and component suppliers. For these companies control is an important driver.

5. Hidden Supply Chain Costs (51.4 percent) - At the beginning when companies moved manufacturing facilities into Asia it was about labor costs and unit costs. Then, it was financial incentives provided by the local government. However, hidden logistics, materials and local contract costs added into the cost equations can increase the total cost of ownership by a significant number of percentage points.

6. Protect Intellectual Capital (48.6 percent). This is an important driver. For example, there is anecdotal evidence from U.S. companies with complex supply chain operations in Far East Asia where IP theft and lax laws is a serious concern.

Note the Hidden Costs of Supply Chain item: what this is telling us is that as we start operating a global manufacturing strategy, we realized that there are other costs that we did not take into account when we did the initial analysis to justify the move to Asia. These are the costs of moving or outsourcing the manufacturing operations to Asia.
2.2.2 Suggested Government Actions to Incentivize Companies to Re-shore

Realizing that most of the companies may have already heavy infrastructure footprint and large investments overseas we have asked the companies: What Government actions are required to incentivize companies to move back? Figure 17 shows the top six actions, the U.S. Government can take to incentivize re-shoring of U.S. Companies:

1. Tax credit
2. R&D Incentives
3. Corporate tax reductions and
4. Provide Better Education/Training for Required Skills
5. Better Infrastructure
6. Raise Duties / Tariffs

In Figure 17b we are distinguishing between the companies’ that are Considering Moving Back. But the answers are more or less the same.
2.2.3 Challenges in Bringing Production Back to US

So, what are the critical drivers of where manufacturing is going to be? What are the challenges of re-shoring? For example, a company may look at what is the impact of tax rate in different countries. And then, based on this information they decide what their manufacturing footprint is. Certain companies, e.g., motor vehicle products, may have a large heavy infrastructure in Asia and it is difficult to move that infrastructure for heavy products back to U.S. But for Consumer Packaged Goods (CPG) companies the situation may be different. The CPG industry infrastructure is not as immobile as the motor vehicle and chemicals ones. The incentive to come back may be a lower tax rate. Figure 18 shows what the companies consider the top challenges are of bringing production / manufacturing back to the U.S. The top challenges are:

1. Labor Cost (84.4 percent)
2. Tax Rate (75.6 percent)
3. Facilities Costs (68.5 percent)
4. Supplier availability (67.1 percent)
5. Environmental Regulations (65.5 percent)
We also performed the same computations for companies that are considering coming back and the results are identical. Hence, the U.S. policy makers may consider policies and plans that will lower tax rates to further incentivize re-shoring.

![Challenges of Bringing Production/Assembly Back To The U.S. (All Companies)](chart)

**Figure 18. Challenges of Bringing Production Back to U.S.**

### 2.2.4 Supply Chain Strategies Used to Support Re-shoring Decision

We asked the companies that are considering moving production/assemble operations back to U.S. “*What Strategies are they using to support their decision to move back?*” What the companies told us is that their potential re-shoring strategy decision is based on “Total Landed Costs.” This strategy makes sense for products with high forecast accuracy, low supply chain risk, slow innovation speed and high financial impact. The top three strategies are shown in Figure 19:

1. Total Cost to Serve (e.g., Total Landed Costs)  
   60 percent
2. Improve Supply Chain Flexibility  
   57 percent
3. Supply Chain Risk Analysis and Mitigation Strategies  
   56 percent
2.2.5 Current Manufacturing Strategy Used by Companies

In order to obtain information on each company’s manufacturing strategies we ask “What Manufacturing Strategy Are You Using, Regional or Non-Regional?” In a regional strategy, manufacturing in Asia is for Asia; manufacturing in North America and Latin America is for North America; and manufacturing in Europe is for Europe. Fifty (50) percent of the companies told us that they are using regional manufacturing strategy (see Figure 20). This explains the presence of a large manufacturing footprint in certain regions.

Figure 20. Current Manufacturing Strategy
But what are the primary drivers that caused US companies to adapt a regional manufacturing strategy and trigger them to move production outside the U.S? The responses are shown in Figure 21. The key drivers are cost reduction to serve the regional demand (sales) and revenue growth from emerging markets. For example, U.S companies moved to China and Far East due to low labor costs and to service the local markets. These insights obtain here also confirm the insights in Sections 2.4 and 2.5.

![Factors for Companies to Move Production Outside the US](image)

**Figure 21. Factors for Companies to Move Production outside of U.S.**

### 2.3 Associations Between Operations, Sales, R&D and Product Development

In this section we are investigating potential correlations between manufacturing, sales, employee force, R&D and product development locations. By performing correlation analysis we are looking at relationships between these variables. The question we are asking is: “Is there a relation between product development and R&D locations?” For example, if the product development is performed ashore is R&D also located ashore too? Similarly, we are examining whether there is there a relation between manufacturing and sales locations. To answer these questions we analyze the correlation graph in Figure 22. We observe only following relations:

1. A relation between Sales and Employees locations
2. A relation between R&D and Product Development locations

Figure 23 shows that R&D and PD variables are highly correlated with an $R^2$ value of 0.832. It shows that R&D and PD locations are dependent. A change in PD location will cause a change in the R&D location. This is an association that needs to be kept in mind. For example, if product development moves ashore it will cause R&D to also move ashore. What it means is
that re-shoring product development is not only about recovering the lost US jobs. It is also about re-shoring R&D. A similar dependence exists between sales and employee locations.

Figure 22. Matrix Correlation Graph
2.4 Summary

Our survey study shows that a significant proportion (33.6%) of the U.S. companies state that they are “considering” moving manufacturing operations back to U.S. The study also shows that 15.3% of the U.S. companies are “definite” planning to move back. The data also show that there is a change from a global manufacturing strategy, where the focus is on low labor cost, to a more regional strategy, where U.S. and Mexico is for the North America markets and Europe is for European markets. These changes indicate the start of a regional strategy trend over the last few years. We used the survey data to identify what drives this trend and whether this trend has made an impact. The companies have cited the following reasons for the re-shoring:

1. Time-to-market – For companies that have a value proposition that is focused on time-to-market then their integrated supply chain is dedicated on responsiveness. For these companies their operations strategy is focusing on speed and a regional strategy can serve that purpose.

2. Product Quality – there are multiple reports of product quality issues as a result of outsourcing. U.S. companies received cheaper quotes from China so they contacted a factory to launch their product there. Very soon these companies realized that the inferior
quality of the products triggered a need for better control of product quality. A number of companies fed up of having low quality products made in China are considering moving production back home.

3. Cost Reduction / Total Landed Costs – Over the years the labor costs in China have increased significantly in comparison to U.S. and Mexico labor costs. Hence, production sourcing decisions may need to be revisited based on the future wages and labor costs.

4. More control over raw materials – Control and distribution of raw materials is essential for production. Raw material scarcity can adversely affect operating conditions. Hence, strategies on how to gain access from overseas to raw materials sources and, lead-times required to obtain sufficient quantities is another decision area to be revisited.

5. Hidden Supply Chain Costs – When moved ashore, a number of companies did not take into consideration hidden logistics, materials and local contract costs added into the cost equations. It generated an increase to the total cost of ownership by a significant percentage points causing companies to re-think their past re-shoring decision.

6. Energy costs – Energy costs have increased over the years impacting logistics and transportation costs. The projected energy boom from new technologies to extract shale oil can cause a reduction in future energy costs thus further motivate re-shoring.

The survey responders also indicated what actions the policy makers can take to incentivize companies to move back. The objectives of these incentives are to change business behavior and motivate to re-shore their business. The top three suggested actions for policy makers to support the re-shoring decisions are to provide:

1. Tax Credits
2. R&D Incentives
3. Corporate Tax Reductions
4. Better Education/Training for Required Skills

The companies will use a number of strategies to support their decision to move production and assembly back to the U.S. The strategies are:

1. Total Landed Costs – Most of the companies told us that their potential re-shoring decision is based on this strategy. This strategy makes sense for products with high
forecast accuracy, low supply chain risk, slow innovation speed and high financial impact.

2. Improve Supply Chain Flexibility – Ensuring that goods are always available requires that companies build flexibility into their supply chain so they can respond to change in supply and demand as it arises. This drives companies to re-assess the global manufacturing strategies in order to reduce risk.

3. Supply Chain Risk Analysis and Mitigation Strategies – Global companies have realized the outsourcing and offshoring have increased risk as the supply chain partner / supplier base have become more complex. This drives companies to rethink their network relations in order to reduce risk and improve their business performance.

4. Advanced Technology – Faster computing, robotics and new sensor technology improves productivity and reduces the importance of low labor costs. The latest applications of software technologies allow faster and reliable information sharing across multiple suppliers/partners enabling upstream and downstream data visibility.

These insightful findings show that the re-shoring trend is picking up speed. It shows that an attractive opportunity exists for policy makers and U.S. companies to help accelerate this trend and contribute to the U.S. manufacturing growth.
3. An Empirical Analysis of Supply Chain and Risk Management

3.1 Introduction

3.1.1 Background
In the mid 70’s and early 80’s most of the companies were basing their operations and sales in US or Western Europe to serve home and neighboring countries. Uncertainty and risk, due to disruption incidences, were present but not in the same scale as it exists today. The company usually provided a stable environment but success on risk management was mostly attributed to the competence and heroics of the staff within the company and not in the use of established and mature risk mitigation processes.

In the 80s the companies established new supply chain and manufacturing technologies strategies that allowed them to reduce costs, increase time to market and better compete beyond the nearby geographical boundaries. In the 80’s companies start learning how to manage risk and uncertainty within local geographical boundaries. Risk reduction was facilitated by the fact that most of the partners/suppliers were within regional boundaries. At that time companies were considering how to strategically position their inventory, start controlling their capacity, and establish a level of visibility within the supply chain. The work products and services satisfied their specified requirements, standards, and company objectives. Uncertainty and risk were measured and contained but not effectively mitigated yet. Robust strategies for mitigating supply chain disruptions [6] have been mentioned in the literature, but there was a still unnecessary cost due to either redundant stock piles or inefficient transportation and logistics strategies. Executive were making decisions considering only the benefits or impacts around their own company.

In the late 1990s and 2000, companies start expanding their business on the global market. Web 1.0 and 2.x Internet technologies and e-business models (e.g., eBay) involved business processes spanning the entire value chain. Order processing, products and services were coming or delivered from all over the world. Rising labor costs at home forced manufacturing to be outsourced in Asia. Now, the logistics supply chain had become increasingly complex. Uncertainty and risk has increased significantly. Companies that did well in that period were well-integrated internally, performed proactive risk management, had product and process standards and had established business continuity plans. Business models were flexible,
allowing the company to adapt easier to changes. The supply chain costs were acceptable but not optimized across all links in the supply chain; new global enterprise supply chain optimization concepts start emerging.

Today, we have a highly competitive global operations and sales environment. Product life cycles have become shorter, time-to-market and technology speeds have become faster, cost reductions are always sought and demands for higher product quality have increased. Global trade introduced new market uncertainties and new types of risks [7]. Now, companies need new business models and agile adaptation to changes. The must invest and use sophisticated techniques and business models to address changing markets environments while maintaining continuity of operations.

3.1.2 The Values of Mature Risk Management and Operational Resiliency

On March 11, 20111, Nissan Motor Company Ltd and its suppliers experienced a 9.0-magnitide earthquake as it struck of the coast of Japan. The quake was among the 5 most powerful earthquakes on record. Tsunami waves in excess of 40 meters traveled up to 10km inland causing a Level 7 meltdown at 3 nuclear reactors at Fukushima Daiichi. The impact of this combined disaster was devastating with 25,000 people dead, missing or injured, 125,000 buildings damages and an estimated economic damage of $200B.

In the weeks following the devastating March 2011 earthquake in Japan, 80 percent of the automotive plants in the country suspended production. Nissan’s production capacity was perceived to be the most impacted by the disaster when compared to its competitors Toyota and Honda: six production facilities and fifty of the firm’s critical suppliers suffered severe damage resulting in 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 production in Japan decreased by 3.8 compared to an industry wide total of 24.8 percent. Nissan ended 2011 with an increase in production of 9.3 percent compared to a reduction of 9.3 percent industry wide.

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

Nissan responded to the disaster by adhering to the principles of its risk management philosophy. It focused on identifying risks as early as possible, actively analyzing these risks, planning countermeasures and rapidly implementing them. Nissan had prepared a continuous readiness plan spread among its suppliers: an earthquake emergency response plan, a business continuity plan and disaster simulation training. Nissan deployed these advanced capabilities both along the supply chain as well as the risk management dimension. First, management was empowered to make decisions in the field without lengthy analysis. The flexibility of its supply chain model structure—decentralization coupled with strong central control when required—was combined with simplified product lines. There was visibility across the extended enterprise and good coordination between internal and external business functions. These supply chain capabilities allowed the company to share information globally, to allocate component part supplies on higher margin products and to adjust production in a cost-efficient way.

3.1.3 The Need for the Study
The Nissan story is at the heart of this study. Without question, it illustrates that companies, such as Nissan, with highly mature capabilities along the two dimensions—supply chain management and risk management—will be able to effectively address risks, outperform the competition and even gain a competitive advantage.

Having the capability to connect the customer value proposition, sound supply chain operations and risk management strategy with principles, frameworks and processes allow companies to address most of today’s and tomorrow’s business challenges. The MIT Forum for Supply Chain Innovation and PwC launched a Supply Chain Risk Maturity Survey for Global Organizations in order to assess 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 customers of PwC. In total, 209 companies have completed the survey, providing their input to this report.

3.1.4 Today’s Challenges
When a company expands from the regional scene to a global one, it is cause for change in the operations strategy. Suddenly, transportation and logistics become a challenge; lead times are longer, costs have increased and end-customer services are impacted. For example, the economic debt crisis in Europe lowers expectations for future demand for products in the
continent, causing companies to change strategies and to seek alternate global markets to sell their products and maintain their ability to compete. A research report into global supply chains [8] identifies many operations strategies, e.g., flexible-response, but it is unclear which one is more resilient to disruptions.

Now that companies have established a global footprint, similar products have dissimilar customers and different distribution channels, which require different supply chains. The first challenge to address is "What are the supply chain complexity drivers for a company with global operations?" and, "What are the sources of risk?" The second challenge poses the questions "How can vulnerability and exposure to high impact supply chain disruptions be properly assessed and managed?" and "How can supply chain resilience be improved?" The third challenge arises as the executives strive for a better understanding of "What supply chain operations and risk principles will guide the improvement of the company's bottom line: the operations and financial performance?"
4. Supply Chain and Risk Management: Survey Demographics

4.1 Survey Data Summary

In total, 209 companies participated and completed the survey of which 65% were manufacturing companies and 35% were non-manufacturing companies. From the 209 companies, 181 of them fully completed all 39 questions. Most of the responses (53%) were originated from companies headquarter in Western Europe, followed by United States (19.1%), Mexico/Central America (11.5%) and Japan (6.2%), see Figure 24. By continent, most of the responses (53.1%) came from Europe, followed by North America (30.6%) and Asia (11%). Since most of our survey data responses came from Western European companies, our results are biased towards European views rather than representing a uniform cross-sectional views across North America, Europe and Asia.

![Company HQ by Region](image)

**Figure 24. Distribution of Companies by Region**

Participating companies came from all spectrum of industries including Pharmaceuticals and Medicines (9%), Food and Beverage Product Manufacturing, (9%), Retail Trade (8%), Chemicals (7%), Computer and Electronics Product Manufacturing (6%), Transportation and Warehousing (9%) and Industrial Machinery Manufacturing (6%), Healthcare and Social Assistance (3%) and Electrical Equipment Manufacturing (6%), as illustrated in Figure 25. There is an almost even distribution of industry participants making the industry distribution in our survey uniform.
Figure 25. Distribution of Company Participants by Industry

Figure 26 depicts the distribution of all participating companies by yearly revenue size. Of the 210 companies, 47.8 percent have revenue less than $500M USD, 12.9 percent have revenues between $500 and $1B, 23.4 percent have revenues between $1B and $10B USD, 7.2 percent have revenues between $10B and $15B and, 8.6 percent have annual revenue sales greater than $25B. Finally, the proportion of companies with revenue sales greater than $1B is 40 percent.
The demographic data will support our research initiative to segment the responses within categories, identify the risk factors and examine how risk maturity behaviors vary among industry or sales revenue size subgroups.

One of the key questions is that given the geographic location of the company's headquarters what percentage of their operations, in terms of volume, and sales are done in all global regions? The results reveal an important insight: A large number of US and Western European Headquarter companies have outsourced their operations in China (see Figure 27). However, while 10.1 percent of their operations are done in China only 4.5 percent of sales (by proportion) is done in China. We see this model increasingly in similar low-cost manufacturing labor and emerging market countries. A similar model is observed with Mexico / Central America. However in our survey, Mexico has a lot of companies headquartered in that region. The insight here is that Mexico is progressively becoming a regional operations and sales center. On the other hand, for the US we observe that sales exceed operations by proportions. U.S. and Europe are considered prime consumer markets.

![Graph](image)

**Figure 27. 2012 Sales vs Operations for the Manufacturing Industry**

### 4.2 Globalization of the Supply Chain

From the survey, (see Figure 28), we also obtain another key insight that gives an opportunity to think about today's global supply chain scale of manufacturing operations. Only 16% of the companies surveyed had 100 percent of their manufacturing operations in one location. The remaining, 84% percent, have their operations dispersed in more than 3 locations spanning
across multiple regions. Thus, supply chain risks due to global scale of product flow from manufacturer to distributor to retailer and finally to customer has grown in complexity [9].

Many companies are outsourcing their product development and manufacturing in low-wage labor markets, such as China and India. This is great from a company’s savings perspective, but has increased the complexity of the supply chain. It has introduced a number of operational inefficiencies such as: increased lead times, increased inventory levels (to maintain lead times) or lower service levels. It has also introduced risks due economic instability in these regions, such as, currency fluctuations, labor unrests or even risk due to natural disasters.

![Bar chart showing percentage of companies with global manufacturing presence vs regional operations.](image)

**Figure 28.** Percent of companies with global manufacturing presence

### 4.3 Sources of Supply Chain Risk

Global supply chains are exposed to many risks from multiple sources. Those risks are associated with known-unknowns and controllable, to unknown-unknowns and uncontrollable ones [10]. For example, 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).

Our scope definition of risk covers the wide area between devastating supply chain disruptions caused by natural catastrophes to rapid or slow structural market shifts to which the value chain needs to adapt due to changes in the business, socioeconomic, geopolitical or technological environment. To uncover the level of exposure to such diverse sources of risk we asked survey participants to present their view with respect to which incidents can potentially have the biggest impact on their supply chain. Figure 29 shows the top six risks: raw material price fluctuation...
(53%), currency fluctuations (47%), market changes (41%), energy/fuel prices volatility (38%) environmental catastrophes (31%) and raw materials scarcity (28%).

All these risks with the exception of environmental catastrophes are known-unknowns and controllable to some degree. A number of these risks have a high likelihood that will materialize, e.g., market changes, while others, like the recent April 2013 American Airlines 24-hour unplanned computer outage, have low likelihood that will materialize. For selected types of risks we can be better prepared for, such as energy/fuel prices changes. But there are some risks that we cannot anticipate, such as natural disasters / environmental catastrophes that have low likelihood but a great impact. Not all risks have the same likelihood of materializing.

![Exposure to Supply Chain Risks](image)

**Figure 29. Supply Chain Risks that a company is most exposed to**

We have asked our survey participants to grade the likelihood that these disruptions will materialize. Their responses are shown in Figure 30. The participants are telling us that the risks with highest likelihood to be materialized are: raw materials price fluctuations (34.9%), currency fluctuations (27.8%), energy/fuel volatility (24.4%) market changes (23.9%), rising labor costs (15.8%) and raw materials scarcity (13.9%).
Similarly, the survey participants ranked what they considered the low likelihood risks: 58% of the participants told us that natural disasters/environmental catastrophes is low likelihood, geopolitical instability (53.9%), telecommunications outages (49%), unplanned IT disruptions (43.5%), and cyber-attacks (43%).

4.4 Measuring Risk

These risks have an Expected Impact when they materialize. The Expected Impact, $E[x\_{\text{disruption}}]$, is measured as the product of (a) the risk likelihood, $Pr(x\_{\text{disruption}})$, that this event will be materialized, times (b) the direct consequence (effect) on business operations (e.g., on lead times) or financial performance (e.g., revenue) values given that the risk event is realized. In mathematical terms:

$$E[x_{\text{disruption}}] = Pr(x_{\text{disruption}}) \times Value$$  \hspace{1cm} (1)

For example, the probability of occurrence of a 7.0 Richter scale earthquake event ($x_{\text{disruption}}$) is low but the consequences are high which drives the expected impact value to be high.

Using the concept from equation (1), the complementary question to “High or Low Likelihood Risk” is “which supply chain risks have the highest potential consequence (or effect) on your company’s operation or financial performance?” Figure 31 shows what our survey participants told us are the top five supply chain risks with high potential impact are: raw material price fluctuation (41%), market changes (30.6%), currency fluctuations (29%), raw material scarcity (27%), and energy/fuel prices volatility (24%). Similarly the ones with low potential impact are:
cyber-attacks (33.5%), telecommunications outages (30%), Counterfeiting (28%), unplanned IT disruptions (26%), supplier / partner bankruptcy (25%) and geopolitical instability (25%).

Figure 31. Risks with High and Low potential impact on performance

4.5 What Parameters are Companies Most Sensitive To

The next question is “What are the parameters that a company’s supply chain operations are most sensitive to?” Figure 32 addresses the question and shows that the supply chain operations are most sensitive to: skill set and expertise (31%), price of commodities (29%), energy and oil (28%) among others. These parameters affect supply chain operations (skill set), transportation (energy and oil) and IT service as a commodity. For example, according to the Department of Energy Information Administration U.S. diesel prices rose 9.5 cents per gallon in February 2012. Shippers are cognizant of the sensitivity and impact diesel prices can have on their financial bottom line and, adjust their budgets in order to offset the increased costs higher fuel prices produce.
High Sensitivity Variables

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliance on skill-sets and expertise</td>
<td>31.1%</td>
</tr>
<tr>
<td>Controlled price of commodities</td>
<td>29.2%</td>
</tr>
<tr>
<td>Reliance on energy / oil</td>
<td>28.2%</td>
</tr>
<tr>
<td>Regional concentration of manufacturing</td>
<td>26.8%</td>
</tr>
<tr>
<td>operations</td>
<td></td>
</tr>
<tr>
<td>Regional concentration of supply base</td>
<td>24.9%</td>
</tr>
<tr>
<td>Reliance on a small supply base</td>
<td>22.0%</td>
</tr>
<tr>
<td>Regional concentration of customers</td>
<td>21.5%</td>
</tr>
<tr>
<td>Reliance on unique technology</td>
<td>16.7%</td>
</tr>
<tr>
<td>Reliance on a small outsourcing base</td>
<td>15.8%</td>
</tr>
<tr>
<td>(e.g., transportation...)</td>
<td></td>
</tr>
<tr>
<td>Reliance on favorable exchange rates</td>
<td>14.8%</td>
</tr>
<tr>
<td>Reliance on external assets and resources</td>
<td>12.9%</td>
</tr>
</tbody>
</table>

Figure 32. Parameters that a company's supply chain operations are most sensitive to.

4.6 What Companies Do to Address Risks

Figure 31 and Figure 32 are tightly coupled as they represent the factors that have direct effect on the right hand side of (1). Putting both high likelihood and high potential impact events together create a powerful outcome. This outcome is derived from equation (1): for example, IF a company has designated raw materials as a critical strategic importance item, THEN without a risk protection plan the expected impact of raw materials price fluctuation on performance is high. The reason for this is that raw materials prices rank high on both the High Likelihood and High Potential impact choices. The insight here is a risk mature company will prepare risk protection plans on critical items.

Given these risks one of our objectives is to understand what the companies do in the face of the expected risk impact on their business performance. The fundamental question is: “Given these risk disruptions and their dimensional characteristics what strategic management decisions and actions these companies consider to address them?” Failure to prepare and act accordingly may cause loss of revenue and potentially significant loss of market share. Rapid recovery with minimal impact on sales revenue and market share speaks about a mature risk company with
good resilience characteristics. Figure 33 addresses what the companies are telling us about their strategies on how they manage supply chain risk disruption. The top 6 strategies are:

1. Use both regional and global strategy (72.5%)
2. Implement dual sourcing (70.7%)
3. Create and implement a business continuity plan (70.5%)
4. Pursue a 1st and 2nd tier supplier collaboration (61.2%)
5. Apply forward buying / hedging strategy (57.1%)
6. Increase inventory levels and safety stock (55.7%)

For example, in the Nissan's case, Nissan had in place a well-thought out and exercised business continuity plan ready to kick into place to facilitate a quick recovery. The responses and their ranking make sense and, there are no surprises. We notice that the top three choices are ranked very close. One can consider these are the top-strategies to address supply chain risk. Important information is also revealed through this analysis. A number of companies are in the process of establishing a risk mitigation strategy right now. These companies are very vulnerable to disruptions and potentially “carry” high risk exposure potential.

![Actions to Address Risks in the Supply Chain](image)

**Figure 33. Company Actions to address supply chain risks**
5. Supply Chain Risk: Capability Maturity Framework

5.1 Levels of Maturity along Two Dimensions

As illustrated in the Nissan case, to succeed in a complex, dynamic and fast-changing environment companies need to deploy advanced capabilities along two sets of dimensions: supply chain management and risk management. We developed an empirical framework that applies set questions across seven supply chain/risk management enablers to characterize the maturity level of the supply chain processes and to characterize the maturity level of risk management processes. The supply chain/risk management maturity model is used to match each company to their appropriate maturity level based on their responses to questions.

5.2 The Seven Supply Chain Risk Enablers of Maturity

We selected seven supply chain/risk management enablers to provide the underlying foundation to designate the maturity levels. For each of the seven enabling areas, we asked participating companies to answer a set of questions concerning the practices they apply in the area. The extent to which the companies have implemented these gradually advancing practices allows us to assess which depth each enabler has been put in place. Scrutinizing this information for each one of the enabling areas we derived the overall maturity level of the company. Companies that have developed these enabling areas in sufficient depth are regarded within our framework to be equipped with advanced capabilities. The seven supply chain/risk management enablers are:

1. Risk Governance - involves the presence of appropriate risk management structures, processes and culture.
2. Flexibility and Redundancy in Product, Network and Process Architectures – involves the ability to position the right levels of flexibility and redundancy across the value chain in order to absorb disruptions and adapt to change.
3. Alignment between partners in the supply chain – involves the strategic alignment on key value dimensions, the identification of emerging patterns and the advancement towards higher value propositions.
4. Upstream and downstream supply chain integration – involves information sharing, visibility and collaboration with upstream and downstream supply chain partners.
5. **Alignment between internal business functions** – involves the alignment and the integration of activities between company value chain functions on a strategic, tactical and operational level.

6. **Complexity Management / Rationalization** – involves the ability to standardize and simplify networks and processes, interfaces, product architectures and product portfolios and operating models.

7. **Data, Models and Analytics** – involves the development and use of intelligence and analytical capabilities to support supply chain and risk management functions.

The study reveals which one of these enablers companies consider the most important for providing key capabilities to deal with supply chain disruptions. Figure 34, indicates companies are considering alignment between partners in the supply chain as the highest risk reduction enabler factor (60%). Internal and external process integration is also very important as companies indicate that by considering both integration between internal business functions (49%) and upstream and downstream process integration (47%). Risk Governance (44%) and, network flexibility and redundancy (37%) are also being included in the mix. Interesting to note data and analytics (28%) and complexity management (26%) are very low on the priority list.

### Top-4 Important Risk Reduction Enablers

<table>
<thead>
<tr>
<th>Enabler</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alignment between Partners in the Supply Chain</td>
<td>60%</td>
</tr>
<tr>
<td>Integration between Internal Business Functions</td>
<td>49%</td>
</tr>
<tr>
<td>Upstream and Downstream Process Integration and Information Sharing</td>
<td>47%</td>
</tr>
<tr>
<td>Risk Governance</td>
<td>44%</td>
</tr>
<tr>
<td>Flexibility and Redundancy in Network and Product Architectures</td>
<td>37%</td>
</tr>
<tr>
<td>Data, Models and Analytics</td>
<td>28%</td>
</tr>
<tr>
<td>Complexity Management</td>
<td>26%</td>
</tr>
</tbody>
</table>

![Figure 34. The 7 Supply Chain and Risk Reductions Enablers](image)
5.3 The Four Levels of Maturity in Supply Chain Risk

The two dimensions, supply chain operations and risk management processes, go hand-in-hand and complement one another. At lower maturity levels the processes are decoupled and standalone 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 processes used to classify the maturity level of the participating companies:

Level I: Functional supply chain management and ad-hoc management of risk. Supply chains at Maturity Level I are organized functionally with a very low degree of integration. They are characterized by high duplication of activities, internally and externally disconnected processes and absence of coordinated efforts with suppliers and partners. Product design is performed independently and there is lack of visibility into partners/suppliers operations. The supply chain is characterized by unbalanced inventory and capacity levels, expediting, 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 at Maturity Level II 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 level – that leads to a one company plan. Risk management processes are documented and internally integrated. Basic threats and vulnerabilities are analyzed. 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 domain.

Level III: External supply chain collaboration and proactive risk response. Supply chains at Maturity Level III 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 standardized and products and processes are rationalized 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 in Maturity Level IV 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.

A company has mature capabilities or processes if the maturity level of supply chain business processes and risk management processes is at least Level III. Similarly, a company has immature processes if the maturity level of supply chain management and risk management processes is at most Level II. A Best-In-Class (BIC) company has a Level IV maturity classification. Figure 35 below summarizes the criteria along the two process management dimensions used to classify the maturity level of each company. Appendix A defines the operational and financial key performance parameter and Appendix B has a detailed description of the Capability Maturity Classification Model. The content within each Capability Level box represents a lower level decomposition of the questions for each of the seven risk reduction enablers.
5.4 Hypotheses and Survey Testing

In this section we state the hypotheses and then we test it through empirical observations. Seven hypotheses statements are prepared and tested. The hypotheses are listed below:

Hypothesis #1: A Significant (majority) of the Companies Have Immature Supply Chain and Risk Management Processes in Place

\[ H_0: \text{All Companies have similar operations and risk management processes in place} \]

\[ H_A: \text{A significant majority of the companies have immature supply chain operations and risk management processes in place} \]

Hypothesis #2: Companies with mature capabilities in supply chain and risk management do better along all dimensions of operational and financial performance

\[ H_0: \text{Mature risk processes have no significant effect business operations and financial performance compared to companies with immature risk processes} \]
Hₐ: Mature risk processes have significant effect on business operations and financial performance

Hypothesis #3: Supply Chain Disruptions Have Significant Impact on a Company’s Business and Financial Performance

H₀: Supply Chain Disruptions Have no Significant Effect on a Company’s Business and Financial Performance

Hₐ: Supply Chain Disruptions Have a Significant Effect on a Company’s Business and Financial Performance

Hypothesis #4: Companies with Mature Supply Chain and Risk Management Processes Are More Resilient to Risk Disruptions than Companies with Immature Risk Management Processes


Hₐ: Mature Risk Management Processes Have a Significant Effect on a Company’s Business and Financial Performance

Hypothesis #5: Mature Companies Investing in Supply Chain Flexibility Are More Resilient To Disruption than Those That Do Not Invest in Supply Chain Flexibility

H₀: Mature Supply Chain Flexibility Processes Have no Significant Effect on a Company’s Business and Financial Performance

Hₐ: Mature Supply Chain Flexibility Processes Have a Significant Effect on a Company’s Business and Financial Performance

Hypothesis #6: Mature Companies Investing in Risk Segmentation Are More Resilient To Disruptions than Those That Are Not Investing in Risk Segmentation

H₀: Risk Segmentation Has no Significant Effect on a Company’s Business and Financial Performance

Hₐ: Risk Segmentation has a Significant Effect on a Company’s Business and Financial Performance

Hypothesis #7: Mature Companies Applying Push-Pull Supply Chain Strategy Are More Resilient To Risk Disruptions Compared To All Companies

H₀: Push-Pull Supply Chain Strategies Have no Significant Effect on a Company’s Business and Financial Performance
HA: Push-Pull Supply Chain Strategies Have a Significant Effect on a Company’s Business and Financial Performance

After excluding mailing errors, 1551 emails were sent out. The survey response rate cannot be calculated because PwC also contacted companies in Japan, India, China, Mexico etc. using their own internal lists. After cleaning the data from test records and screening them for missing values the sample of 209 companies was retrieved and used to test the hypotheses. Statistical methods were used to develop the conclusions of the tests.

6. Supply Chain Risk: Key Insights

The empirical study offers valuable insights into how mature capabilities in supply chain and risk management leads to better operational performance. At the same time, it provides value insights into the impact of disruptions on the company’s business and operational performance indicators over the last 12 months for mature vs. immature companies. These indicators cover the full spectrum of company performance along the profitability, efficiency and service dimensions. In particular, the study measures the scale of the impact as well as the time it took to recover to prior or improved levels of performance. The important contribution of this work is that the key insights offered are not based on anecdotal evidence but are validated using the data the 209 companies provided by participating in this study.

6.1 Key Insight #1: The Majority of the Companies Have Immature Supply Chain Operations And Risk Management Processes In Place

The framework presented in the previous section is critical in evaluating each company’s strategy. It reveals an important insight in the current maturity state of the company’s supply chain operations and risk management processes. The data demonstrates that:

*The majority of the companies have immature supply chain operations and risk management processes in place.* Figure 36 suggests that most of the companies pay marginal attention to managing supply chain risk. Only 41 percent of the companies are classified as having mature processes. The study suggests that 59 percent of the companies have immature risk governance, internal integration, external collaboration, supplier alignment or flexible business processes in place to effectively address incidents. Most of companies (42%) are in Level II, a sizeable piece (32%) belongs to Level III and only a small part (9%) belongs to the highest Level IV. This
maturity profile illustrates that only a minority of companies are fully prepared to address potential challenges from supply chain disruptions in increasingly complex environments.

![Capability Classification of Companies](image)

**Figure 36. Capability Maturity Profile of the Surveyed Companies**

We have asked our participants to indicate "what department or functional area is responsible risk management within the organization. Figure 37 shows the responses: Operations (26.4 percent), Finance (23.6 percent), Corporate (11.5 percent) and Procurement (10.3 percent). It is noted that the majority (80%) of the companies that selected "None" are Immature Companies. In the "Other" category, the functional areas that were denoted were: Risk Management, Supply Chain, or Cross Department (managed by Corporate)
6.2 Key Insight #2: A Company May Be Mature In One Risk Reduction Enabler Area and Immature In Another

Table 2 shows a company’s supply chain and risk management classification ranking against each enabler. For example, based on our criteria, Company 2 is assessed as Level 4 with respect to Risk Governance, Level 2 with respect to Flexibility, Level 1 with respect to Upstream and Downstream Integration and, Level 3 with respect to Alignment, Integration, Data Models and Analytics. The assessment shows that Company 2 is immature in the Flexibility and, Upstream and Downstream Integration areas but mature in the other areas. Overall, Company 2 is assessed as Level 3, matured. Table 2 reveals the following observation:

*A company may be mature in one risk reduction enabler area and immature in another*
6.3 **Key Insight #3: Companies with Mature Capabilities In Supply Chain And Risk Management Do Better Along All Dimensions Of Operational And Financial Performance**

A closer look into the supply chain / risk management framework suggests that company executives need to comprehend and determine what are the business and financial consequences of their last 12 months’ supply decisions. The capability maturity evaluation will enable company executives to assess the risk position and maturity of the company measured in terms of their operations and financial performance.

Figure 38 illustrates the prior 12 months’ business and operational performance for all companies that participated in our survey. Using the capability maturity model we compared the differences in overall performance between companies with mature and companies with immature risk processes. The multiple graphs in Figure 13 show that for each measure of supply chain indicator the mature companies have better performance overall. For example, immature companies have far less Inventory Days of Supply (56.8 days) than mature companies (80.3 days), a 29 percent improvement. Similar results are obtained for Lead Time in the supply chain, on-time delivery performance to requested date (.5 percent), inventory carrying costs (24 percent), fill-rate level (6.8 percent), costs of obsolescence -34 percent), cash-to-cash cycle
(5.9%), inventory turnover and total asset turnover. In some cases best-in-class companies are performing even better. The study divulges a very key insight:

*Companies with mature risk processes achieve better business operations and financial performance than companies with immature risk processes*

![Graphs showing performance metrics for mature and immature companies](image)

**Figure 38.** Mature capability companies performed operationally better than immature ones

Similarly, Figure 39 shows the revenue growth for mature capability companies is 11.6 percent vs 6.3% for immature ones, an 84 percent difference. Mature capability companies have an average EBIT Margin of 13.7 percent vs. 11.7 percent for immature ones, an 18 percent difference.
Figure 39. Mature capability companies performed financially better than immature ones

Figure 38 and Figure 39 provide an important insight to Chief Executive Officer of the Company. Actual data show that companies with mature risk processes in-place perform far better across the board on both operations and financial performance than companies with immature risk processes. Risk Mature supply chain strategies and decisions have a direct impact on working capital, but working capital flows and balances have a direct impact on the financial viability and performance of a company.

**In Summary, the company’s supply chain and risk management strategies have direct implications on the company’s competitive advantage**

### 6.4 Key Insight #4: Supply Chain Disruptions Have Significant Impact on a Company’s Business and Financial Performance

To better understand the impact of disruptions\(^2\), we assessed the performance of companies that were faced with at least three disruption incidents over the last twelve months. Survey findings reveal that these supply chain disruptions have had a significant impact on companies’ profitability, efficiency and service indicators over the last 12 months. For example, as shown in Figure 40, 54 percent of all companies faced with three or more supply chain disruption incidents over the last twelve months suffered a three percent or higher impact on their sales revenue as a result of these disruptions. Similarly, 64 percent of all companies with three or more supply chain disruptions suffered a 3 percent or higher decline in their customer service level as a result of these disruptions. In all the operational KPIs examined, at least 60 percent of companies that faced supply chain disruptions reported a 3 percent or higher loss of value. The high percentage

\(^2\) Information about disruption impacts are self-reported by survey participants.
of impacted companies demonstrates the importance of having mature capabilities in place to deal with supply chain disruptions.

![% Companies Impacted](image)

**Figure 40. Percentage of Companies that suffered 3% or higher impact on their performance**

### 6.5 Key Insight #5: Companies with Mature Supply Chain and Risk Management Processes Are More Resilient to Risk Disruptions than Companies with Immature Risk Management Processes

The company classification profile, which is shown in Figure 36, divides the companies into a set of immature and mature capability clusters of observation for the purpose of generating insight. The study shows a significant performance difference due to the impact of disruptions between the two clusters. Figure 41 shows the percentage of companies with more than 3 incidents that suffered an impact 3 percent or higher on their performance as a result of supply chain disruptions in the last twelve months. The results provide a validation of an obvious statement:

*The percentage of mature companies suffering more than 3 percent impact on their performance as a result of disruptions is significantly less than companies with immature risk processes*

*Companies with mature risk management processes are more resilient to risk disruptions than companies with immature risk management processes*
For example, only 44 percent of the companies with mature processes, faced with three or more supply chain disruption incidents, suffered a 3 percent or more decline in their revenue in comparison to 57 percent to companies with immature processes. This is a 13 percent difference in the number of companies between the two groups. The difference is striking in key areas such as total supply chain cost, order fulfillment lead-times and lead-time variability. Considering that these areas are among the ones most heavily impacted by supply chain disruptions, mature companies gain an advantage that is potentially decisive.

Figure 41. Key Performance Indicator resilience to disruptions between mature and immaturity levels

6.6 Key Insight #6: Mature Companies Investing In Supply Chain Flexibility Are More Resilient To Disruption than Those That Do Not Invest In Supply Chain Flexibility

Flexibility is a very important aspect of a company's capability to adapt to change. For example, companies may respond to demand changes, labor strikes, technology changes, currency volatility, volatile energy / oil prices based on the degree of flexibility in their businesses. The higher the degree of flexibility the more expensive it is to achieve it. There is a similar situation with the customer service levels. On the other hand, certain companies strive for
minimizing costs vs. investing in flexibility or customer service level. In the study we asked the companies to identify the key supply chain value drivers for their leading customer value proposition. Figure 42 shows that high customer service level (34%) and flexibility (27%) are the top two drivers followed by cost minimization (22%) and efficient use of the inventory (14%).

![Value Drivers](image)

**Figure 42.** Key supply chain value driver to match customer value proposition

Apparently, the choice of supply chain value drivers form two very interesting groups: the cost-efficient group, which contains the mature companies that at the same time selected a cost or an efficiency supply chain value driver, and the flexible-response group which contains the mature companies that at the same time selected flexibility or customer service levels as their key supply chain value driver.

The performance resilience to supply chain disruptions for both groups is assessed. Figure 43 highlights the major difference between the two groups. The percentage of companies that suffered a 3 percent or higher impact on their KPIs as a result of more than 3 supply chain disruptions faced in the last twelve months is significantly lower for the flexible-response group. The performance of cost-efficient companies has suffered more from the changes and disruptions in their supply chain even if they possess mature capabilities in deploying their strategy. This observation leads to another important insight:
Mature companies investing in flexibility, responsiveness and customer service, demonstrate higher performance resilience compared to companies whose strategies emphasize cost and efficiency.

Figure 43. Performance of mature cost-efficient vs mature flexible-response companies

The findings presented in Figure 42 also illustrate that the largest majority of cost-efficient companies are faced with high variability in their supply chain lead-times once a supply chain disruption takes place. This observation is interesting considering that low variability is one of the key drivers of an efficient operations strategy.

6.7 Key Insight #7: Mature Companies Investing in Risk Segmentation Are More Resilient To Disruptions than Those That Are Not Investing In Risk Segmentation

Companies with different value propositions within the supply chain emphasize different value dimensions. At the same time, today in order to target different market segment companies you need to typically compete with more than one customer value proposition. It is common, for example, that one part of the product portfolio may emphasize the price dimension as key
differentiator while a second part may emphasize product innovation or product selection and availability. Figure 44 shows the key dimension of the leading customer value proposition for the companies participating in the survey. The top three choices are: Quality (23%), Innovation (14%) and Price (14%).

**Customer Value Proposition**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td>23.2%</td>
</tr>
<tr>
<td>Innovation</td>
<td>14.0%</td>
</tr>
<tr>
<td>Price</td>
<td>13.7%</td>
</tr>
<tr>
<td>Brand</td>
<td>11.9%</td>
</tr>
<tr>
<td>Product Selection and Availability</td>
<td>10.8%</td>
</tr>
<tr>
<td>Customer Experience</td>
<td>9.1%</td>
</tr>
<tr>
<td>Delivery Reliability</td>
<td>8.2%</td>
</tr>
<tr>
<td>Value Added Services</td>
<td>6.2%</td>
</tr>
<tr>
<td>Volume Flexibility</td>
<td>2.9%</td>
</tr>
</tbody>
</table>

![Bar chart showing customer value proposition](chart.png)

**Figure 44.** 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. For example, consider a value proposition emphasizing 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. For example, 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 the build-up of inventory buffers is appropriate. Figure 45 shows what percentage of companies actively pursued risk strategy segmentation: almost 60 percent of the companies apply risk segmentation strategy across their product portfolio and 40 percent do not apply risk segmentation.
The companies that pursued risk segmentation were asked the question "What are the product differentiators for their strategy?" Figure 46 reveals that the top three choices were: strategic importance (56%), then demand volatility (52%) and finally sales volume (45%).
The study clustered all companies with mature capabilities into two main groups: the ones that perform risk strategy segmentation and the ones that do not. Then, the performance resilience to supply chain disruptions for both groups was assessed. Figure 47 highlights the major difference between the two groups across operations and financial performance indicators. For example, in the sales revenue category, only 32 percent of the mature companies were significantly impacted as a result of incidents that occurred in comparison to 70 percent of immature companies - this is a 38 percent difference! This observation presents the following insight:

*Mature companies investing in risk segmentation strategies based on different value proposition risk profiles, demonstrate higher performance resilience compared to companies that do not segment their risk strategies.*

**Figure 47.** Difference in performance impact based on risk strategy segmentation

Figure 48 highlights another key insight: a company that uses mature supply chain and risk management methods has a resilient supply chain that allows it to recover faster from disruptions in comparison to a company that uses immature methods. For example, in the customer service
level function, only 50% of the mature companies with 3 or more incidents recover in more than 2 weeks vs 70% of immature companies. This observation presents the following insight:

*Mature companies investing in risk segmentation strategies based on different value proposition risk profiles, demonstrate lower than 2 week recovery time in their KPIs compared to companies that do not segment their risk strategies.*

6.8 **Key Insight #8: Mature Companies Applying Push-Pull Supply Chain Strategy Are More Resilient To Risk Disruptions Compared To All Companies.**

Manufacturing supply chain strategies are categorized into push, pull and push-pull strategies: the push strategy where production and distribution is based on long-term forecasts and pushes inventory to retailers, the pull strategy where production and distribution respond to customer demand and the push-pull strategy, a hybrid combination of the push and pull. As expected, almost 60 percent of the companies use the combination of push-pull strategy, 24 percent use the pull strategy and 16 percent use the push strategy. Figure 49 shows the distribution.
The study looked at the relation between operations strategy and performance parameter resilience. Figure 50 shows that the percentage of mature companies with a combination of push-pull operations strategy are less impacted. This finding leads to another observation:

*Mature companies applying a combination of push-pull supply chain strategy are more resilient (exhibit 3% or high impact to their KPIs) to risk disruptions compared to all companies.*
6.9 Linking Supply Chain Risk with Operational and Financial Performance

The analysis and the key findings are summarized in Figure 51. The horizontal axis provides information about the maturity levels of the risk management processes, and the vertical axis provides information about the maturity levels of the supply chain functions. Box A represents companies with immature supply chain and risk management processes. The study shows that these companies' operations and financial performance is impacted significantly in the face of disruptions. The impact is on inventory days of supply, cost of obsolescence, inventory carrying costs, sales revenue and EBIT margin.

<table>
<thead>
<tr>
<th>Supply Chain Functions</th>
<th>Immature Risk Management Processes</th>
<th>Mature Risk Management Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box B</td>
<td>Integrated and Collaborative Supply Chain with Buffer planning capability</td>
<td>C Dynamic supply chain functions and flexible risk management</td>
</tr>
<tr>
<td></td>
<td>• Systems internally &amp; externally integrated</td>
<td>• Superior operations/financial performance</td>
</tr>
<tr>
<td></td>
<td>• Information sharing btw internal functions</td>
<td>• Mature risk segmentation strategy</td>
</tr>
<tr>
<td></td>
<td>• Build capacity/invest in inventory to mitigate risk</td>
<td>• Invest in flexibility to mitigate risks</td>
</tr>
<tr>
<td></td>
<td>• Better operations and financial improvement potential</td>
<td>• Higher sales revenues</td>
</tr>
<tr>
<td></td>
<td>• Better resilience improvement potential</td>
<td>• Superior resilience to disruptions</td>
</tr>
<tr>
<td>Box A</td>
<td>Adhoc risk management, disconnected supply chain processes</td>
<td>D Proactive Risk Management with Integrated supply chain management</td>
</tr>
<tr>
<td></td>
<td>• Lower than average operations &amp; financial performance in face of disruptions</td>
<td>• Systems internally integrated</td>
</tr>
<tr>
<td></td>
<td>• Slower time to recover</td>
<td>• Visibility among supply chain partners</td>
</tr>
<tr>
<td></td>
<td>• Higher percentage of companies impacted in the face of disruptions</td>
<td>• Proactive risk management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Business continuity plans in place</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Better operations and financial improvement potential</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Better resilience improvement potential</td>
</tr>
</tbody>
</table>

Figure 51. Link between Supply Chain Risk decisions and performance

Box B represents companies with mature supply chain processes and immature risk management processes. Box D represents companies with immature supply chain processes and mature risk management processes. Both B and D type of companies perform better that the companies in Box A but they still have a lot of performance improvement potential. The operation and financial performance is above average and their resiliency to disruptions is good.
Box C represents companies with mature supply chain and risk management process. The companies are resilient to risk disruptions and exhibit better operations and financial performance. They apply effectively risk segmentation and push-pull strategies, and invest in flexibility in order to reduce the impact of disruptions. The study has proven the higher a company’s maturity level in supply chain and risk management the higher performance yield. What is not clear yet is where the boundaries between mature supply chain / immature risk processes, immature supply chain / mature risk process and mature / mature processes are. The cases require further analysis.
7. Supply Chain Risk: Summary and Recommendations

The objective of this study is to analyze the supply chain operations and risk management approaches of large revenue size companies with global footprint and propose a framework and a set of principles that will help all companies manage today’s risk challenges and prepare them for future opportunities.

The MIT/PwC Global Survey solicited input from 209 companies. The data indicate that globally operating organizations are faced with incidents that exposed them to high risk scenarios ranging from controllable risk such as raw material price fluctuation, currency fluctuation, market changes or fuel price volatility to uncontrollable ones such as natural disasters. These risks have a disruptive impact on the company’s operations and financial performance. The study shows that 65 percent of the companies suffered impact of three percent or higher on their performance indicators as a result of supply chain disruptions in the past twelve months. The degree of disruption depends on the strategic mitigation actions the company takes to anticipate and plan in advance to address these risks. The survey responders specified three top strategic actions to address these risks: (a) use both regional and global strategy, (b) implement a business continuity plan and, (c) implement a dual sourcing strategy. Implementing these strategies does not mean that the risk will be totally avoided when the incidence occurs, but rather it will minimize the likelihood of a significant impact and expedite time to recover.

We developed a supply chain operations and risk management model to provide a capability maturity framework to classify how well the companies are applying the most important supply chain and risk reduction enablers (e.g., flexibility, risk governance, alignment, integration, information sharing, data analysis and models, and complexity) and their associated processes. The model reveals where a company stands in relation to its competition and the rest of the industry. The data show that 60 percent of the companies pay marginal attention to risk reduction processes. These companies have immature risk processes in place and address risk by either increasing capacity or strategically positioning additional inventory. This is not a surprise as most of these companies are focused either on maximizing profit, minimizing costs or maintaining service levels.
Our data also illustrate that 40 percent of the companies pay strong attention and invest in acquiring advanced risk reduction enabler capability. These companies think beyond the economics that made off-shoring attractive in the first place (e.g., low cost labor). The study reveals five key insights:

a. **Key Insight #1:** Supply chain disruptions have significant impact on company business and financial performance

b. **Key Insight #2:** Companies with mature risk management processes are more resilient to risk disruptions than companies with immature risk management processes

c. **Key Insight #3:** Mature companies investing in supply chain flexibility are more resilient to disruption than those that do not invest in supply chain flexibility

d. **Key Insight #4:** Mature companies investing in risk segmentation are more resilient to disruptions than those that are not investing in risk segmentation

e. **Key Insight #5:** Companies with mature capabilities in supply chain and risk management do better along all dimensions of operational and financial performance

Insights #1-#5 display the competitive power of being capability mature. One important contribution of this work is that the key insights offered are not based on anecdotal evidence but are validated with the 209 companies that participated in this study. Using the data we validated that companies with mature risk processes do operationally and financially better. This is an important message to the CEO and CFO. Managing risk is not only about operations and supply chain management but includes every aspect in a CEO’s sphere of influence for product design, development, operations and sales. Insurance is not the solution to address risk incidents; insurance does not cover everything. Using the capability maturity model we can “assess” each business’s ability to respond.

Finally, a company needs to be self-aware where they and their competition stand with respect to managing risks. If the competition has a lower risk maturity capability level than your business, then this attribute is your competitive advantage over them.
8. Appendix A - Operations and Financial Definitions

The key operations [11] and financial performance [12] 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. For example, Mattel, the world’s largest toymaker, had to issue a major product recall due to quality assurance and consumer product safety risks. Mattel’s stock-price suffered a steep fall when the recall was announced in Q3 2007 and did not recover for many months to come.

**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 capability of delivering the value proposition and can lead to loss of sales volume and sales revenue.

**Market-Share:**

It is the company’s sales over the period and 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**

It is the earnings before interest and tax (EBIT) divided by total revenue. EBIT margin can provide an investor with a cleaner view of a company’s core profitability.

**Total Supply Chain Cost:**

It is the costs to procure materials and, manufacture and deliver products to customers. 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 to adjust and recover.

**Supply Chain Asset Utilization:**
Supply chain asset utilization 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 utilization 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.

Customer Service Levels:

It is 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 Fulfillment 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 supply chain stages.

Total Supply Chain Lead-Time Variability:
Total supply chain lead-time variability is the time variation around the total supply chain lead-time mean. Supply chain disruptions can introduce variability and fluctuations in the standard lead-time levels within the supply chain.
9. Appendix B. Capability Maturity Classification Model

Table 3 provides amplifying information about the Supply Chain Risk Maturity Classification Model.

Table 3. The Capability Maturity Classification Model

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Supply Chain Management</th>
<th>Risk Management</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level I</strong></td>
<td>Functional</td>
<td>Adhoc</td>
</tr>
<tr>
<td></td>
<td>- internally and externally disconnected plans and processes</td>
<td>- Ad-hoc risk management processes</td>
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<tr>
<td></td>
<td>- Lock-off visibility into supplier/partner operations and business data</td>
<td>- Product design is performed independently</td>
</tr>
<tr>
<td></td>
<td>- Resources are locally owned and managed</td>
<td>- Absence of common standards and processes</td>
</tr>
<tr>
<td></td>
<td>- Performance is measured separately based on functional KPIs</td>
<td>- No planning of redundancy buffers towards potential disruptions</td>
</tr>
<tr>
<td><strong>Level II</strong></td>
<td>Integrated</td>
<td>Buffer Planning</td>
</tr>
<tr>
<td></td>
<td>- Internally aligned and integrated functions</td>
<td>- Can absorb limited volatility around standard functional input parameters</td>
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<td></td>
<td>- Information sharing and planning activities between internal functions</td>
<td></td>
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<tr>
<td></td>
<td>- Use postponement strategy</td>
<td></td>
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<tr>
<td></td>
<td>- Measure supply chain performance</td>
<td></td>
</tr>
<tr>
<td><strong>Level III</strong></td>
<td>Collaborative</td>
<td>Proactive</td>
</tr>
<tr>
<td></td>
<td>- External and internal collaboration</td>
<td>- Anticipatory risk planning</td>
</tr>
<tr>
<td></td>
<td>- Visibility and information sharing between supply chain partners</td>
<td>- Build capacity / invest in inventory</td>
</tr>
<tr>
<td></td>
<td>- Full integration of key functions</td>
<td>- Position redundancy buffers based on a common cross-functional plan</td>
</tr>
<tr>
<td></td>
<td>- Incorporation of external input into internal planning activities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Supply chain rationalization</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Measure and forecast performance</td>
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</tr>
<tr>
<td><strong>Level IV</strong></td>
<td>Dynamic</td>
<td>Flexible</td>
</tr>
<tr>
<td></td>
<td>- Dynamic supply chain adaptation to value chain change</td>
<td>- Invest in flexibility (processes, products, plants, capacity)</td>
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<tr>
<td></td>
<td>- Full enterprise integration</td>
<td>- Manage risk pressure away from weak suppliers</td>
</tr>
<tr>
<td></td>
<td>- Full upstream and downstream visibility</td>
<td>- Common standards and processes</td>
</tr>
<tr>
<td></td>
<td>- Complete alignment on key customer value dimensions across the enterprise</td>
<td>- Timely supply chain bottlenecks management</td>
</tr>
<tr>
<td></td>
<td>- Sophisticated operations models in use</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Supply chain segmentation matches multiple customer value proposition</td>
<td></td>
</tr>
</tbody>
</table>
10. Bibliography


