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ANALYSIS OF RISK BY FMEA IN MANUFACTURING OUTSOURCING FOR BATCH TYPE INDUSTRIES

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ABSTRACT

In today's business environment, it's difficult to find a manufacturing industries that produce 100% of its product internally. This indicates that outsourcing is unavoidable due to its benefits leading to improvement in performance. Hence an effective vendor selection process is very important to the success of any manufacturing organization.

However, many firms have been disappointed with the results they have achieved from outsourcing. The reason for this disappointed lies in the methodologies and having little attention to risk involved. To minimize the risk organization should a strategic decision about the vendor selection, as it helps in streamline material and /or service flow, reduce manufacturer and vendor cost, improve quality and customer service (delivery) performance and create a long term partnerships. Different vendors provide different level of risk for an industry. Failure mode and effect analysis (FMEA) is a well established technique for evaluating and prioritizing the risks. This paper seeks to provide a tool to help decision maker to evaluate his risk by quantifying the risks associated with each vendor.

KEYWORDS: Failure Mode and Effect Analysis (FMEA), Vendor Selection, Risk, Outsourcing

1. INTRODUCTION

To flourish and survive in today's competitive global marketplace, firms are increasingly focusing on their core competencies and turning towards outsource functions in which they possess no expertise to maintain effective cost structures and to improve their top and bottom lines. In today's hypercompetitive global marketplace no firm can go it alone and become successful because of lack of key talents and knowledge experience bases are not available in all areas and the benefits due to outsourcing.

The benefits associated with outsourcing include reducing operating costs; exchanging fixed costs with variable costs; elimination of infrastructure investments; access to world-class processes, products, services or technology; better cash-flow; improved ability to sense and respond real-time to changes business environments; sharing risk; and access to resources not available in-house. Besides the advantages of outsourcing at the strategic, financial, organizational, and operational levels, there are a number of outsourcing risks which can greatly affect the business performance.

As manufacturing outsourcing continues to grow, risks associated with it are growing as well. Some of these risks include Cost, Quality, long lead time, operational, technical etc. As the manufacturing industry supply-chain strategies

evolve, managing the associated risks in outsourcing has assumed greater dimension. Because of product variety and volume variety involve more risks and expensive, leading manufacturing industries are entering into risk-sharing outsourcing partnerships in order to minimize risks in outsourcing by sharing management and financial responsibilities. Choosing the right method for vendor selection effectively leads to a reduction in buying risk and increases the number of JIT vendors and TQM production.

The paper is organized as follows. A background for vendor selection criteria and major risks considered for FMEA will be given in the section 2. FMEA methodology will be given in section 3. While Section 4 illustrates a case study in which methodology proposed is applied. Finally, with concluding remarks paper would end.

2. LITERATURE REVIEW

Outsourcing has proven to be effective, but it brings significant risks that must be recognized and managed. In outsourcing, a company is relying on someone else to run certain business functions. The product or service can be outsourced, but the risk cannot. A failure caused by the vendor is viewed as a risk for the manufacturer.

The literature survey is done for knowing the considerations of different researchers about vendor selection criteria which is viewed as a risk in outsourcing.

The vendor selection problem in a supply chain system is a group decision according to multiple criteria from which a number of criteria have been considered for vendor selection (Chen-Tung et al., 2006). The purchasing manager must know a suitable method, then use the best method from the different types of methods to select the right vendor. Selecting the right vendors is an important step in vendor management (Shu and Wu, 2009; Tseng, Chiang, and Lan, 2009; Wu et al., 2006). The selection of the right vendors can reduce operational costs and delivery time (Che & Wang, 2008). Similarly, choosing the wrong vendors may increase the number of defective products, unstable deliveries, all of which can increase company's total cost. There-fore, how to select the right vendors has become an essential topic for industry wishing to minimize their risks. Based on the relationships between vendors and manufacturers, following table no. 1 shows review for vendor selection criteria used by different researcher.

Table 1: For Vendor Selection Criteria Used by Different Researcher

Sr. no	Name of Researcher	Criteria
1	Dickson (1966)	23 criteria, which fell into four categories: quality, deliverability, performance, and warranty policy
2	Tracey and Tan (2001)	Quality, delivery reliability, product characteristics, and unit price
3	Katsikeas, Paparoidamis, and Katsikea (2004)	Vendors' reliability, competitive price, service, and technical skills
4	Ho et al. (2010)	Quality as the critical criterion, followed by deliverability, price, manufacturing capability, service, management, and technology
5	Wu et al. (2006)	Vendor risk-: internal controllable, internal partial controllable, internal uncontrollable, external controllable, external partial controllable, and external uncontrollable
6	Schoenh-err et al. (2008)	Quality, cost, service, and management capabilities
7	Sarkis and Talluri (2002)	Cost, quality, time, flexibility, culture, technology, and relationship

The literature survey done by Ozden Bayazit, Birsen Karpak,(2005) about the vendor selection criteria are summarized in the following

Table 2

Sr. no	Name of Researcher	Criteria
1	Ellram (1990)	Quality, cost, ontime delivery, and service
2	Weber et.al. (1991)	Quality, delivery and net price
3	Nydick and Hill (1992)	Quality, price, delivery, and service.
4	Verma and Pullman (1998)	Quality, cost, on-time delivery, delivery lead-time and flexibility
5	Karpak et. al. (2001)	Cost, quality and delivery reliability
6	Bhutta and Huq (2002)	Manufacturing costs, quality, technology, and service

Table 3: Shows the Vendor Selection Criteria Based on Studies Carried Out by Researcher from Literature Review

	Criteria	Author	
1	Cost	Dickson (1966)	A
2	Quality	Ellram (1990)	B
3	Deliver	Weber et al. (1991)	C
4	Service	Nydick and Hill (1992)	D
5	Flexibility	Verma and Pullman (1998)	E
6	Technology	Karpak et al. (2001)	F
7	Price	Tracey and Tan (2001)	G
8	Cultural	Bhutta and Huq (2002)	H
9	Management capabilities	Sarkis and Talluri (2002)	I
10	Performance	Katsikeas, Paparoidamis, and Katsikea (2004)	J
11	Warranty	Schoenh-err et al. (2008)	K
12	Manufacturing capability	Wu et al. (2006)	L
13	Risk	Ho et al. (2010)	M
14		Hudymáčová, M., Benková, M. (2010)	N
15		S. K. Jarial & R. K. Garg (2012)	O

Table 4: Vendor Selection Criteria

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Number of Times Factors Considered
1		√			√	√		√	√		√		√	√	√	9
2	√	√	√	√	√	√	√	√	√		√		√	√	√	13
3	√	√	√	√	√	√	√		√				√	√	√	11
4		√		√				√		√	√				√	6
5	√				√				√					√	√	5
6								√	√	√			√			4
7			√	√			√			√			√			5
8									√						√	2
9											√					1
10	√															1
11	√															1
12												√	√			2
13												√				1
Total no. of factors considered per research work	**5**	**4**	**3**	**4**	**4**	**3**	**3**	**4**	**6**	**3**	**4**	**2**	**6**	**4**	**6**	

In vendor selection criteria, the vendor risk depends on the type and degree of risks. A failure caused by the vendor is viewed as a risk for the manufacturer. The manufacturer should then evaluate and score the impact of each failure; the sum of the scores is the vendor risk. Therefore, the preferred vendor selection procedure is equal to the vendor lowest risk assessment procedure. Through the vendor evaluation, a industry could understand its supply risks based on each factor and decide which vendor was the most preferred. Thun and Hoenig (2011) surveyed 67 German automotive manufacturers to investigate the supply from vendor vulnerability and the key drivers of supply risks. They applied the probability-impact-matrix to analyze the internal and external supply risks. They then offered suggestions for mitigating these supply risks. Beside these vendor risk assessments, the failure mode and effects analysis (FMEA) is a popular method of measuring preventive risks (Ko, 2013; Liu, Liu, & Liu, 2013). The FMEA has been extensively applied in product design and manufacturing process planning (Almannai, Greenough, & Kay, 2008; Chen & Ko, 2009; Ekmekcioglu & Kutlu, 2012).

Failure mode and effect analysis is an analytical tool used to identified, quantify and prioritize risks. The traditional FMEA evaluated risks by calculating the risk priority number (RPN). The RPN was computed by multiplying three factors (O S, and D), where O and S represented the occurrence and severity of a failure, and D is detection. The severity rating represent impact on the use of product if the failure occurs. The occurrence is the probability of the failure actually occurring. The detection that meant the ability to detect the failure before it reached the customer (George, 2002, Chin, Wang, Poon, & Yang, 2009). Each category is rated on a scale from 1 to 5 (or 1 to 10-point scale) with a lower rating representing a lower risks.. After calculating the RPNs of each failure, managers could sort the RPNs from largest to smallest. A higher RPN number for a potential failure represent higher overall risk. The RPN values are used to prioritize process improvement efforts. Failures with higher RPNs could be viewed as more important and as mitigation more attention. Therefore, the FMEA could help managers assess the risks of failures and provide the managers with guidelines for improvement. After the system was improved, a reevaluated version of the FMEA could be implemented. New RPNs of failures would be generated. The cycle would continue until the system reached a level of low or acceptable risk ranges.

MAJOR RISK CONSIDERED FOR FMEA

From Table No. 3 and Table No. 4 we considered risk associated with major factors like cost, delivery, quality, operational and technology.

- Total cost of Buying- Cost risk is the risk associated with the outsourcing and the effect on cost in case some problems with the outsourced parts. This will includes the product cost + Transport + Insurance, as quoted by vendors.
- Quality – Quality Risk is the propensity for a product or service to be defective, due to operations-related issues, poor buyer-supplier communication, lack of supplier capabilities / resources / capacity, or buyer-supplier enforceability. The quality factor is measured, in terms of vendors ability to provide inputs that are reliable, durable and confirms to buying firms specifications. It also includes repair and return rate, product reliability, vendor quality systems and quality certifications.
- Operational risk- This risk caused by the breakdown in operations at the vendor location.

These risks are not caused by deliberate actions by the vendor or by unethical behavior of the vendor. Rather, they are a by-product of the complexity of operations.

- Lead time/ Delivery - This risk caused by Delay in production start-up, Delay in manufacturing process, Delay in transportation of goods. Delivery -Increased reliance upon outsourcing has made the issues of vendor selection criteria even more critical to the success of the organization.
- The delivery factor is measured on the basis of importance of the delivery dimensions in buying firms vendors selection process: ability and willingness to expedite an order, how quickly a vendor can deliver, the amount of time that it takes a vendor to deliver prototype, the ability of the vendor to meet due date.
- Technical - Technical risks are those events or issues associated with research and development (R&D), design, construction, and operation that could affect the actual level of performance on short and long term basis.
- Some of the technical risks are: Technology failure from the service provider. The risks are due to operational problems in providing services or preparing products, and the incompetence to react adequately to unforeseen negative situations. Insufficient knowledge of vendor capacity limitations. Outsourcer's loss to Skill erosion, loss of control /core competence, less flexibility, disregard of technological advances.

3. METHODOLOGY

An FMEA can be used to provide a structured methodology to evaluate vendor based on risk that they for an industry. Severity represent the impact on an industry performance if the failure occurs. Probability calculating the severity levels for a classification ranking that encompasses different factors. It determines how affect the potential failure mode on the industry. The occurrence is the probability of the failure actually occurring. The probability score may be developed by examining the previous performance data, or may based on subjective judgment if no data is available. The frequency criterion is used for detection and it represent a rating of how often a vendor perform the activity where risk exposure occurs. If the vendor perform task daily where the exposure to a risk, the frequency criteria is rated as a high. If the vendor perform the task less than one per month, the frequency rating would be low. The frequency criterion is a rating of how often the vendor perform the task. Each category is rate from 1-10 reflecting the level of risk.

STEPS IN FMEA

- Identify risk categories. These are categories of potential failure such as cost, quality, delivery, operational and technology. This step can be accomplished through brainstorming sessions with employees knowledgeable in an industry.
- Identify specific risk that would cause a failure. Potential risks from vendor might include failure such as delays due to strike, delays due to transportation, lack of material availability, financial instability, poor product quality, delay due to equipment or utilities. Here decision maker must be able to draw on past experience as well as predict potential failures in the future
- Rate the severity, occurrence and detection for each risk
- Calculate the RPN's for each risk

- Sorting risk in descending RPN's will help to priorities risk
- RPN values from each vendor should be analyzed for vendor comparison
- Vendor should be selected based on the overall RPN's as well as the highest individual RPN for a specific risk

A business risk is classified (as per pilot study carried out) as follows

Table 5: Business Risk Table

Sr. No	Risk Category	RPN Score	Risk in %
1	Very low	100	1
2	Low	100-200	2
3	Medium	200-300	3
4	High	300-400	4
5	Very high	Above500	5

Ranking Scale for severity, occurrence, detection.

Table 6: Severity Ranking Scale

Sr. No	Severity	Rating	Definition
1	None	1	Failure would not noticeable to buyer and would not affect the buyer process or product or industry is not affected
2	Very minor	2	Failure may not be readily apparent to the buyer, but would have minor effect on the buyer process or product or industry is not affected
3	Minor	3	Failure would create a minor nuisance to the buyer, but buyer can over come it without performance loss or industry minimally affected, repaired easily
4	Very low	4	Failure can be over come with modification to the buyer process or product, but there is no minor loss or industry minimally affected, repaired easily
5	Low	5	Failure creates enough of a performance loss to cause the buyer to complain or industry affected but repairable
6	Moderate	6	Failure results in a subsystem or partial malfunction of a product or industry affected but repairable
7	High	7	Failure causes a high degree of buyer dissatisfaction or industry largely affected, repairable, but difficulty
8	Very high	8	Failure renders the unit inoperable or unfit for the use or industry largely affected, repairable, but difficulty
9	Extremely high	9	Failure would create noncompliance and legal regulations or industry is affected beyond repair
10	Dangerously high	10	Unpredictable failure with hazardous effects almost certain. Non-complaint with regulations or industry is affected beyond repair

Table 7: Occurrence Ranking Scale

Sr. No	Occurrence	Rating	Definition
1	Very High-failure almost inevitable	10	Occurs very frequently (P>0.7)
2	High: Failures occur almost as often as not.	9	0.55<P<0.7
3	High repeated failures	8	Occurs rather frequently (0.5<P<0.55)
4	High: Failures occur often.	7	0.45<P<0.50
5	Moderately High: Frequent failures.	6	0.40<P<0.45
6	Moderate occasional failure	5	Occurs a substantial amount (0.30<P<0.40)
7	Moderately Low: Infrequent failures	4	0.25<P<0.30
8	Low relatively few failures	3	Occurs a little amount (0.15<P<0.25)
9	Low: Failures are few and far between.	2	0.10<P<0.15)
10	Remote failure is unlike	1	Occurs very minimally (P<0.10)

Table 8: Detection Ranking Scale

Sr. No	Detection	Rating	Definition
1	Almost Certain	1	Buyers control will detect potential cause/mechanism and subsequent failure mode
2	Very High	2	Very high chance the buyer control will detect potential cause/mechanism and subsequent failure mode
3	High	3	High chance the buyer control will detect potential cause/mechanism and subsequent failure mode
4	Moderately High	4	Moderately High chance the buyer control will detect potential cause/ mechanism and subsequent failure mode
5	Moderate	5	Moderate chance the buyer control will detect potential cause/mechanism and subsequent failure mode
6	Low	6	Low chance the buyer control will detect potential cause/mechanism and subsequent failure mode
7	Very Low	7	Very low chance the buyer control will detect potential cause/mechanism and subsequent failure mode
8	Remote	8	Remote chance the buyer control will detect potential cause/mechanism and subsequent failure mode
9	Very Remote	9	Very remote chance the buyer control will detect potential cause/mechanism and subsequent failure mode
10	Absolute Uncertainty	10	Buyer control cannot detect potential cause/mechanism and subsequent failure mode

4. CASE STUDY

Decision problem- Due to product Variety, demand, manufacturing cost and space, M/s Deltech Flow control Pvt. Ltd Pune (MH). Company wants to outsource the some manufacturing parts which involved in manufacturing components of a valve.

The variation in demand of the products, limitation of space most of the components are outsourced. These constraints have influenced the company to outsource the components. The company provides the design; material and technical know-how to the vendors for efficient manufacturing resulting in reduce cost of manufacturing and timely delivery. While outsourcing they were came across following major risk. Through brainstorming sessions with employees knowledgeable in an industry the potential risk are categorized as cost, quality, delivery, operational and technology. The potential failure for each risk is noted. Rating is done for the severity, occurrence and detection as per ranking scale for each failure of risk. Calculate the RPN's for each risk and Sorting the risk in descending RPN's order to priorities the risk (Table no. 9).

Table 9: Risk Assessment by FMEA

Risk	S	O	D	RPN	Recommended Action	Action Taken	S	O	D	RPN
Cost										
Unit price increase	2	4	2	16	Survey in market the other vendors and the unit prices	Negotiate and select the vendor with minimum unit price	2	3	2	12
Transportation cost increase	2	4	2	16	Check up survey the vendors for the same components in near vicinity and their transportation cost	Select the vendor with minimum unit price and transportation cost in near by vicinity	2	3	2	12
Lead Time/Delivery										
Delay in production start-up	4	4	2	32	Expidate the production start up to cover up late start up of the component delay	Study the cushioning time for start up of the production of other component of overlapping activities and reduce the total production time	3	4	2	24
Delay in manufacturing process	3	2	5	30	Reschedule the manufacturing process of the components requiring the same machine of delayed component.	Rescheduling of the components save the machine time or process time for a component delay to Match up delivery schedule	2	2	4	16

Table 9: Contd.,

Delay in transportation of goods	2	2	4	16	Survey the other mode of transportation of goods	Select the transportation mode with minor rise or reduction in transportation of good but matching the delivery time Discuss with the regular client of the at product requirement whose delivery is ready and cooperate for time being the delay in delivery of this lot	2	2	3	12
Quality										
Component will not fit with mating parts—requiring rework	4	2	5	40	Check up the time available of the machines required for the rework in house or any availability of the same components with vendor 2 and 3	Either rework the component inhouse or at supplier end without disturbing delivery or if same parts are available with other vendors pick up lot from them and reject this lot	3	2	3	18
Structural defect—function failure	5	1	5	25	Check up the design, material selection and effects in assembly work	Change the design or material if necessary or develop the fixture to ensure the proper assembly	4	1	5	20
Operational										
fractioning machine breakdown	3	2	4	24	refining machine breakdown plan	Send employee for proper Implementation of breakdown plan	3	2	3	18
Technical										
Control of the processes	4	3	5	60	Check up the process methodology and alternatives available	Develop jig or fixture to acquire maximum possible control over the process than the intervention required by human skill-change the process which can give you more control over the process	4	2	4	32
Technical skill to support the processes	3	1	5	15	Survey the technical skill available with the individual operator against required to support the process	Provide the training to cover up the technical skill gap between required technical skill and available technical skill	3	1	4	12
Over all RPN				274		Over all RPN				176

5. CONCLUSIONS

Manufacturing outsourcing has a various components of risk. It is well understood that it is important to make outsourcing decision correctly in order to reduce risk and are acting towards avoiding the potential pitfalls. Outsourcing has proven to be a risky business endeavor that has the potential for failure, techniques are needed that help identify, access and reduce the effects of failures. This paper proposes the use of FEMA to evaluate risk and guide risk mitigation efforts. This technique can be used by supply chain decision makers to help minimize the risks of supply chain management. Without the FMEA based outsourcing risk assessment tool, unforeseen problems might have impacted the overall success of the global outsourcing efforts.

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