PFDA-FMEA-VSM application for outsourcing risk analysis

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Abstract: Manufacturing corporations has the acceptance of the Outsourcing Process (OP) to improve industrial activities as well as to archive the revenue objectives, and with this, Risk Analysis (RA) tools are constantly used to assure expected results. Failure Mode and Effect Analysis (FMEA) is one of preferred RA tools, moreover, it is proven that FMEA adds uncertainty because of the human participation at the RA, afterward it is demonstrated that Pythagorean Fuzzy Dimensional Analysis – FMEA – Value Stream Mapping (PFDA-FMEA-VSM) method removes the uncertainty in RA, likewise it aids to the stakeholders for decision making, giving more advantages improving the use of the resources on the project. This document exhibits a real case scenario in a manufacturing firm applying PFDA-FMEA-VSM method adapted for manufacturing OP. The application of PFDA-FMEA-VSM shows solid RA results, removing the human intervention uncertainty added to the risk ranking, gives advantages to the stakeholders for visualize the main risks in detailed diagram, as well as make easier to take better decisions on where to apply resources and mitigate risks during OP.

Keywords: Failure Mode and Effect Analysis (FMEA); Pythagorean Fuzzy Dimensional Analysis (PFDA); Value Stream Mapping (VSM); Outsourcing Process (OP); Risk Analysis (RA).

1. Introduction

The Outsourcing Process (OP) is nowadays used by the industrial corporations with the intention to simplify their internal manufacturing activities, and to get the expected revenue while a third party manufacture their products [1]. Risk for customers and new products are also important aspects to consider during the OP process [2], likewise, the recent global COVID-19 situation is driving the firms to use OP [3], in addition, global companies look for OP as a business model [4]. Though, OP represents several risks because the intervention of different processes and cross-functional areas are interconnected [5], adding new risks for the firms to manage, making them to look for new Risk Analysis (RA) tools to mitigate the risks and archive the projected goals.

Failure Mode and Effect Analysis (FMEA) is an effective tool to manage risks because it helps to perform an extensive RA, giving a quick guide on what are main risks and how to mitigate them. FMEA is as well a common tool use during the OP [6], however, FMEA is adding uncertainty to the RA since the intervention of the human final decision on what are the risks [7], [8]. Additionally, different studies are showing how to remove the uncertainty while using the FMEA combining Multicriteria methods [9], [10], [11], [12], [13]. Furthermore, Pythagorean Fuzzy Dimensional Analysis – FMEA- Value Stream Mapping

(PFDA-FMEA-VSM) [14], is a proved method to remove the uncertainty during the RA. PFDA-FMEA-VSM. Furthermore, it adds the advantage to allow the stakeholders taking better decisions before the OP execution, meanwhile improving where to allocate the budget using just the required resources at the right process step, and risk identified.

This document presents a real case scenario in a manufacturing company, using the PFDA-FMEA-VSM method to perform a RA before manufacturing OP. Furthermore, a comparison between conventional FMEA and PFDA-FMEA-VSM analyzing the differences.

The rest of this document is organized as follows. Section 2, described to the basic concepts required to apply PFDA-FMEA-VSM method. Then section 3, contains the real case scenario, applying PFDA-FMEA-VSM method in a manufacturing company for an OP. Later section 4 covers the results and discussion. Finally, section 5 includes the conclusion of this work.

2. Basic Concepts

This segment shows the main concepts used to deploy PFDA-FMEA-VSM method and to apply it in a manufacturing OP. The full details of the used methodology can be found in [14].

Definition 1. Subject Matter Expert team (SMEt), is the group of OP experts which analyze the OP steps and performs the RA. The SMEt should be created by the project leader considering at least three experts, desirable from different functional areas.

Definition 2. SME weights (SMEw) assignation, refers to a value assigned to each SME member, based on their OP experience. The sum of the SME weights must be equal to 1. It is suggested that the project leader assigned the SME weights.

During this exercise, the SMEt is formed by three senior managers from different functional areas, since the three experts have similar experience in OP, the SMEw are divided by equally.

PFDA-FMEA-VSM method is originally suggested for new product development process risk management, then to allow the adjustment of this methodology to a manufacturing OP, it is required to use next analogies.

1. Phase 1 represents the period between planning stage to the kickoff meeting
2. Phase 2 is the initial segment of the project
3. Phase 3 symbolizes the project implementation

3. PFDA-FMEA-VSM Application

This section shows the steps to complete the PFDA-FMEA-VSM method application for an OP in a manufacturing company. Figure 1 depicts the main steps followed to apply PFDA-FMEA-VSM methodology.
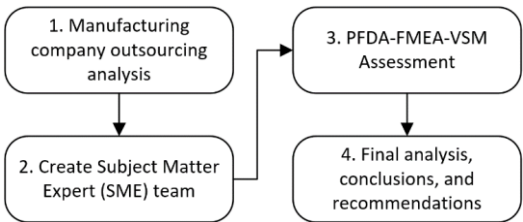

Figure 1. PFDA-FMEA-VSM application summary diagram.

4. Results and Discussion

This section shows the PFDA-FMEA-VSM application result, along with the comparison between the conventional FMEA analysis and the PFDA-FMEA-VSM analysis, this comparison is just for reference and to remark the advantages of the PFDA-FMEA-VSM method. Table 1 shows the list of the risks identified during the SMEt assessment.

Table 1. Potential failure modes (risks) identified by the SMEt.

ID	Risk
1	Schedule Execution issues
2	Continues improvement vs targets
3	People turnover
4	Product validation
5	Supplier capacity issues
6	Sales projection inaccurate
7	Product changes not communicated
8	Poor supplier quality
9	Manufacturing issues not communicated
10	Manufacturing errors, bad execution
11	Poor engineering changes implementation
12	Project scope changes
13	KPI bad results from supplier
14	Lack of right resources assigned
15	Lack of product history tracking at supplier
16	Product specs not shared
17	Slow response to peak of demand
18	Raw material Long Leadtime
19	Raw material Long Leadtime
20	Lack of administrative resources
21	Slow hiring process
22	People not hired on time
23	Lack of right equipment
24	People turnover during transition
25	Poor process documentation
26	Production forecast not well communicated
27	Product quality does not meet prior transition
28	Poor raw material management
29	External agencies approvals long Leadtime
30	Poor communication Customer-supplier
31	Missing information during transition
32	Poor training on new processes
33	Poor transition product information
34	Poor knowledge transfer
35	Administrative resources not properly assigned
36	Confidential information in risk
37	Raw material obsolescence not identified
38	Single manufacturing source
39	Lack of manufacturing space because of budget
40	Process capability issues
41	Schedule execution issues
42	Poor infrastructure at supplier
43	Poor engineering changes implementation
44	People not hired on time
45	Supplier decommit
46	Supplier lack of capacity
47	Logistics issues
48	Manufacturing certifications issues
49	ERP system issues
50	Lack of expertise on manufacturing services
51	Financial issues (supplier)

52	Lack of administrative resources
53	Project transition delay

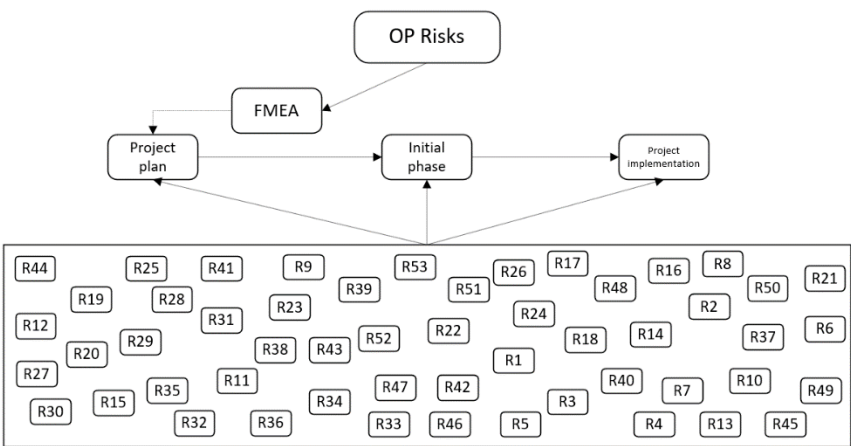Figure 2 illustrates the VSM current state.

Figure 2. OP VSM current scenario.

Following, the PFDA-FMEA-VSM ranking in Table 2.

Table 2. PFDA-FMEA-VSM ranking results

ID	Risk	PFDA-FMEA-VSM Ranking
1	Schedule Execution issues	17
2	Continues improvement vs targets	13
3	People turnover	37
4	Product validation	35
5	Supplier capacity issues	25
6	Sales projection inaccurate	40
7	Product changes not communicated	42
8	Poor supplier quality	48
9	Manufacturing issues not communicated	25
10	Manufacturing errors, bad execution	8
11	Poor engineering changes implementation	18
12	Project scope changes	46
13	KPI bad results from supplier	47
14	Lack of right resources assigned	5
15	Lack of product history tracking at supplier	10
16	Product specs not shared	24
17	Slow response to peak of demand	52
18	Raw material Long Leadtime	50
19	Raw material Long Leadtime	49
20	Lack of administrative resources	3
21	Slow hiring process	3
22	People not hired on time	16
23	Lack of right equipment	6
24	People turnover during transition	31
25	Poor process documentation	7
26	Production forecast not well communicated	27
27	Product quality does not meet prior transition	8
28	Poor raw material management	36
29	External agencies approvals long Leadtime	12
30	Poor communication Customer-supplier	1
31	Missing information during transition	11
32	Poor training on new processes	38
33	Poor transition product information	30

34	Poor knowledge transfer	15
35	Administrative resources not properly assigned	23
36	Confidential information in risk	1
37	Raw material obsolescence not identified	33
38	Single manufacturing source	41
39	Lack of manufacturing space because of budget	18
40	Process capability issues	45
41	Schedule execution issues	42
42	Poor infrastructure at supplier	22
43	Poor engineering changes implementation	34
44	People not hired on time	32
45	Supplier decommit	51
46	Supplier lack of capacity	21
47	Logistics issues	28
48	Manufacturing certifications issues	20
49	ERP system issues	39
50	Lack of expertise on manufacturing services	14
51	Financial issues (supplier)	29
52	Lack of administrative resources	44
53	Project transition delay	53

Following, the VSM future state is executed. SMEt agreed to select the top 15 risks as potential threads, highlighted in Figure 3.
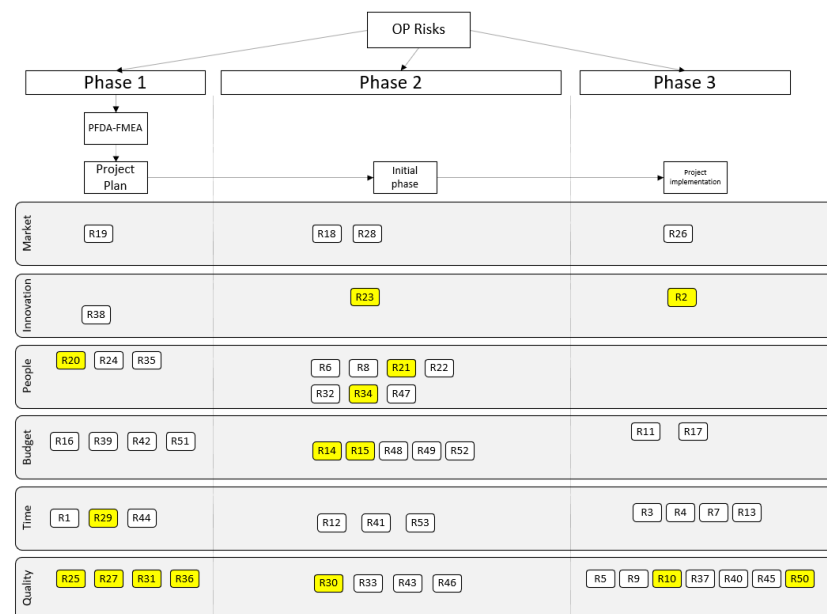

Figure 3. PFDA-FMEA-VSM future state chart result.

For comparison proposes, a conventional FMEA was performed by the same SMEt, Table 3 depicts the FMEA results. SMEt considered to mitigate any risk above RPN of 25.

Table 3. Conventional FMEA assessment by SME.

ID	Risk	S	O	D	RPN
1	Schedule Execution issues	5	5	3	75
2	Continues improvement vs targets	4	2	4	32
3	People turnover	5	3	5	75
4	Product validation	5	5	3	75
5	Supplier capacity issues	5	5	3	75
6	Sales projection inaccurate	5	5	3	75
7	Product changes not communicated	5	3	3	45
8	Poor supplier quality	5	3	3	45

9	Manufacturing issues not communicated	3	2	3	18
10	Manufacturing errors, bad execution	3	2	3	18
11	Poor engineering changes implementation	3	3	3	27
12	Project scope changes	3	3	3	27
13	KPI bad results from supplier	5	5	1	25
14	Lack of right resources assigned	5	5	2	50
15	Lack of product history tracking at supplier	5	5	1	25
16	Product specs not shared	5	5	1	25
17	Slow response to peak of demand	5	5	1	25
18	Raw material Long Leadtime	5	5	1	25
19	Raw material Long Leadtime	5	5	1	25
20	Lack of administrative resources	5	5	1	25
21	Slow hiring process	5	5	1	25
22	People not hired on time	1	2	3	6
23	Lack of right equipment	1	2	3	6
24	People turnover during transition	1	2	3	6
25	Poor process documentation	5	3	1	15
26	Production forecast not well communicated	5	2	3	30
27	Product quality does not meet prior transition	1	5	3	15
28	Poor raw material management	3	1	5	15
29	External agencies approvals long Leadtime	1	1	1	1
30	Poor communication Customer-supplier	5	1	3	15
31	Missing information during transition	5	3	1	15
32	Poor training on new processes	5	3	1	15
33	Poor transition product information	3	5	1	15
34	Poor knowledge transfer	5	3	1	15
35	Administrative resources not properly assigned	5	3	1	15
36	Confidential information in risk	5	3	1	15
37	Raw material obsolescence not identified	1	3	3	9
38	Single manufacturing source	3	3	1	9
39	Lack of manufacturing space because of budget	1	3	3	9
40	Process capability issues	4	2	4	32
41	Schedule execution issues	4	2	4	32
42	Poor infrastructure at supplier	5	1	1	5
43	Poor engineering changes implementation	3	1	1	3
44	People not hired on time	1	3	1	3
45	Supplier decommit	5	3	2	30
46	Supplier lack of capacity	5	3	2	30
47	Logistics issues	5	3	2	30
48	Manufacturing certifications issues	5	3	2	30
49	ERP system issues	5	3	2	30
50	Lack of expertise on manufacturing services	5	3	2	30
51	Financial issues (supplier)	5	3	2	30
52	Lack of administrative resources	5	3	2	30
53	Project transition delay	5	3	2	30

Conventional FMEA assessment shows 31 identified risks above 25 RPN value, while PFDA-FMEA-VSM top 15 ranking captured the main risks to consider as potential real threats for the OP project.

Using conventional FMEA method, all risks with RPN above 25 should have a mitigation recommended activity, besides, PFDA-FMEA-VSM top 15 optimize the resources at mitigation process, just applying preventive methods where and when required. Table 4 reveals the comparison between PFDA-FMEA-VSM and FMEA.

Table 4. FMEA vs PFDA-FMEA-VSM rankings comparison.

ID	Risk	S	O	D	RPN	PFDA-FMEA-VSM Ranking
1	Schedule Execution issues	5	5	3	75	17

2	Continues improvement vs targets	4	2	4	32	13
3	People turnover	5	3	5	75	37
4	Product validation	5	5	3	75	35
5	Supplier capacity issues	5	5	3	75	25
6	Sales projection inaccurate	5	5	3	75	40
7	Product changes not communicated	5	3	3	45	42
8	Poor supplier quality	5	3	3	45	48
9	Manufacturing issues not communicated	3	2	3	18	25
10	Manufacturing errors, bad execution	3	2	3	18	8
11	Poor engineering changes implementation	3	3	3	27	18
12	Project scope changes	3	3	3	27	46
13	KPI bad results from supplier	5	5	1	25	47
14	Lack of right resources assigned	5	5	2	50	5
15	Lack of product history tracking at supplier	5	5	1	25	10
16	Product specs not shared	5	5	1	25	24
17	Slow response to peak of demand	5	5	1	25	52
18	Raw material Long Leadtime	5	5	1	25	50
19	Raw material Long Leadtime	5	5	1	25	49
20	Lack of administrative resources	5	5	1	25	3
21	Slow hiring process	5	5	1	25	3
22	People not hired on time	1	2	3	6	16
23	Lack of right equipment	1	2	3	6	6
24	People turnover during transition	1	2	3	6	31
25	Poor process documentation	5	3	1	15	7
26	Production forecast not well communicated	5	2	3	30	27
27	Product quality not meet prior transition	1	5	3	15	8
28	Poor raw material management	3	1	5	15	36
29	External agencies approvals long Leadtime	1	1	1	1	12
30	Poor communication Customer-supplier	5	1	3	15	1
31	Missing information during transition	5	3	1	15	11
32	Poor training on new processes	5	3	1	15	38
33	Poor transition product information	3	5	1	15	30
34	Poor knowledge transfer	5	3	1	15	15
35	Administrative resources not properly assigned	5	3	1	15	23
36	Confidential information in risk	5	3	1	15	1
37	Raw material obsolescence not identified	1	3	3	9	33
38	Single manufacturing source	3	3	1	9	41
39	Lack of manufacturing space because of budget	1	3	3	9	18
40	Process capability issues	4	2	4	32	45
41	Schedule execution issues	4	2	4	32	42
42	Poor infrastructure at supplier	5	1	1	5	22
43	Poor engineering changes implementation	3	1	1	3	34
44	People not hired on time	1	3	1	3	32
45	Supplier decommit	5	3	2	30	51
46	Supplier lack of capacity	5	3	2	30	21
47	Logistics issues	5	3	2	30	28
48	Manufacturing certifications issues	5	3	2	30	20
49	ERP system issues	5	3	2	30	39
50	Lack of expertise on manufacturing services	5	3	2	30	14
51	Financial issues (supplier)	5	3	2	30	29
52	Lack of administrative resources	5	3	2	30	44
53	Project transition delay	5	3	2	30	53

5. Conclusions

A recurrent issue identifying risks in OP, is the uncertainty added by the human intervention ranking the risks, moreover by using PFDA-FMEA-VSM method, this problem is solved and improves OP with significant advantages over the conventional FMEA. Following, a list of the primary benefits of using PFDA-FMEA-VSM for OP.

- Ranking uncertainty removed
- Clear visibility on the risks to be mitigated
- Optimize resources mitigating just the major risks
- Visual risks identification, where and when is the risk

PFDA-FMEA-VSM method was at first used to new product introduction process, moreover, this application reveals that it is well adapted to OP making clear and easier the OP. Likewise, there is a value added using this method, because of the risk classification by area and the project period.

Furthermore, future works are considered applying and adapting PFDA-FMEA-VSM to other processes, as well as trying to automate the process using a programmed software.

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