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Developing strategies to improve agility in the project procurement management (PPM) process

Perspective of business intelligence (BI)

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Abstract

Purpose – The ability of an organization to observe varying demands and efficiently meet them can be described as agility. Project procurement management (PPM) in the past was stable as things did not change very often and were very predictable. Due to hyper-competition, less predictable market and exponential innovation, the existing PPM becomes very unstable which marks the requirement of an agile model to manage procurement projects effectively. The paper aims to discuss this issue.

Design/methodology/approach – For achieving the improvements, various barriers to improving agility in PPM were identified from the literature and experts' review, followed by obtaining quantified impacts of identified barriers from the experts using the Delphi technique. Finally, interpretive structural modeling along with Matrice d' Impacts Croises Multiplication Appliqué an Classement analysis was used to analyze the interactions among barriers to prioritize and strategize their mitigation.

Findings – As per the analysis, the lack of top management alignment and commitment, lack of digital strategy, lack of new technology competencies and inefficiencies of financial factors were the most critical barriers that would come across while improving agility in PPM for any organization. Industries should have a stable, well-established and supportive top management that has a vision for digital transformation along with upgrading the companies' technology layer for automating most of the manual processes to have intelligent decision-making capability.

Originality/value – Industries need to be agile in their operations for being more competitive and responsive to the market. PPM being the most critical part of the entire value chain needs to be agile in the first place. The strategies developed as an output of this research can be utilized by industries for improving agility in their business processes.

Keywords Delphi, Agility, Business intelligence, Interpretive structural modelling, MICMAC, Project procurement management

Paper type Research paper

1. Introduction

There has been a considerable transformation in procurement since its discovery as primarily a manufacturing-sector discipline in the mid-twentieth century. Traditionally, it was simply a process involving the acquisition of goods and services but underwent great changes during the 1980s and 1990s due to rising cost-cutting pressures in an increasingly global market (Tassabehji and Moorhouse, 2008; Rozemeijer, 2008; Reynolds and Thompson, 2008). Every organization purchases items, i.e., every organization requires to purchase supplies, perhaps as raw materials, components, sub-assemblies, spares, equipment, services and consumables (Zhelyazkov, 2011). Project procurement interacts

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with every single entity in the organization including sales and marketing to engineering design and manufacturing making it a very important process for the organization. Selecting the right supplier for an assignment, as well as evaluating this supplier's performance while the contract is being implemented, plays an important role in ensuring a good project outcome (de Araújo *et al.*, 2017). Procurement is currently recognized as a strategically significant function (Spekman *et al.*, 1994; Tan *et al.*, 1998; Humphreys, 2001) that is capable of driving and delivering competitive advantage (Mol, 2003; Ubeda *et al.*, 2015; Atmo *et al.*, 2017). Enabling the development of strategic procurement has long been recognized as contributing to an effective organization, but companies in both the public and private sector still seem to find it challenging (White *et al.*, 2016).

When volatility creates unpredictability in supplies and prices, an agile and prepared purchasing function is essential (Fouhal *et al.*, 2012). More than 50 percent of sales revenue is spent on procurement by industries like automotive, electronics and consumer goods, due to existing cumbersome project procurement management (PPM) techniques. As per Fouhal *et al.* (2012) volatility and scarcity events are increasingly common in food commodities where volatility has increased by 50–80 percent between 2008 and 2011, as well as in a growing number of basic materials including metals, rubber and coal, where volatility has increased by up to 60 percent in the same period. According to the McKinsey Global Institute, the demand for energy will increase by 70 percent by 2030. On top of all these, the economic impact of natural disasters is rising too. While best-in-class companies have over 85 percent of their spend under management, all other companies are stuck around the halfway mark: 54.4 percent. The most important competitive differentiator factor for any company will be the ability to deal with the mentioned challenges. Limberakis (2016) stated that procurement officers and executives always had and have a focus on controlling cost, and 74 percent of the global respondents note cost reduction as the top priority to sustain growth in a slowing market, whereas it also requires adaptability, agility and flexibility to adjust things around it. Kuuse (2014) stated that poor PPM wastes time and the whole team waits for missing materials; deadlines are breached, and costs spiral out of control as materials are purchased last minute from random suppliers. This mismanagement creates big trouble for project managers. A lack of technology competency and random way of maintaining record hides the real facts and important decision-making insights under piles of files, old messages/emails, etc. Majority of the market has not yet implemented the most established PPM technologies (Bartolini, 2013). There are a lot of available solutions such as eProcurement, spend analysis, contract management, etc., but no such functionality was being used by more than half of the companies that were surveyed by Bartolini (2013).

2. Literature survey

2.1 Project procurement management

This section aims to provide an overview of PPM and related concerns. PPM is a properly defined framework for doing procurement activities systematically. PPM is the one that includes the processes necessary to procure or acquire products, services, or results needed from outside the project team. It also involves agreements that describe the relationships between buyer and seller (PMI, 2017). PPM has a systematic framework that includes initiating and planning (what to procure, when and how to do it, make-buy decisions, identify suppliers, set timelines, etc.), contract writing (conditions of the relationship between the company and the supplier), execute procurement (obtaining seller responses, selecting sellers and awarding contracts), monitoring/administer contracts or purchase orders issued by authorized project team members, closing and completing. Depending on the nature of the project, resources can include machinery, equipment, tools, materials, tradespeople, supervisors, consultancy services, employee training as well as a host of other goods and services (Pheng, 2018). Extensive research has been conducted in the domain of

PPM by de Araújo *et al.* (2017); Mosley and Bubshait (2017), Lonsdale *et al.* (2017) and have presented case studies that cater to various domains (Walker and Rahmani, 2016; Dandage *et al.*, 2018, 2019; Plantinga and Dorée, 2016). As discussed by Bartolini (2013), the available tools and methodologies are not being used wisely leading to inefficiencies in PPM. As understood from the literature about the importance of PPM, it makes it necessary to bring a paradigm shift in existing PPM techniques.

2.2 Significance of agility in PPM

This section aims to have an overview of agility and how it can help PPM. Agility, as described by Maltaverne (2016), is the ability to: maximize positive outcomes (opportunities) and minimize negative outcomes. Agility is directly associated with the performance of an organization in a highly competitive environment (Bernardes and Hanna, 2009; Goldman *et al.*, 1995; Yusuf *et al.*, 1999, 2003). Agility refers to adapting and reacting to unexpected changes within and between organizations quickly (Aziz and Zailani, 2011; Sherehiy *et al.*, 2007; Swafford *et al.*, 2006, 2008). By definition agility is highly dependent on a wide range of operation management capabilities like available information and communication technology infrastructure, adequate knowledge and decision-making capabilities of people, involvement of people and adequate support (Burgess, 1994; Vastag *et al.*, 1994).

Improving procurement's business agility was cited as the third most critical goal, right after the cost reduction (Burnson, 2015) increasing the agility of PPM process, thus becomes very essential (Nicoletti, 2018). Maltaverne (2016) mentioned that this is the right time to put agility on the top of the executive management's agenda. In order to become agile, the PPM in an organization will have to align its capabilities (People, Process and Technology) with its needs and priorities (Braunscheidel and Suresh, 2009; Mike *et al.*, 2012; Jain *et al.*, 2008).

Agility is a methodology that will use relevant tools, techniques and work culture to bring a paradigm shift in the existing PPM (Gosling *et al.*, 2010; Van Hoek, 2001; Agarwal *et al.*, 2006), but implementing or improving any process in an organization has to go through a lot of road-blocks. This paper thus considers various barriers that may come across while improving agility in PPM and also strategies to mitigate them. Aziz *et al.* (2014) have examined various issues and challenges faced in procurement/sourcing agility, manufacturing agility and logistics/distribution agility by the practitioners as well as the relevant parties involved in the industry. Noble (2014) has identified barriers for implementing agility in organizations. Further literature was reviewed for identifying relevant barriers to improving agility in PPM; Section 6 provides a detailed summary of the same.

2.3 Business intelligence to overcome barriers for improving agility in PPM

This section aims to have an overview of how to utilize business intelligence for overcoming the barriers that would encounter while improving agility in PPM. Agile methodology has a specific way of working and is enabled by using the latest tools and techniques (Aitken *et al.*, 2002; Naim and Gosling, 2011; Kisperska-Moron and de Haan, 2011). Business intelligence can provide special benefits to improving the agility of the PPM process (Nicoletti, 2018). Having the right information and appropriate tools at the fingertips can help project procurement managers to work in a more agile way and have a winning edge over the competitors (Van-Hau, 2017; Chongwatpol, 2016; Rane and Mishra, 2018). Business intelligence is capable of extending right insights to the procurement managers, for making the right decisions at the right time (Nicoletti, 2018; Rouhani *et al.*, 2016; Alon *et al.*, 2016). Business intelligence, in general, is neither a product nor a system, in a broader sense, it is a set of concepts, methods, applications and technologies, which are utilized to collect data and transform the raw data into meaningful information (Khan, 2014) that can be utilized by procurement managers to make vital decisions more quickly.

Procurement process intelligence is a business intelligence approach focused on the optimal management of procurement processes with improved agility (Nicoletti, 2018).

A large amount of information is hidden due to conventional data management techniques, making it nearly impossible to analyze and extract useful insights. Bringing agility in PPM can be achieved by enabling seamless data collection and integration between applications by using the latest tools and techniques, and finally deriving business intelligence from the gathered data. Business intelligence provides analysis and visualization for procurement decision makers (Friend, 2015) to develop strategy proactively, have better visibility on make-buy-rent decisions, visibility selecting the right supplier and transporter network, visibility on setting accurate timelines and cost estimates, visibility on spend, visibility on processes that lag, visibility on tracking consignments, visibility on service level agreement (SLA) compliances, etc., which will enable faster, more efficient and more accurate decisions about procurement management. According to Thamir and Poulis (2015), business intelligence provides managers and their teams with new tools to enhance the processing of data, and thus decision making becomes more efficient.

There is a need to improve the PPM process (Al-Mashari *et al.*, 2001; Al-Mashari and Zairi, 1999, 2000) by providing intelligence to the procurement managers for improving the overall agility of the process, which can be referred to as procurement process intelligence (Nicoletti, 2018).

3. Research gaps

Research gaps identified based on literature survey and based on interactions with the experts, and are summarized as follows.

3.1 Research gaps based on literature survey

The significance of the PPM process has been identified from the literature. PPM is the key process for enabling successful outcomes to projects, and there is a need to improve the agility in this process. Based on the analysis of limitations and future scopes from the literature, there is a need to improve agility in PPM for significant business results. After analyzing the findings of the literature, it has also been identified that there is a need to develop strategies based on effective utilization of business intelligence, to mitigate the barriers for improving agility in PPM.

3.2 Research gaps based on experts' view

Inputs were received from experts having varied experience dealing with multiple industry domains and business process who were directly or indirectly associated with PPM. Following are the major challenges addressed by the experts which enterprises face in PPM:

(1) high turnaround time from requirement generation to meeting the requirement;

(2) a huge amount of time is spent to on-board an eligible and trusted supplier;

(3) no visibility to the project team about the progress on the procurement process;

(4) human-intensive and manual intervened process; and

(5) conflicts and disagreements between parties related to payments, delivery, quality, SLA breaches and many more.

All these factors waste a lot of time, money and efforts, making the entire PPM process lag which marks the need for agility improvement.

4. Research objectives

In order to overcome the research gaps, this research defines the following objectives:

(1) to improve agility in the PPM process;

(2) to identify barriers hampering successful implementation of agility in PPM;

(3) to prioritize the barriers based on expert survey and the interpretive structural model;

(4) to find interactions among barriers based on interpretive structural model analysis;

(5) to identify the driving and dependence power of barriers based on Matrice d' Impacts Croises Multiplication Appliqué an Classement analysis; and

(6) to formulate strategies by leveraging business intelligence for mitigating the barriers based on ISM and MICMAC analysis.

5. Research methodology

Considering the challenges faced and the need for agility improvement in the PPM process, this paper aims to identify the barriers to implementing agility in PPM based on the literature review and expert input. Post identification, the barriers were prioritized by conducting a Delphi survey based on their significance. Top critical barriers with a strong impact on agility improvement in PPM were considered for ISM and MICMAC analysis to establish relationships and interactions among barriers. Based on this analysis strategies were formulated by leveraging business intelligance, for strategic and systematic mitigation barriers for a successful agility improvement in PPM. The research methodology adopted to achieve successful agility improvement is as shown in Figure 1.

The first step shown in Figure 1 was to identify various barriers that hamper the improvement of agility in the existing PPM process. As an outcome of this exercise, 20 barriers were identified from the literature and experts' inputs.

After identifying the barriers, the next step was to identify and quantify the impacts of these barriers on the improvement of agility in PPM from the experts. The quantified impacts of barriers were received from over 37 experts having varied experience in terms of domain, designation, years of experience, nature of the business, etc., which were directly or indirectly associated with the PPM process. The quantified impacts of barriers were prioritized as per criticality which led to identification to top 10 high-impacting barriers. These ten critical barriers were considered for further analysis. The next step was to develop Structural Self-Interaction Matrix (SSIM) for the ISM which was developed by identifying relationships among barriers. The relationship was established by having brainstorming sessions with experts. Followed by developing SSIM, other steps in ISM were carried out, as shown in Figure 1. ISM along with MICMAC analysis was used to find the interactions among the prioritized barriers. These interactions gave clear visibility in terms of criticality, driving and dependency between the barriers which helped strategize the elimination of barriers systematically. This research provides strategies which were developed based in ISM-MICMAC analysis for eliminating the barriers strategically and improving the agility of the overall PPM process.

6. Exploring barriers to improving agility in PPM

This section aims to identify key barriers that will hamper the improvement of agility in the PPM process. The various barriers to improve agility in PPM identified from the literature are shown in Table I. These identified barriers were verified for their authenticity based on discussions with few of the domain experts considered in Section 7.1.

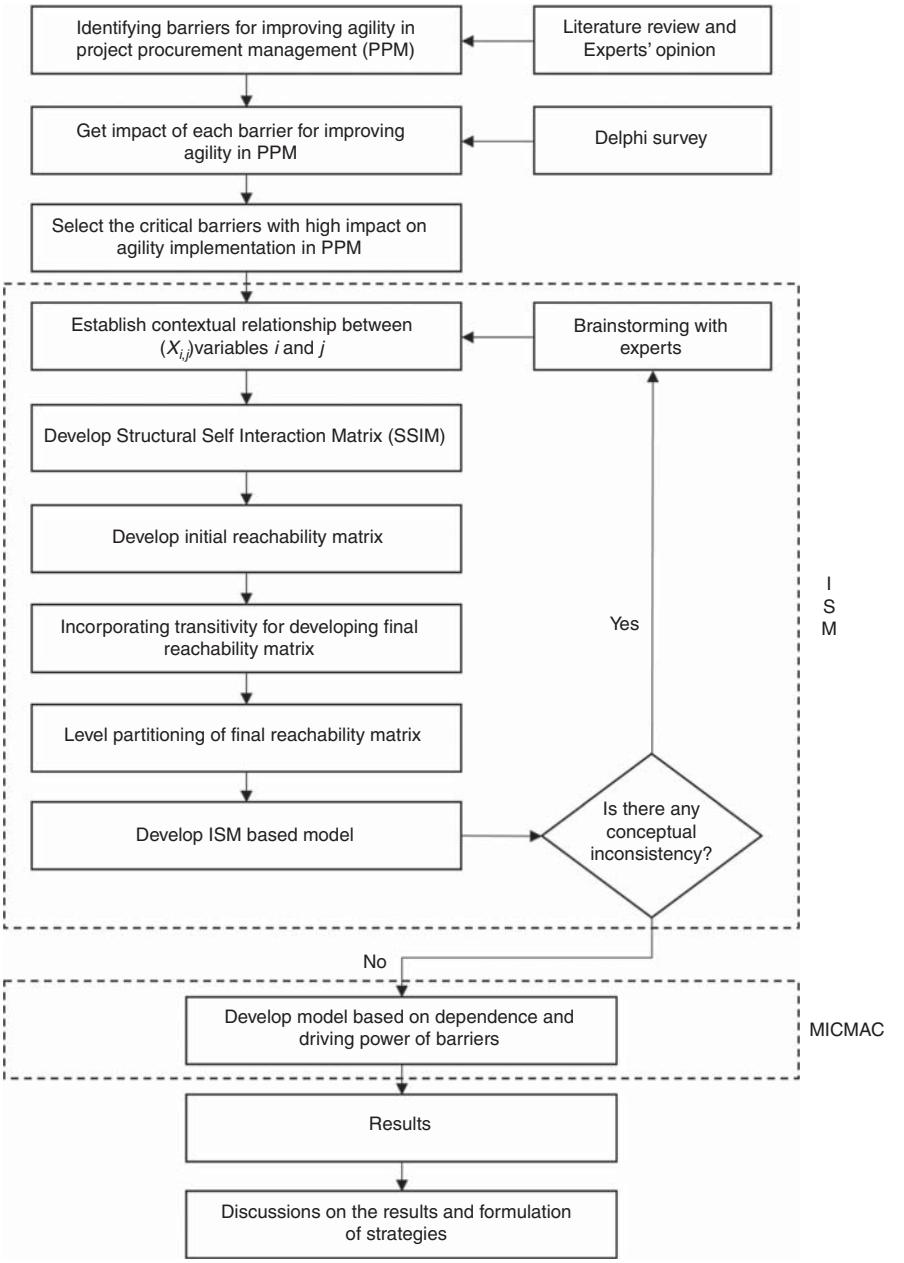

Figure 1.
Research methodology flow chart

7. Identifying the impacts of barriers to improving agility

After identifying the barriers from literature and conducting the first round of Delphi for validating the barriers, the second round of Delphi was conducted to find the impact of each barrier on improving agility in PPM. The quantified impacts of barriers helped in prioritizing and selecting the critical barriers for further analysis.

Sr. No.	Barriers	Description	Relevant PPM processes affected by barriers	Source
1	Lack of new technology competencies	Investing in Process Digitization, Automation, Development of Business intelligence and big data analytics capabilities. PPM has the opportunity to drive insights and powerful strategic advantage if it can improve its ability to capture and analyze both information generated internally and also data from suppliers and other external sources to improve project procurement agility. Technology is seen as an expense rather than an investment; this leads to this barrier	Plan, Conduct, Control and Close	Zairi and Al-Mashari (2005), Burnson (2015), Limberakis (2016), Geissbauer *et al.* (2016), Liebenthal (2015), GEP (2013); Yadav (2017); Donati (2015)
2	Lack of training and information	Organizations may have advanced systems for providing necessary business intelligence and dealing with responsibility principles within the organization Often business intelligence consultants are poorly equipped to handle their role in guiding a project to success because the person leading a project is either: a technical expert knowing business intelligence tools but may not be a competent manager or a component project manager who does not have the required business intelligence awareness Due to improper training and information, people may have very little understanding of what challenges can arise in the procurement management, how they can affect the reputation and how to develop a system for addressing procurement management related responsibility challenges	Plan, Conduct, Control and Close	Bowen *et al.* (2001), Jadhav *et al.* (2014b), Mathiyazhagan *et al.* (2013), Toke *et al.* (2012), Hemmingsen (2013), Staff (2017), Wittemann (2010)
3	Lack of top management alignment and commitment	Top management commitment is one of the crucial factors in implementing agility in PPM. Lack of alignment and commitment results into the lack of financial support, lack of approvals for mobilizing the organizations' resources and lack of information communication technologies (ICT) infrastructure which finally affects agility severely	Plan, Conduct, Control and Close	Dashore and Sohani (2013), Jadhav *et al.* (2014a, b), Zhu and Sarkis (2007), Hemmingsen (2013), Limberakis (2016)
4	Inefficiencies of financial factors	Lack of financial support, inappropriate financial planning and inappropriate financial decision making will severely affect the organizations' timely performance which ultimately affects the agility in PPM	Plan, Conduct, Control and Close	Mollenkopf *et al.* (2010), Jadhav *et al.* (2014b), Paulraj (2009), Rao and Holt (2005), Rao (2002)

(*continued*)

Table I.
List of barriers to improving agility in project procurement management

Sr. No.	Barriers	Description	Relevant PPM processes affected by barriers	Source
5	Lack of supplier effectiveness	Lack of supplier effectiveness in terms of quick response to the requirements will result into shortages of stocks, inability to adopt the variation in demand and change in product specification which finally affect agility in PPM of the organization	Plan and Conduct	Thakker, and Rane (2018), Jadhav *et al.* (2014a, b), Hsu and Hu (2008), Kannan *et al.* (2008), Mangla *et al.* (2014a, b), Rane and Mantha (2008)
6	Lack of competitiveness	Organizations that fail to adopt the latest technologies, new methodologies and efficient work practices will put them out of the competitive world which will severely affect agility in PPM	Plan	Mollenkopf *et al.* (2010), Zhu and Sarkis (2007)
7	Lack transportation effectiveness	High transportation time and cost, due to problems like technology incompetency, changing laws, traffic jam, under-maintained roads, etc., that leads to transporter ineffectiveness making it a hurdle to agility in PPM for organizations	Plan and Conduct	Newton (2016), Russell (2017), Editor (2016)
8	Lack of digital strategy	Lack of adoption of the latest technologies and new methodologies results in tedious and cumbersome work habits which affect agility in PPM of the organization	Plan, Conduct, Control and Close	Deign (2016)
9	Need to justify activities and its associated cost to the board of directors	As a normal practice all the financial and business decisions are taken in the boardroom, this adds time and reduces the agility of PPM	Plan	Hemmingsen (2013)
10	Excessive overhead costs	Unorganized way of working, lack of adoption of appropriate tools and excessive variation in demand and product specification leads to huge overhead costs which impact agility in PPM	Conduct and Control	Hemmingsen (2013)
11	Lack of legislation in responsible project procurement	Procurement managers should be aware of the relevant legislation in place when conducting procurement projects at a global or local level. Lack of such information will create an unnecessary problem which will finally affect agility in PPM	Plan and Conduct	Hemmingsen (2013), Jadhav *et al.* (2014b)
12	Difficulties with imposing changes	Lack of effective strategy and unclear roll-out roadmap makes it difficult to impose changes, which acts as a barrier to agility in PPM	Conduct, Control and Close	Hemmingsen (2013)
13	Significant input of time	A full-fledged operating organization finds it difficult to invest much time and financial resources for exploring	Plan and Conduct	Jadhav *et al.* (2014b)

Table I. (*continued*)

Sr. No.	Barriers	Description	Relevant PPM processes affected by barriers	Source
	and financial resources	new areas and investments, this will act as a barrier to agility in PPM		
14	Unclear customer requirements	Unclear customers' requirements may mislead in delivering required outputs which will act as a barrier to agility in PPM	Plan	Vachon and Klassen (2006). Rane *et al.* (2017)
15	Issues in change management	New management/new policy/new workflow/etc. comes with new visions, focus and roadmaps leading to disruption in existing planning which will significantly impact agility in PPM	Plan and Conduct and Close	Rane *et al.* (2016), Donati (2015)
16	Lack of a user-friendly environment	Lack of user-friendly environment skills innovative thinking, learning and reduces work efficiency which will be a significant barrier to agility in PPM	Conduct, Control and Close	Rane *et al.* (2016), Jadhav (2014a), Donati, 2015
17	Challenges in finding and qualifying supplier	Buyers face difficulty in finding suppliers and getting reliable suppliers. Inefficiencies in finding suppliers, supplier relationship management and performance evaluation will severely affect agility in PPM	Plan	Thakker, and Rane (2018), Jadhav *et al.* (2014a, b), (2015a, b), Ohlmann (2016)
18	Incapability in dealing with accidental order	Wrong item or wrong quantity ordered consumes huge cost and a lot of time is consumed in rectifying the same	Control	Jadhav *et al.* (2015), Whitmore (2017)
19	Incapability in dealing with exceeding budget	Procurement transactions that exceed budget are more likely due to communication gap/coordination gap which will demand for more discussions, more deliberation and time investment for decision making, which severely impacts agility in PPM	Control	Jadhav *et al.* (2015b), Whitmore (2017)
20	Incapability in dealing with damaged goods	Impulse buying, making emotional decisions based on the preference of suppliers and phoning in order, etc., are often the most common causes that lead to procurement errors. These errors will result in unnecessary activities, rework, rejections, etc., impacting agility in PPM	Control	Whitmore (2017)

Table I.

7.1 Delphi for prioritization of critical barriers

To collect the data, the second round of Delphi was conducted where the inputs in terms of impacts were recorded from the experts. As a part of this survey, experts from different domains, role-plays, industries, years of experience and professional designations were identified who had relevant experience in managing procurement projects, agility, business intelligence and other areas which are directly or indirectly related to the context of this paper. Experts that belong to various industrial verticals are shown in Table II, the various knowledge areas of experts are shown in Table III, and finally, Table IV gives a classification of experts based on the number of years they have served the industry as well as their professional designation. The total number of experts that attempted the survey were 37; however, the total count in Tables II and III varies due to cross-functionalities of experts serving multiple domains and roles.

Industry	Count	Percentage
Manufacturing	17	26
Oil and Gas	12	18
Information Technology	9	14
Engineering and Construction	6	9
Utility and Facility	6	9
Retail	5	8
Petrochemical	4	6
Transportation	3	5
Healthcare	2	3
Education	1	2
FMCG/CPG	1	2
Total	66	

Table II. Classification of experts based on industry

Role	Count	Percentage
Academician	2	4
Agile practitioner	5	11
Business intelligence consultant	5	11
Project manager	12	26
Buyer	1	2
CEO/CPO/CFO	3	7
Procurement consultant	8	17
Other	10	22
Total	46	

Table III. Knowledge domain of experts

	Experience		
Years of experience	Count	Percentage	Professional designations
Less than 10	12	32	Consultants, technical engineers and managers
10–20	13	35	Specialist engineers, Sr Consultants, Delivery managers
20–30	8	22	Heads, Directors and CEO/CFO/CIO/COO/CPO
30–40	4	11	
Total	37		

Table IV. Years of experience and professional designation of experts

The experts were allowed to rate the barriers between 1 and 10, where 1 signifies that the respective barrier has no impact on agility improvement and 10 signifies that it will have a very strong impact.

After the experts' data collection, Cronbach's α was computed to test the reliability. The Cronbach's α value for the collected data was 0.8365 which falls in the range of $0.8 \leqslant \alpha < 0.9$ which is considered to have a good internal consistency, and hence the collected data were acceptable. To summarize and have a single rating for each barrier, the median of the data was considered, as shown in Table V.

In order to shortlist the critical barriers, the barriers with median > 7 were considered. Table VI provides a summary of the same.

8. Interpretative structural modeling

This section aims to understand the relationships and interactions among the identified barriers. ISM methodology proposes the use of the expert opinions based on various

Sr. No.	Barriers	Impact on agility improvement
1	Lack of new technology competencies	8.5
2	Lack of training and lack of information	8.0
3	Lack of top management alignment and commitment	8.5
4	Inefficiencies of financial factors	8.0
5	Lack of supplier effectiveness	8.0
6	Lack of competitiveness	7.0
7	Lack transportation effectiveness	8.0
8	Lack of digital strategy	8.0
9	Need to justify each activity and its associated cost to the board of directors	6.5
10	Excessive overhead costs	6.0
11	Lack of legislation in responsible procurement	5.0
12	Difficulties with imposing changes	8.0
13	Significant input of time and financial resources	6.0
14	Unclear customer requirement	7.0
15	Issues in change management	8.0
16	Lack of a user-friendly environment	7.5
17	Finding and qualifying supplier	6.0
18	Incapability in dealing with accidental order	5.0
19	Incapability in dealing with exceeding budget	6.0
20	Incapability in dealing with damaged goods	6.0

Table V.
Impact of barriers to agility improvement

Barrier No.	Barriers	Impact on agility improvement
1	Lack of new technology competencies	8.5
2	Lack of training and lack of information	8.0
3	Lack of top management alignment and commitment	8.5
4	Lack of digital strategy	8.0
5	Inefficiencies of financial factors	8.0
6	Lack of supplier effectiveness	8.0
7	Lack transportation effectiveness	8.0
8	Difficulties with imposing changes	8.0
9	Issues in change management	8.0
10	Lack of a user-friendly environment	7.5

Table VI.
Top critical prioritized barrier

management techniques such as brainstorming and nominal group discussion technique in developing the contextual relationship among the barriers (Jadhav *et al.*, 2013, 2014, 2015; Rane and Kirkire, 2017). ISM enables establishing of relationships among specific items/elements to define a problem by means of their dependency and driving power (Gandhi *et al.*, 2015; Lin, 2013; Luthra *et al.*, 2013; Madaan and Mangla, 2015; Mani *et al.*, 2014).

Four standard symbols were suggested by Jadhav *et al.* (2014, 2015); Rane and Kirkire (2016), Pramod and Banwet (2010), Rajesh *et al.* (2007) to denote the direction of relationships between the variables:

- V – Variable *i* will influence variable *j*.
- A – Variable *i* will be influenced by variable *j*.
- X – Variables *i* and *j* will influence each other.
- O – Variables i and j are unrelated.

8.1 Structural self-interaction matrix development

ISM methodology receives experts' inputs in the form of SSIM matrix. SSIM indicates pairwise relationships among variables of the system under consideration (Dandage *et al.*, 2017; Tiwari, 2013). In order to construct the SSIM, brainstorming sessions were conducted with few of the experts considered in Section 7.1; Table VII represents the final SSIM for the top 10 prioritized barriers.

8.2 Initial reachability matrix development

The next step in the ISM methodology is to develop a reachability matrix by transforming SSIM into a binary matrix. The initial reachability matrix was obtained from SSIM by transforming information of each cell of SSIM into binary digits (i.e. 1 or 0) as per the following rule (Chidambaranathan *et al.*, 2009; Rane and Kirkire, 2016):

- If the entry in the SSIM is V, then substitute 1 in the reachability matrix
- If the entry in the SSIM is A, then substitute 0 in the reachability matrix
- If the entry in the SSIM is X, then substitute 1 in the reachability matrix
- If the entry in the SSIM is O, then substitute 0 in the reachability matrix.

Table VIII shows the initial reachability matrix obtained by applying the above rule in Table VII.

8.3 Final reachability matrix development

To obtain the final reachability matrix from the initial reachability matrix, the concept of transitivity was used. If a variable "*I*" is related to "*j*" and "*j*" is related to "*k*", then

Table VII. Structural self-Interaction matrix for top 10 prioritized barriers

Barrier No.	1	2	3	4	5	6	7	8	9	10
1	X	V	A	A	A	O	V	V	V	O
2	A	X	A	O	A	O	O	O	A	O
3	V	V	X	V	V	V	V	V	V	V
4	V	O	A	X	A	O	O	O	A	O
5	V	V	A	V	X	V	V	V	O	O
6	O	O	A	O	A	X	X	O	A	O
7	A	O	A	O	A	X	X	O	A	O
8	A	O	A	O	A	O	O	X	X	O
9	A	V	A	V	O	V	V	X	X	V
10	O	O	A	O	O	O	O	O	A	X

Table VIII. Initial reachability matrix

Barrier No.	1	2	3	4	5	6	7	8	9	10
1	1	1	0	0	0	0	1	1	1	0
2	0	1	0	0	0	0	0	0	0	0
3	1	1	1	1	1	1	1	1	1	1
4	1	0	0	1	0	0	0	0	0	0
5	1	1	0	1	1	1	1	1	0	0
6	0	0	0	0	0	1	1	0	0	0
7	0	0	0	0	0	1	1	0	0	0
8	0	0	0	0	0	0	0	1	1	0
9	0	1	0	1	0	1	1	1	1	1
10	0	0	0	0	0	0	0	0	0	1

transitivity implies that variable "*i*" is necessarily related to "*k*". The final reachability matrix developed after incorporating the transitivity in Table VIII is represented in Table IX wherein entries marked as "* " show transitivity.

The driving power shown in the last column of Table IX is computed by summing the respective row, and the dependence shown in the last row of Table IX is computed by summing the respective column. As seen from Table IX, barrier no. 3, i.e., "Lack of top management alignment and commitment" has the maximum driving power and least dependence which implies that barrier no. 3 is a driver to all other barriers; however, the other way does not stand true.

8.4 Level partitioning the final reachability matrix

The next step in ISM methodology is to level partition the final reachability matrix. Level partitioning is carried out to know the level-wise placement of elements (Warfield, 1974). As a part of level partitioning, reachability set and antecedent set for all the barriers were identified from the final reachability matrix shown in Table IX. The reachability set for a particular barrier consists of the barrier itself and the other barriers which it influences, whereas the antecedent set consists of the barrier itself and other barriers which may influence it (Dandage *et al.*, 2017). Post this intersection set of reachability set and the antecedent set was derived.

For determining the levels, barriers for which reachability sets and intersection sets are identical top level were assigned to it in the ISM hierarchy. Top-level barriers are those that will not lead the other barriers above their level in the hierarchy (Dandage *et al.*, 2017). Once the top-level barriers were identified, they should be removed from the set and the exercise is to be repeated iteratively till all the levels are determined. It is possible that in a particular iteration, more than one barrier (individually) may have identical reachability set and the intersection set; the same level will be assigned to these barriers (Jadhav *et al.*, 2015). Relationship of reachability set with antecedent set to get intersection set and levels are as shown in Tables X–XV.

As mentioned, barriers 2, 6, 7 and 10 have identical reachability set and intersection set which puts all of them at the same level. These barriers will have to be discarded for the next iteration in Table XI.

As per the second iteration, barriers 8 and 9 have identical reachability set and intersection set positioning them at the same level and, hence, eliminating barriers 8 and 9 for the next iteration in Table XII. The similar process was carried out until all the barriers get a level.

Table XVI shows the summary of all the iterations for level partitioning (entries marked as "*" show transitivity).

Barrier No.	1	2	3	4	5	6	7	8	9	10	Driving power
1	1	1	0	0	0	0	1	1	1	*1**	6
2	0	1	0	0	0	0	0	0	0	0	1
3	1	1	1	1	1	1	1	1	1	1	10
4	1	*1**	0	1	0	0	*1**	*1**	*1**	*1**	7
5	1	1	0	1	1	1	1	1	*1**	*1**	9
6	0	0	0	0	0	1	1	0	0	0	2
7	0	0	0	0	0	1	1	0	0	0	2
8	0	*1**	0	0	0	0	*1**	1	1	*1**	5
9	*1**	1	0	1	0	1	1	1	1	1	8
10	0	0	0	0	0	0	0	0	0	1	1
Dependence	5	7	1	4	2	5	8	6	6	7	

Table IX. Final reachability matrix

Table X.
Level partitioning – iteration 1

Barrier No.	Barriers	Reachability set	Antecedent set	Intersection set	Level
1	Lack of new technology competencies	1, 2, 7, 8, 9, 10	1, 3, 4, 5, 9	1, 9	
2	Lack of training and lack of information	2	1, 2, 3, 4, 5, 8, 9	2	I
3	Lack of top management alignment and commitment	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	3	3	
4	Lack of digital strategy	1, 2, 4, 7, 8, 9, 10	3, 4, 5, 9	4, 9	
5	Inefficiencies of financial factors	1, 2, 4, 5, 6, 7, 8, 9, 10	3, 5	5	
6	Lack of supplier effectiveness	6, 7	3, 5, 6, 7, 9	6, 7	I
7	Lack transportation effectiveness	6, 7	1, 3, 4, 5, 6, 7, 8, 9	6, 7	I
8	Difficulties with imposing changes	2, 7, 8, 9, 10	1, 3, 4, 5, 8, 9	8, 9	
9	Issues in change management	1, 2, 4, 6, 7, 8, 9, 10	1, 3, 4, 5, 8, 9	1, 4, 8, 9	
10	Lack of a user-friendly environment	10	1, 3, 4, 5, 8, 9, 10	10	I

Table XI.
Level partitioning – iteration 2

Barrier No.	Barriers	Reachability set	Antecedent set	Intersection set	Level
1	Lack of new technology competencies	1, 8, 9	1, 3, 4, 5, 8, 9	1, 9	
3	Lack of top management alignment and commitment	1, 3, 4, 5, 8, 9	3	3	
4	Lack of digital strategy	1, 4, 8, 9	3, 4, 5, 9	4, 9	
5	Inefficiencies of financial factors	1, 4, 5, 8, 9	3, 5	5	
8	Difficulties with imposing changes	8, 9	1, 3, 4, 5, 8, 9	8, 9	II
9	Issues in change management	1, 4, 8, 9	1, 3, 4, 5, 8, 9	1, 4, 8, 9	II

Table XII.
Level partitioning – iteration 3

Barrier No.	Barriers	Reachability set	Antecedent set	Intersection set	Level
1	Lack of new technology competencies	1	1, 3, 4, 5	1	III
3	Lack of top management alignment and commitment	1, 3, 4, 5	3	3	
4	Lack of digital strategy	1, 4	3, 4, 5	4	
5	Inefficiencies of financial factors	1, 4, 5	3, 5	5	

Table XIII.
Level partitioning – iteration 4

Barrier No.	Barriers	Reachability set	Antecedent set	Intersection set	Level
3	Lack of top management alignment and commitment	3, 4, 5	3	3	
4	Lack of digital strategy	4	3, 4, 5	4	IV
5	Inefficiencies of financial factors	4, 5	3, 5	5	

8.5 Development of digraph and the ISM-based model

The ISM-based model is a graphical representation of elements arranged as per their levels, and linkages between elements are based on the relationships in the reachability matrix. Figure 2 shows digraph, where the nodes are connected with one another as per the levels and relationships. Replacing the node number in Figure 2 with the respective statements gives the ISM-based model as shown in Figure 3. From Figures 2 and 3 it can be seen that the top-level (level I) barriers, i.e., 2 – lack of training and lack of information, 6 – lack of supplier effectiveness, 7 – lack transportation effectiveness and 10 – lack of a user-friendly environment are placed at the right end. Moving from right to left the next level barriers are placed, until the last-level (level VI) barrier, i.e., 3 – lack of top management alignment and commitment, and was placed at the extreme left.

From left to right, the power to influence other barriers decreases, whereas from right to left, the tendency to get influenced by other barriers increases (Dandage *et al.*, 2017). Thus, barrier 3 is the most influencing, whereas barriers 2, 10, 6 and 7 have the highest influence from other barriers.

9. MICMAC analysis

After obtaining the ISM model for the agility implementation barriers in PPM, MICMAC analysis was applied to prioritize the barriers based on their driving power and dependence. MICMAC analysis is to sort out the variables according to their driving power and dependence (Faisal *et al.*, 2006; Mandal and Deshmukh, 1994). The MICMAC principle is based on the multiplication properties of matrices (Mudgal *et al.*, 2010; Jadhav *et al.*, 2015).

Table XIV. Level partitioning – iteration 5

Barrier No.	Barriers	Reachability set	Antecedent set	Intersection set	Level
3	Lack of top management alignment and commitment	3, 5	3	3	
5	Inefficiencies of financial factors	5	3, 5	5	V

Table XV. Level partitioning – iteration 6

Barrier No.	Barrier	Reachability set	Antecedent set	Intersection set	Level
3	Lack of top management alignment and commitment	3	3	3	VI

Table XVI. Summary of iterations

Iteration No.	Barriers	Level
1	2. Lack of training and lack of information	I
1	6. Lack of supplier effectiveness	I
1	7. Lack of transportation effectiveness	I
1	10. Lack of a user-friendly environment	I
2	8. Difficulties with imposing changes	II
2	9. Issues in change management	II
3	1. Lack of new technology competencies	III
4	4. Lack of digital strategy	IV
5	5. Inefficiencies of financial factors	V
6	3. Lack of top management alignment and commitment	VI

Higher driving power indicates that the barrier highly influences other barriers whereas higher dependence indicates that the barrier is highly influenced by other barriers. In the MICMAC analysis, four clusters, namely, autonomous, dependent, linkage, and independent are represented at the four corners of the square (Dandage, *et al*., 2017).

The significance of each cluster: Cluster I (autonomous barriers), these barriers are relatively disconnected from the system with very few weak links. Cluster II (dependent barriers) consists of dependent variables that have low driving power and high dependence. These barriers are automatic followers of other barriers. Cluster III (linkage barriers) contains linkage variables that have high driving power and high dependence (Pishdar and Toloun, 2014). These barriers are unstable because any action on these will have an effect on others and also feedback on themselves. Cluster IV (independent barriers), these barriers are the key drivers; immediate attention has to be given to these barriers for quick and sustainable results.

The dependence and driving power diagram as shown in Figure 4 was constructed based on the driving power and the dependence power for each of the barriers as computed in Table IX. To illustrate: as per Table IX, barrier 1 has driving power of 6 and dependence as 5, positioning it inside cluster IV as shown in Figure 4. Similarly, all the barriers were positioned in their respective clusters.

10. Results

The purpose of this paper was to identify the most prominent barriers in improving agility, prioritize the barriers and to understand their interactions among the prioritized top 10 selected barriers. ISM assisted with MICMAC analysis provides a model as well as dependence-driving power diagram of barriers giving better visibility on areas to focus, prioritize and strategize for improving agility in PPM. Out of 20 identified barriers 10 barriers to agility improvement in PPM have been prioritized and modeled using ISM in this research; as a result of this, we get a hierarchical structure of barriers that provide a roadmap to tackle them as per their significance. Table XVII provides a summary of the barriers in each cluster with its significance.

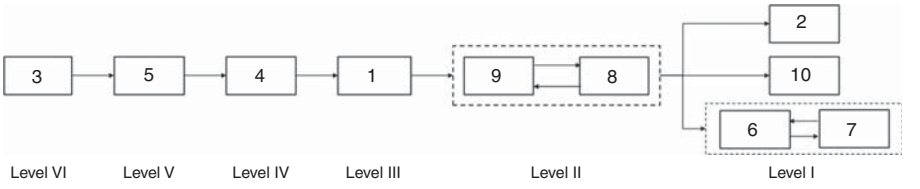

Figure 2.
Digraph for barriers to improve agility in PPM

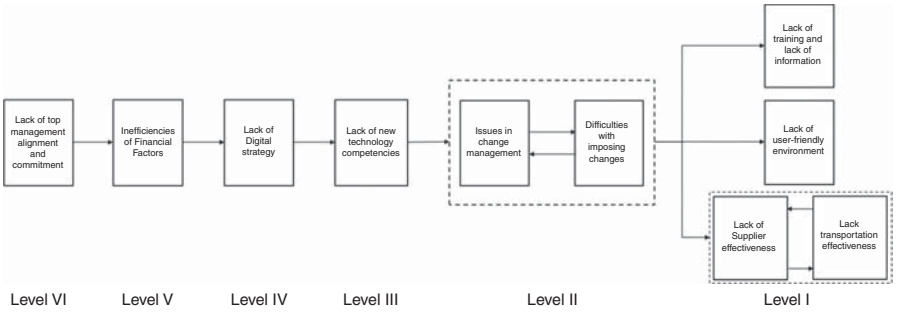

Figure 3.
ISM model for barriers to improving agility in PPM

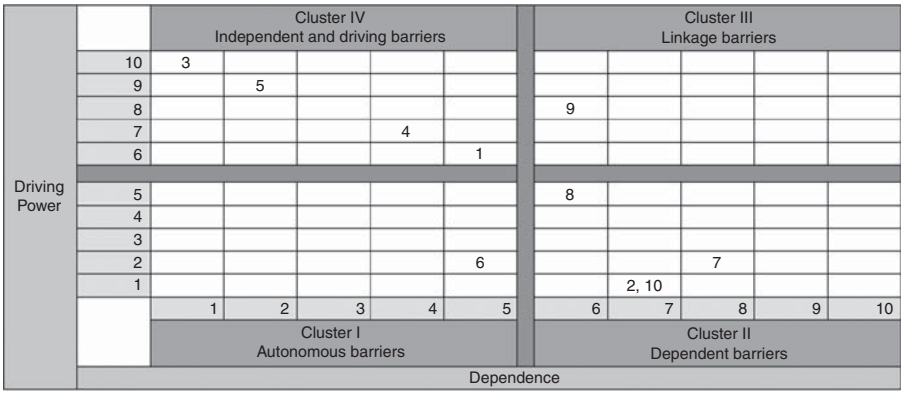

Figure 4.
Dependence and driving power diagram

Cluster no	Title	Driving power	Dependence	Barriers
I	Autonomous barriers	Weak	Weak	Lack of supplier effectiveness
II	Dependent barriers	Weak	Strong	Lack of training and lack of information Lack of transportation effectiveness Difficulties with imposing changes Lack of a user-friendly environment
III	Linkage barriers	Strong	Strong	Issues in change management
IV	Independent and driving barriers	Strong	Weak	Lack of new technology competencies Lack of top management alignment and commitment Lack of digital strategy Inefficiencies of financial factors

Table XVII.
Summary of barriers as per cluster with characteristics

As per Table XVII, cluster IV barriers (independent and driving barriers) have less dependency on other barriers but have very high power to drive barriers in other clusters. This cluster consists of barriers like lack of top management alignment and commitment, inefficiencies of financial factors, lack of digital strategy and lack of new technology competencies. These barriers are the key drivers for improving agility in project procurement and, hence, maximum attention has to be paid on these barriers for attaining quick and sustainable results.

Cluster III barriers (linkage barriers) have high driving power on subsequent clusters along with high dependency on cluster IV barriers. This results in making them the most unstable ones as any action on these barriers have a large effect on other barriers and feedback on themselves too. From Table XVII it is seen that barrier Issues in change management forms a part of this cluster.

Cluster II barriers (dependent barriers) are highly dependent on clusters III and IV with a very low capability to drive other barriers. As per Table XVII, barriers difficulties with imposing changes, lack of training and lack of information, lack of a user-friendly environment and lack of transportation effectiveness are associated with this cluster.

Cluster I barriers (autonomous barriers) have weak driving power and low dependency on other barriers. Barrier lack of supplier effectiveness forms a part of this cluster.

11. Discussions: strategy development based on ISM and MICMAC analysis of barriers for improving agility in PPM by leveraging business intelligence

To overcome the barriers, organizations need to formulate and implement an effective strategy. As an outcome of this entire exercise, the following strategies have been developed which will enable significant improvement of agility in PPM:

(1) Strategy to overcome barrier – Lack of top management alignment and commitment

As per Figure 3 this barrier appears at level VI, i.e., the final level, and according to Figure 4 this barrier belongs to cluster IV with the highest driving power. In order to improve agility in PPM, top management has to be convinced about this initiative. Once convinced, automatic attention and support will be gained by the initiative. Top management must depute a dedicated team for this, ensuring they get every necessary support easily and developing a monitory body that will report significant achievements and impediments to the top management.

Top management should conduct weekly/fortnightly rigorous review meetings to address the problems faced, listen to suggestions from employees, understand on-ground challenges, develop strategies, provide them with confidence and arrange for all the appropriate resources as and when required. Top management should act as a friend philosopher and guide to the team members for implementing and improving agility. Top management should provision a systematic data collection of all the activities and leverage business intelligence on top of it which will provide top management summarized visualization dashboards of all the activities. This will enable top management to keep a track of all the initiatives, identify the events that need attention, identify people/processes which are lagging, milestone tracker, etc., at a glance. Business Intelligence will help top management to govern the entire project review mechanism more effectively by giving a glance at various key performance indicators. Top management should always ensure strategic alignment of project objectives, departmental objectives and organizational objectives for implementing and improving agility to obtain necessary business results.

(2) Strategy to overcome barrier – Inefficiencies of financial factors

As per Figure 3 this barrier is positioned at level V which is driven by barrier 3 – lack of top management alignment and commitment, and as per Figure 4 this barrier belongs to cluster IV. Top management should ensure adequate financial support for installing the latest information systems, training for employees to upgrade knowledge and skills, availing resources, etc., that are necessary to improve agility in PPM. Employees at every level should be encouraged by the top management to generate revenue/savings per year. A percentage of this can also be incentivized to motivate the employees. Management should motivate and involve the employees in revenue generation by using value engineering, design thinking, Kaizen, brainstorming, etc., for the creation of wealth and attain paradigm shift.

Using business intelligence tools tools like data mining, predictive analytics, analytical processing, business activity monitoring, financial modeling and financial decision making which provides visibility in terms of return on investment, return on asset, yield, spend analysis on capital expenditure (CAPEX)/ operational expenditure (OPEX), year-over-year growth rate, etc.; this will help management to have clear visibility on the flow of funds and take appropriate decisions on how, where from and how much budget can be allotted for this initiative. Business intelligence will help mitigate the issues faced in the financial factor that will enable effective implementation and improvement of agility in PPM for total project profitability.

(3) Strategy to overcome barrier – Lack of digital strategy

As per Figures 3 and 4, the success of this barrier is after the alignment of top management and having sufficient funds. Being part of cluster IV, this barrier is very crucial, and its success will drive other barriers. In order to overcome this, the chief information officers (CIOs) and chief digital officers should have a strategy and vision for organization wide digitization drive. This will bring a paradigm shift in the way of working and the culture. Organizations after adopting a digital journey can have better project visibility, supply chain visibility, organization's operation visibility and visibility across departments and phases of the project along with better control on people and business processes. Digital strategy can help to achieve visibility to control the flow of funds, information and goods by effectively and efficiently using information communication technologies. Strategies should be developed for effective utilization of ERP, big data, industrial internet of things (IIOT), mobility, chatbot, robotic process automation (RPA), cloud computing, etc., for the enablement of machine to machine, machine to system, machine to people and system to system communication. Leveraging of all these digital technologies will provide necessary business intelligence for achieving quick information access and quick decision making which will, in turn, improve the agility of PPM.

(4) Strategy to overcome barrier – Lack of new technology competencies

Forming the part of cluster IV as per Figure 4 and occurring at level III as per Figure 3, this barrier becomes a very crucial one with a high dependency on barrier 4 but a strong driver to barriers in other clusters. With a proper digital strategy in place, companies can then assess, justify and prioritize technical capabilities to meet the business requirement. Applications like ERP, warehouse management, smart inventory management, procurement management, etc., are expected to be built and effectively utilized by the organization. New-age digital technologies like IIOT can enable to capture real-time data and requirements; mobility can provide ease of accessibility and visualization from anywhere; blockchain can provide a trustless, tamperproof, traceable and decentralized network which can be established between the buyer and all the sellers for all kinds of transactions including exchanging information, payments, status updates, maintaining documents and records, etc., in real time; RPA intends to offload repetitive, non-intellect, high-volume mundane tasks done by humans; big data analytics can utilize the real-time generated data for predictions; all of these technologies are capable of generating huge insights that can provide sufficient business intelligence to the procurement managers to perform and act with better agility. Intelligence could be with regard to taking a right make-or-buy-or-rent decision at the right time, know the available resources data, financial data, inventory data, savings in terms of time, money and efforts, better bidding and project awarding systems for faster short-listing of potential suppliers, etc. Building technology competency will also enable seamless integration and collaboration between the project team, procurement management team, finance team and other associated stakeholders by using a single platform where all the activities are traceable in real time so that there is a smooth positive flow of all the activities. This will drastically reduce purchase requisitions rejections/modifications and will reduce the entire turnaround time which ultimately improves agility in this process.

(5) Strategy to overcome barrier – Issues in change management

This barrier forms the part of cluster III (Linkage barrier) of Figure 4 and is placed at level III of Figure 3. Being a linkage barrier, it is very unstable with a high dependency on levels VI, V and IV barriers; at the same time has a high driving power making this factor an enabler for others.

Change management is omnipresent in organizations as companies have to transform constantly. Implementing and improving agility in PPM will have to go through drastic change management in terms for process training, technology training, adoption of a new culture, dealing with people psychology and orienting their mentality for adopting the change.

In order to execute change management effectively workshops, surveys and trainings should be conducted where the organization should communicate the benefits of change management, benefits employees can reap and expectation of well-defined involvement/contribution to the employees. Data collected from such exercises will provide the organization with necessary business intelligence on which group of people to focus, which department will need more mentoring, who will be the easy adopters, who will be the resisting group, who should be selected for successful roll out of this initiative, which process needs improvement, etc.

With increased interdepartmental cooperation and strong collaboration with the cross-functional team, easy execution of change management can be achieved. Change management strategies should be effectively used for successful roll-out; these include strategic planning and business process re-engineering that can be used by the top management to bring paradigm shift in the organization; balance scorecard can be used for long-term strategy implementation; Baldrige's criterion based on total quality management can be used for the overall development of organization; Kaizen for implementing small changes continuously, etc., which will provide necessary business intelligance to help improve agility in PPM.

(6) Strategy to overcome barrier – Lack of training and lack of information

This barrier is at level I as shown in Figure 3 and cluster II of Figure 4 having low driving power but high dependence. With the new technology implementation and change management for improving agility, appropriate training and information sharing is necessary for developing the skills and upgrading knowledge. A cross-functional team can be developed by selecting team members from different departments like project management, marketing, design, manufacturing, distribution, etc., for better information sharing. Data from human resources management system and other systems should be leveraged for deriving business intelligence on "training which group with what" so that there is maximum percolation of knowledge and it becomes more of a train the trainer mechanism. This will enable management to ensure proper training is delivered throughout the organization, by virtue of which agility will improve.

(7) Strategy to overcome barrier – Lack of a user-friendly environment

This barrier is at the level I as shown in Figure 3 and cluster II of Figure 4 having low driving power but high dependence. Lack of a user-friendly environment limits innovation and creativity. Project managers and top management should ensure proper interdepartmental cooperation, collaboration, information sharing and technology competency developing. Surveys and design thinking workshops should be conducted to know how the workplace can be more user friendly. Data generated from such activities will derive intelligence to create a user-friendly environment which will ultimately improve agility in PPM.

(8) Strategy to overcome barrier – Lack of transportation effectiveness and lack of supplier effectiveness

Both of these barriers form the same level I as per Figure 3 with high interaction within each other. Though Figure 4 shows that both of these barriers are in different clusters, they are having the same driving power but different dependencies. It is seen that barrier 6 has less dependency, whereas barrier 7 has a very high dependence.

Choosing the right supplier and transporter from the huge available network has always been a pain for procurement managers. To have the best quality, best price, in-time untampered safe delivery, etc., it is very difficult to achieve using conventional methods of management. For analyzing right data at the right time to get the right results to take right decisions, from a huge chunk of data, there has to be a proper mechanism to derive business intelligence. Third party logistics (3PL), fourth party logistics (4PL) and other techniques should be effectively deployed and utilized to increase the transporter effectiveness. IOT and mobility can provide better visibility on real-time consignment tracking, monitoring driver safety parameters, utilizing the shortest path algorithm for package delivery, etc., which provides intelligence to the buyer, seller and transporter for making smarter decisions. There has to be a continued supplier/transporter development and training program; all of these will help in improving agility in PPM.

12. Implications of research

12.1 Implications of research for practitioners

Improving agility in PPM will change the way practitioners work. New skills would be required, and practitioners will have to upgrade them self for being technologically competent to deal with the transformation. This research will also offload practitioners from doing conventional cumbersome non-intellect tasks, due to which practitioners can focus on tasks which require human intelligence, invest more time in research and development and can be utilized for expanding the business.

12.2 Implications for the research community

This research will open new areas of research which will need an intensive collaboration of researchers from multiple research disciplines. This research will also require better industry-academic relationship where industries will try to include new-age technology requirements in the academics, and research institutes will produce students which are well aligned with the needs of the industrial transformation. The savings generated as an outcome of this research can be diverted to extend more industrial projects, internships, sponsorships and better job opportunities to the research community.

13. Conclusions

Due to excessive competition in the market and reduction in time to market of new products, a lot of pressure is laid on existing PPM. Due to shorter project/product development time, there is a need for faster planning which may ignore some vital dimensions during planning. The missed-out dimensions may lead to variations in requirements, and a change in the procurement request would be required at any point in time during the project execution. The conventional techniques of PPM are not agile and flexible enough to handle such drastic variation. Improvement in agility will enable project procurement managers to take care of such variation by using latest tools and techniques that can provide real business intelligence which will help in providing clear visibility on right areas to focus and to take right decisions.

To improve agility in PPM for an organization, this paper identifies various barriers that would come across during the execution. This exercise receives valuable inputs on such barriers from the experts working in this domain that vary in experience, role-play, type of industry, etc. The results obtained with such experts' inputs becomes more robust, practical and authentic. As a result of this research, it can be concluded that the success of agile PPM will be not only entirely based on the support of top management alone but also needs adequate finance, application and utilization of proper tools and techniques. Top management plays a key role in how the strategy is understood, implemented and deployed effectively throughout the organization.

There are four broad conceptual contributions that this research makes. First contribution, it identifies various barriers that may hamper a successful agile PPM model implementation. Second contribution, it prioritizes the top 10 barriers to improving agility in PPM. Third contribution, it offers an ISM model and MICMAC analysis for identifying interactions among barriers, and fourth contribution, it develops strategies for mitigating the barriers and successfully improve agility in PPM with the perspective of business intelligence.

14. Limitations and future research directions

The interactions among barriers were analyzed using ISM which provides relationships within barriers based on the judgment and experience of the experts involved. The interpretation of the interactive relationships represented by directed links for the identified barriers relatively lacks in the ISM approach as ISM interprets only the nodes ignoring the transitive links. To have enhanced results total ISM can be used that interprets both, nodes and links in the digraph. It can also have some important transitive links which can provide a better explanatory framework.

This research uses MICMAC analysis, which considers only binary type of relationships, to increase the sensitivity of conventional MICMAC and to have an additional input of possibility of interaction between the elements, Fuzzy MICMAC can be used.

Though the ISM model in this research has been developed and validated with domain experts, its statistical validation is also required. Structural equation modeling (SEM) can be used on the developed model for statistical validation which will be a useful future research.

The interaction among barriers can also be analyzed using other modeling techniques like analytic network process. The model that will be developed using these techniques can be compared with the one which was developed in this paper. After considering and comparing both of these models, a hybrid model can be developed that can be further validated using SEM.

The strategies developed as a result of this research can be utilized by the researchers and practitioners for developing agile models for their business in other project management knowledge areas and can explore on how business intelligence can provide meaningful insights for taking smarter and proactive decisions. Finally, this research provides guidelines and a roadmap for practitioners and researchers working in this domain.

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