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Global Perspectives on Operational Excellence: Unveiling Critical Failure Factors and Sustainable Pathways

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Abstract:	

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Abstract

Purpose: The purpose of this global study is to investigate the critical failure factors (CFFs) in the deployment of Operational Excellence (OPEX) programs as well as the key performance indicators (KPIs) that can be used to measure OPEX failures. The study also empirically analyses various OPEX methodologies adopted by various organizations at a global level.

Methodology: This global study utilized an online survey to collect data. The questionnaire was sent to 800 senior managers resulting ultimately in 249 useful responses.

Findings: The study results suggest that Six Sigma is the most widely utilized across the OPEX methodologies, followed by Lean Six Sigma and Lean. Agile manufacturing is the least utilized OPEX methodology. The top four critical failure factors (CFFs) were *poor project selection and prioritization, poor leadership, lack of proper communication and resistance to change issues.*

Implications: This study extends the current body of knowledge on OPEX by first delineating the CFFs for OPEX and identifying the differing effects of these CFFs across various organizational settings. Senior managers and OPEX professionals can use the findings to take remedial actions and to improve the sustainability of OPEX initiatives in their respective organizations.

Originality: This study uniquely identifies critical factors leading to OPEX initiative failures, providing practical insights for industry professionals and academia, fostering a deeper understanding of potential pitfalls. The research highlights a distinctive focus on social and environmental performance metrics, urging a paradigm shift for sustained OPEX success, differentiating itself in addressing broader sustainability concerns. By recognizing the interconnectedness of 12 critical failure factors, the study offers a pioneering foundation for future research and the development of a comprehensive management theory on OPEX failures.

Keywords: Critical Failure Factors; Operational Excellence; Lean, Six Sigma; Lean Six Sigma, Global Survey

1. Introduction

Many organizations employ Operational Excellence (OPEX) methodologies/methods to improve productivity, reduce costs due to poor quality, enhance product/service quality, improve customer experience (Antony *et al.*, 2022; Gólcher-Barguil *et al.*, 2019) and consequently aid organizational improvement (Naik *et al.*, 2023). The concept of identifying inefficiencies and implementing solutions to address them falls under the umbrella of Operational Excellence (OPEX) programs. OPEX methodologies, *e.g.*, Lean, Six Sigma, Lean Six Sigma (LSS) and Agile, have significant potential to eradicate the causes that throttle growth in organizations. With their ability to improve productivity, enhance product/service quality, improve customer experience (Chiarini and Kumar, 2021) and consequently aid organizational improvement (Naik *et al.*, 2023), they have been the preferred choice of industry. Out of all OPEX methodologies, Lean, Six Sigma, Lean Six Sigma (LSS) and Agile are three methodologies that are predominantly deployed in organizations (Antony and Sony, 2021; McDermott *et al.*, 2021), with Lean, Six Sigma and Lean Six Sigma being heavily utilized in over 95% of Pharmaceutical and MedTech industries (McDermott, Antony, Sony and Healy, 2022), (McDermott, Antony, Sony and Daly, 2022).

Despite their common characteristics, OPEX methods also present some fundamental differences (Antony and Gupta, 2018; Persis *et al.*, 2022). A prime example is Six Sigma, a systematic approach primarily used for measuring defect levels, reducing process variation and improving product and service quality (Kwak and Anbari, 2006). Six Sigma, as a set of statistical and non-statistical tools integrated within the Define, Measure, Analyse, Improve, and Control (DMAIC) structured problem-solving methodology, ensures the reduction of process variation, which results in superior products/services (Antony and Banuelas, 2002; Snee, 2004; Taj, 2008). On the other hand, Lean is defined as a method that adds value by systematically reducing waste, creating flow and seeking perfection via continuous improvement (Womack *et al.*, 1990).

The integration of Lean and Six Sigma into Lean Six Sigma (LSS) was later proposed as a strategy to reduce waste and increase the speed of processes while concurrently reducing their variability to achieve consistency in quality (George and George, 2003). Conversely, Agile is a concept coined in software engineering (Antony, Lizarelli, *et al.*, 2020a; Janssen and van der Voort, 2020), strongly associated with robustness, adaptability, and responsiveness that consequently results in an organization's ability to manage service demand fluctuations and variability. It is considered the method of choice in the event of sudden changes with its ability to handle direction changes (Olsson and Aronsson, 2015). Understanding the unique abilities and limitations of each OPEX methodology allows them to be implemented in unison to reduce non-value-added activities and defects caused by excessive process variation. Sustaining their utilization over their lifetimes helps improve quality, flexibility, efficiency, organizational performance and customer satisfaction (Antony and Banuelas, 2002; Kwak and Anbari, 2006; Snee, 2004). To better understand the impact of the portrayed collection of OPEX methodologies in actuality, the first research question *seeks to identify the most commonly implemented operational excellence (OPEX) methodologies (RQ1)*.

Despite their proven capabilities, there is an overwhelming number of studies that report on failing OPEX implementation attempts without achieving the desired performance levels (McLean *et al.*, 2017; Naik *et al.*, 2023). Previous studies also indicate a strong correlation between the benefits of the successful implementation and sustainment of OPEX methods and improvement in organizational performance (Adel, 2020). On the other hand, the failure of these methods greatly impacts various organizational measures, *i.e.,* Operational, Financial, Environmental, and Social performances (Antony *et al.*, 2019). Lean has not always been successfully deployed and maintained in organizations either, resulting in waste of financial resources and time, poor utilization of physical resources, and reduced organizational image (Antony, Lizarelli, *et al.*, 2020a; DeSanctis *et al.*, 2018).

Similarly, Six Sigma (McLean *et al.*, 2017) and Lean Six Sigma deployment (Switek *et al.*, 2021) failures are not uncommon. Adding to the pool, various Agile methods have also been reported as unsuccessful in a number of organizations (Adel, 2020; Denning, 2019). A common denominator in these failed attempts to implement OPEX initiatives is the lack of successful sustainment following their relatively effective implementation.Despite the extensive evidence of OPEX initiative failures, related literature offers a limited number of studies that identify and analyse the fundamental barriers to their sustainment (Friedli and Bellm, 2013; Tariq *et al.*, 2021). In particular, there is a conspicuous gap in the literature regarding the CFFs of OPEX initiatives and how these can be analysed collectively (Antony *et al.*, 2022; DeSanctis *et al.*, 2018; McLean *et al.*, 2017; Prashar and Sunder, 2021). Parenthetically, the majority of studies primarily focus on individual countries and hence, derive their results and conclusions on specific contextualization, culture and/or leadership style. This additional gap in the literature calls for research into the critical differences in CFFs of OPEX across various regions, sectors and organizational sizes.

Another integral component that the current body of knowledge fails to offer includes an in-depth analysis of the impact of various CFFs on OPEX failures. To address these issues, this study *aims to determine the most common critical failure factors (CFFs) and identify how these vary across sectors, organizational size and developed vis-á-vis developing countries (R Q 2).* Extending the analysis to focus on CFFs and their role in different contextualities, the study looks at their impact across various sectors and organizational sizes and in developed and developing economies.

Moreover, we specifically focus on the sustainability of OPEX initiatives. Poor project selection and prioritization have been identified as the most important impediment to the sustainability of OPEX project results (Albliwi *et al.*, 2014; McDermott, Antony, Sony and Healy, 2022; Sreedharan *et al.*, 2018; Swarnakar, 2021). Therefore, we question *the relationship between poor project prioritization and other CFFs in detail (RQ 3)*.

The highly dynamic and complex nature of OPEX implementation requires a breakdown of the effect of key performance indicators (KPIs) on operational, financial, environmental and social performance measures (Antony *et al.*, 2022; Luz Tortorella *et al.*, 2022; Naik *et al.*, 2023). This calls for a better understanding of the relations between the preferred OPEX methodology and whether key performance indicators (KPIs) are significantly associated with each individual methodology. Therefore the *fourth research question aims to identify the key performance indicators (KPIs) associated with the failures of commonly implemented operational excellence (OPEX) methodologies, such as Lean, Six Sigma, Lean Six Sigma, and Agile manufacturing (RQ4)*.

The rest of the paper is structured as follows: Section 2 presents a literature review. Section 3 outlines the research methodology employed. The key findings of the survey are reported in Section 4, and a discussion of these key findings is presented in Section 5. Section 6 offers an analysis of the implications of the study, and the paper concludes with a summary of the findings, an assessment of the limitations, and directions for future research.

2. Systematic literature review

As part of this study, a systematic literature review (SLR) was conducted to determine the factors contributing to organizations failing to sustain OPEX initiatives. The SLR process and stages followed are illustrated in Figure 1. The SLR consisted of six phases, starting with planning the review. In this phase, the study's objectives were aligned with the formulation of the review (Tranfield *et al.*, 2003). This is followed by formulating the literature search method. The keywords "Operational Excellence" OR "Lean" OR "Six Sigma" OR "Lean Six Sigma" OR "Agile" AND "failure factors" were employed to identify relevant literature. Various databases of bibliographic citations including *Web of Science, IEEE Xplore, Scopus, Science Direct and Google Scholar* were utilized. Out of the articles pertaining to the search words, only the ones that were published between *2000-2022* were included in the study. 418 articles were identified in the initial search. The selected articles were subjected to a rigorous quality assessment to ensure that they met the predetermined inclusion and exclusion criteria. Additionally, any articles published in predatory journals, according to the Cabells list, were excluded (Cabells, 2018; Das and Chatterjee, 2018). After the first screening, a total of 191 articles were removed and hence 221 were considered for the study. After further screening based on their titles, abstracts and duplicates, 161 more articles were removed. Each contributing author independently reviewed the remaining articles for their relevance and to ensure consensus (Bettany-Saltikov, 2016). This further screening resulted in 62 deemed-relevant articles that were included in the thematic analysis.

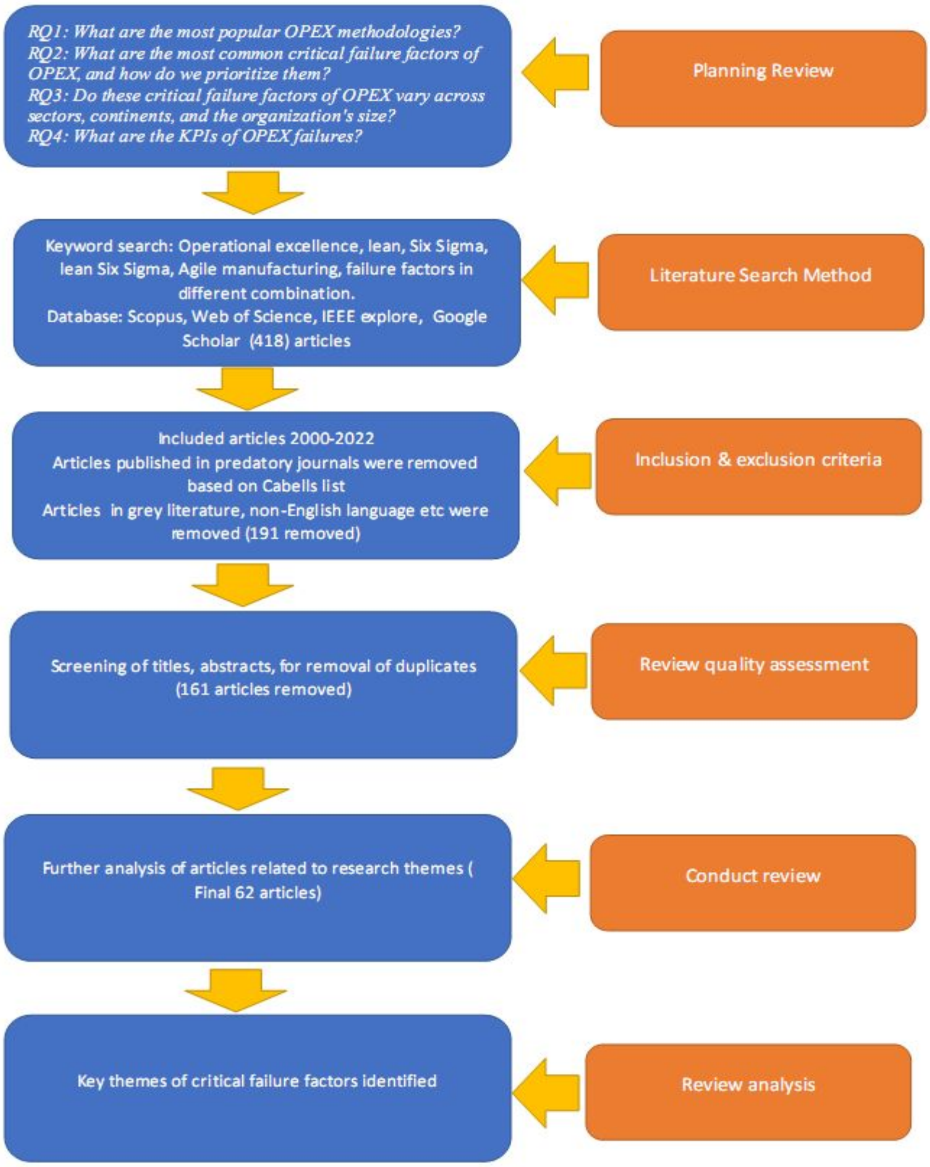

Figure 1. Systematic Literature Review Methodology

The research team conducted an independent review of the articles, focusing on identifying recurring patterns or themes related to failures following an inductive category formation process (Lameijer et al., 2022). These patterns, which shared similarities in nature, were then organized into categories representing different failure factors. Subsequently, the researchers engaged in collaborative discussions to deliberate on these categorized factors, ensuring a comprehensive consideration of all aspects. Through these discussions and further deliberations, a final consensus was reached to collectively determine the most relevant failure factors. Similar protocols were followed in previous studies (Albliwi *et al.*, 2014; Antony *et al.*, 2021; Gupta *et al.*, 2019).

The thematic analysis revealed the inappropriate selection of OPEX initiatives as one of the key factors for their failures in many organizations. This is not surprising since the execution of inappropriate projects not only leads to a waste of time but also leads to avoidable financial investments and poor utilization of resources (Kumar *et al.*, 2009). Despite many OPEX success stories, the thematic analysis suggested that few studies have shown that OPEX initiatives fail to sustain in many manufacturing and service organizations due to modern-day challenges such as volatility, uncertainty, ambiguity, and complexity (Prashar and Sunder, 2021; Rüttimann *et al.*, 2015; Virmani and Salve, 2021). One of the most significant factors for the failure of OPEX was identified as poor project selection (Kumar *et al.*, 2009; Padhy, 2017; Snee and Rodenbaugh Jr, 2002). Further, there is evidence that a weak alignment between OPEX initiatives and organizational strategy, distorted communication, and poor project selection increase the probability of OPEX failures (Snee and Hoerl, 2018). Table 1 presents the 12 most common failure factors identified through the SLR and thematic analysis.

Table 1. Failure factors in sustaining OPEX initiatives

SN.	Failure Factors	Description	Literature Source
1	Resistance to change issue	Incorporating OPEX initiatives in the organization will bring many changes to existing facilities, roles/responsibilities, and learning towards understanding the OPEX initiative. However, organizational members often resist learning new aspects due to fear of failure in adopting new methods.	(Antony and Gupta, 2018; Iyede *et al.*, 2018; Swarnakar, Singh, Antony, *et al.*, 2020; Yadav and Desai, 2017)
2	Poor organizational culture	A strong and positive culture is one of the most important aspects of sustaining OPEX initiatives in a competitive environment. Such cultures have the potential to create harmony by developing good relations with employees, establishing good communication devices, and developing different reward and recognition systems. Weak and poor organizational cultures lead to unmotivated employees, mismatch with company values, work-life imbalance	(Albliwi *et al.*, 2014; Antony *et al.*, 2022; Antony, Lizarelli, *et al.*, 2020a; Bortolotti *et al.*, 2015; Hardcopf *et al.*, 2021; Swarnakar, Singh, Antony, *et al.*, 2020)

SN.	Failure Factors	Description	Literature Source
		problems, and poor customer relations and experiences.	
3	Poor Organizational strategy and its alignment with OPEX initiatives	It is imperative to ensure the success of OPEX to select a critical approach. Organizations must adopt an approach within the scope of the organization's objectives and vision. The lack of alignment between OPEX and organizational aims led to the OPEX initiatives' catastrophic failure.	(Antony *et al.*, 2022; Singh and Rathi, 2021; Swarnakar, 2021)
4	Poor leadership	Poor leadership works as an implementation barrier that obstructs the successful execution of an OPEX approach. Strong leadership capability helps to complete tasks within a time limit, leading to achieving targets. A good leader makes an organization competitive, develops confidence in the workforce, takes responsibility for failures, and recognizes that success belongs to employees.	(Laureani and Antony, 2017, 2018; Swain *et al.*, 2018; Swarnakar, Singh and Tiwari, 2020)
5	Lack of proper communication	Efficient two-way information flow between employees and management is the key to ensuring OPEX initiatives' success. Therefore, management must develop proper communication plans and discuss execution plans, strategies, pitfalls and gains with all stakeholders.	(Antony *et al.*, 2022; Antony and Gupta, 2018; Kumar *et al.*, 2011; McLean *et al.*, 2017)
6	Poor project selection and prioritization	Inappropriate selection of a project is one of the key factors for failures of OPEX in organizations. Inappropriate projects not only lead to a waste of time but also result in financial waste and inefficient use of resources.	(Antony *et al.*, 2022; Antony and Gupta, 2018; Kumar *et al.*, 2009; McDermott *et al.*, 2021)
7	Lack of employee engagement at all levels	Incorporating OPEX in organizations will bring many changes to existing facilities, roles/responsibilities, and learning about OPEX. Organizational members must understand their roles and be engaged.	(Albliwi *et al.*, 2014; Antony *et al.*, 2022; Prasanna and Vinodh, 2013)
8	Lack of training and education provided to employees	It is imperative to have a systematic and thorough employee training structure to ensure the success of OPEX efforts within an organization. This training not only includes fundamental concepts and principles, tools and techniques and the associated methodology required during implementation but also requires expertise building and practical roadmap creation to handle challenges throughout the implementation process.	(Antony *et al.*, 2022; Antony and Gupta, 2018; Yadav and Desai, 2017)
9	Lack of reward and recognition system in the organization	Organizations must have some form of reward and recognition system to encourage their employees. The employees must be rewarded, recognized, and incentivized promptly for their involvement in initiatives. This is imperative in introducing healthy competition and harmony among the employees to work towards excellence in the organization. The lack of reward and recognition systems has been recognized as a critical factor in CI measures' failure within organizations.	(Antony *et al.*, 2022; Antony and Gupta, 2018; Prasanna and Vinodh, 2013; Swarnakar, Singh and Tiwari, 2020)
10	Lack of OPEX roadmap or framework for sustainability	To meet global environmental targets, organizations must meet sustainability pursuits within their existing methods or processes to improve environmental performance. In addition, organizations must develop concrete frameworks to embed sustainability measures in their existing OPEX programs. The lack of an	(Antony *et al.*, 2022; Chugani *et al.*, 2017; Garza-Reyes, 2015; Garza-Reyes *et al.*, 2014; Kumar *et al.*, 2011)

SN.	Failure Factors	Description	Literature Source
		empirical and pragmatic framework leads to the failure of the OPEX initiatives.	
11	Poor alignment between OPEX and organizational learning	Organizational learning is an important pillar for implementing any OPEX initiative. Unfortunately, OPEX initiatives frequently fail due to improper adoption of learning initiatives for any new approach. This has happened mainly due to poor alignment between experiential learning and improvement initiatives.	(Albliwi *et al.*, 2014; Antony *et al.*, 2022; Swarnakar, Singh and Tiwari, 2020)
12	Lack of top management support	Management commitment is one of the key aspects of initiating and executing an OPEX initiative. The successful adoption of OPEX initiatives includes the selection of strategic projects, a focus on business objectives and customer needs, and alignment with the strategic goals of the organization. Top management commitment and support throughout the implementation process are crucial.	(Albliwi *et al.*, 2014; Antony *et al.*, 2022; Antony and Banuelas, 2002)

To validate and prioritize the fragmented findings derived from the SLR and thematic analysis, a coherent global empirical study was conducted to better understand the importance and relativity of CFFs that may impede the sustainment of OPEX initiatives. The research methodology followed in conducting the empirical study and its analyses, results and findings are presented in the subsequent sections.

The choice of poor project prioritization and selection as the dependent variable in the analyses that followed is rooted in its significance as a critical failure factor (CFF) within the context of OPEX. Numerous studies and scholarly research, including (Albliwi *et al.*, 2014; McDermott, Antony, Sony and Healy, 2022; Sreedharan *et al.*, 2018; Swarnakar, 2021), have consistently identified poor project prioritization and selection as the most impactful factor. The selection of projects plays a pivotal role in comprehending the larger framework of operational excellence (OPEX) failures, as the success of project selection is intricately connected to various other crucial elements that contribute to OPEX success (Kumar *et al.*, 2009; Padhy, 2017). Investigating the relationship between poor project prioritization and selection and the other CFFs sheds light on the intricate web of factors that contribute to OPEX failures. It helps discern how shortcomings in project selection ripple through an organization's processes, affecting other CFFs. Furthermore, the analysis underscores the substantial potential benefits of accurately identifying and proficiently executing projects. The empirical evidence, including data from the American Society for Quality (ASQ) and success stories from Fortune 500 companies like Motorola, GE, Honeywell, and Ford, showcases the immense financial savings that can be achieved through effective project selection and execution. For example, research by the American Society for Quality (ASQ) has revealed that many Fortune 500 companies have implemented operational excellence (OPEX) methodologies such as Six Sigma, resulting in significant cost savings. The ASQ (2009) reported that Six Sigma saved Fortune 500 companies an estimated $427 billion in the last two decades. At the firm level, Motorola reportedly saved $15 billion over the last 11 years, whereas GE saved $4.4 billion, Honeywell saved $1.8 billion, and Ford saved $1 billion (Cyger, 2003). Opting for an inappropriate project can be a common temptation when initiating a OPEX initiative such as lean six sigma deployment. It's often alluring to select a project with easily attainable improvements, referred to as "low hanging fruit," as it seems straightforward to see it through to the finish. However, this approach can result in outcomes that lack the necessary intrigue or significant impact to truly captivate management and emphasize the potential of the entire process(Montgomery, 2016). One of the contributing factors that can result in the discontinuation of OPEX methodologies such as LSS initiatives is the limited success rate of OPEX projects (Antony, Lizarelli, *et al.*, 2020a). Due to the importance of project selection in terms success it can bring to OPEX initiative and the drastic consequences, it can bring to OPEX initiative if projects are not selected appropriately, we have framed poor project selection as a dependent variable. Thus, we framed poor project prioritization and selection as the dependent variable, the analysis, to emphasize the critical role it plays in influencing an organization's overall success and bottom-line impact.

The relationships between poor project selection, prioritization, and other CFFs in addition to a list of hypotheses are provided in Figure 2. Table 2 outlines the hypotheses that will be tested.

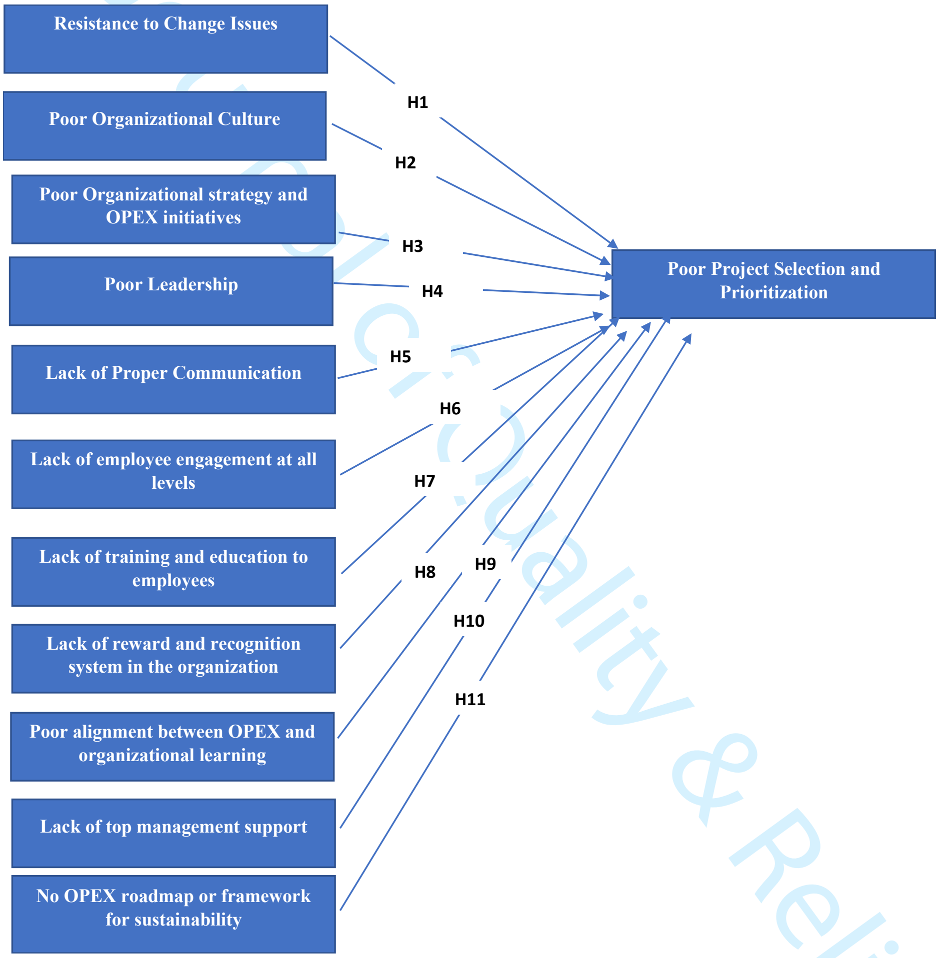

Figure 2. Conceptual Model

Table 2. List of hypotheses focusing on poor project selection and prioritization.

H1: A positive relationship exists between resistance to change issues and poor project selection and prioritization.
H2: A positive relationship exists between poor organizational culture and poor project selection and prioritization.
H3: There is a positive relationship between poor OPEX strategy & OPEX initiative and poor project selection and prioritization
H4: A positive relationship exists between poor leadership and project selection and prioritization.
H5: A positive relationship exists between a lack of proper communication and poor project selection and prioritization.

H6: A positive relationship exists between a lack of employee engagement at all levels and poor project selection and prioritization.
H7: There is a positive relationship between employees' lack of training and education and poor project selection and prioritization.
H8: A positive relationship exists between the organization's lack of a reward & recognition system and poor project selection and prioritization.
H9: A positive relationship exists between poor alignment between OPEX & organization learning and poor project selection and prioritization.
H10: A positive relationship exists between a lack of top management support and poor project selection and prioritization.
H11: There is a positive relationship between no OPEX roadmap or framework for sustainability and poor project selection and prioritization.

3. Research methodology

The study was conducted in two stages. Stage 1 involved the identification of critical failure factors and the development of a conceptual model. A systematic literature review was conducted to identify the CFFs and develop the conceptual model. Stage 2 aimed to test the validity of the conceptual model. Step 1 of stage 2 involved designing and validating a questionnaire survey to gather data to answer the research questions. Step 2 was dedicated to sampling and data collection, and step 3 focused on data analysis. These steps are depicted in Figure 3.

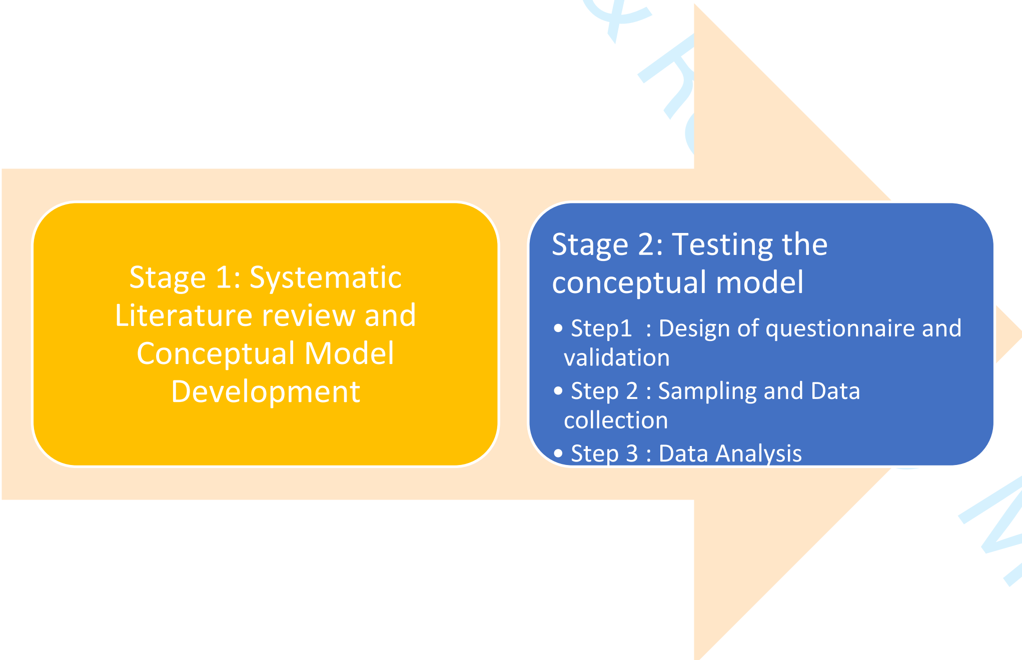

Figure 3. Research Methodology

3.1. Design of questionnaire and validation

The questionnaire was divided into three parts. Part A was dedicated to obtaining background information on the participants; Part B was reserved for information related to OPEX initiatives in the organization, while Part C was the repository for the CFFs for OPEX. The questions in Part B and Part C were devised based on a thorough literature review utilizing a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). The method was chosen for its simplicity and popularity compared to higher-point scales presenting the respondents' choices without overwhelming them (Chomeya, 2010; Leung, 2011). The Likert scale is widely used in surveys and questionnaires when a quick and precise tool is needed. The scale was appropriate for accurately measuring the time-scarce high-level officers working in OPEX or Quality/Continuous Improvement (CI) projects (Allen and Seaman, 2007). Prior to conducting the full-scale distribution of the questionnaire (the final survey), a pilot test was undertaken involving 14 respondents. Following valuable feedback from these experts, minor modifications were made, resulting in the final questionnaire.

3.2. Sampling and data collection

Aiming to delineate the impact of critical failure factors (CFFs) on the sustainment of operational excellence (OPEX) initiatives, an online survey was utilized. The online platform gave the authors the ability to collect a significant amount of data globally. The online survey was also effective in its distribution and in increasing the participation rate (Bonometti and Tang, 2006; Van Selm and Jankowski, 2006). The selection method was purposive sampling, or selective sampling, a preferred sampling method when respondents are selected based on predetermined criteria such as experience, knowledge about a phenomenon and exposure to it (Morse, 1991; Sandelowski, 2000). Purposive sampling provides additional benefits compared to its counterparts since it is time and cost-effective in addition to being more suitable for information-rich cases (Emmel, 2013). The online survey was designed with the sole purpose of collecting specific information regarding OPEX failures which required the respondents to possess extensive knowledge and expertise in OPEX. The questionnaire was distributed to 800 senior managers in six continents who hold various appointments as OPEX Managers, OPEX Vice Presidents, Heads of OPEX, OPEX Directors, Lean Managers, Heads of Continuous Improvement, LSS Master Black Belts and LSS Black Belts. To identify the potential respondents for this global study, the popular professional networking site LinkedIn was employed (Antony, Lizarelli, *et al.*, 2020b; Antony, Sony, *et al.*, 2020; Stokes *et al.*, 2019). In particular, the distribution strategy focused on identifying OPEX professionals with over 5 years of experience in a relevant position. After the initial e-mails were sent informing the respondents about the study, its objectives, and ethical considerations, a request to participate was sent to each individual. Dillman's approach (Dillman *et al.*, 2014a, 2014b; Dillman and others, 1978) was incorporated to design a user-friendly survey with basic features and a simple and logical flow of questions to increase the response rate. A cover letter stating the objective of the study with specific instructions regarding how to answer the questions was included. The distribution strategy also included a follow-up email with a reminder and a note emphasizing the value of their participation to the non-respondents (Dillman *et al.*, 1998; Dillman and others, 1978; Schaefer and Dillman, 1998). The final number of valid and useful responses for the study was 249, corresponding to a response rate of 31.25 percent, which is above the reported adequacy rate of 20 percent (Easterby-Smith *et al.*, 2012). The manufacturing firms that are included in the study were those whose core businesses were purely manufacturing.

Similarly, the service firms included were the ones who were only involved in service activities (Table 3). A third category was added to include manufacturing and service firms given that services have conventionally been entrenched throughout the manufacturing value chain (Yang and Su, 2007). That is, it is common for manufacturing firms to have in-house service activities such as maintenance and repairs, in addition to analysis of product usage data to devise new services. A common example is GE, which uses flight service data to provide customized services (Ayeni *et al.*, 2011; B. Xu *et al.*, 2023).

Table 3. Sample demographics of the survey respondents

	Type of organization			Gender				Continent				
Row Labels	**LE**	**SME**	**Grand Total**	**Female**	**Male**	**I prefer not to say**	**Grand Total**	**Asia**	**Europe**	**North America**	**Others**	**Grand total**
Manufacturing and Service	40	22	62	9	53		62	26	21	13	2	62
Manufacturing	102	18	120	19	99	2	120	39	56	20	5	120
Service	55	12	67	20	45	2	67	32	24	9	2	67
Grand Total	197	52	249	48	197	4	249	97	101	42	9	249

To ensure completeness in data collection, we included a question for respondents: "Would you think any of the OPEX failure factors is missing, please feel free to add them in the following space provided?" However, it's worth noting that only a limited number of respondents provided answers to this question. Upon examining their responses, we found that the factors they mentioned were similar to the 12 CFFs we had initially identified. As a result, we retained these original 12 CFFs for our subsequent analysis.

4. Analysis and results

The analysis plan was carefully designed to address the research questions (Figure 4).

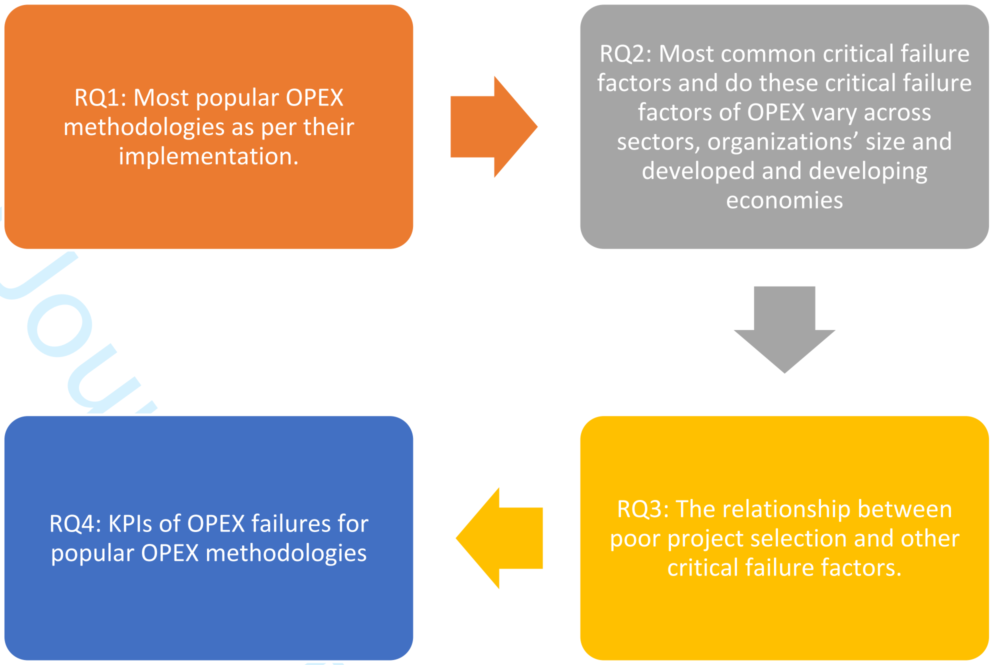

Figure 4. Analysis Plan

4.1. Popular OPEX methodologies as per their implementation

To understand the popularity of implementing various OPEX initiatives, the question" What *type of OPEX initiatives have the organizations implemented?*" was posed to the respondents. The results are depicted in Table 4.

Table 4. Type of OPEX methodology implemented in organizations.

OPEX Methodology	Frequency	Percentage (N=249)*
Six Sigma	188	76%
Lean Six Sigma	164	66%
Lean	131	53%
Agile	59	24%
Not adopted any OPEX initiative	26	10%

As can be observed from the table, Six Sigma is the most widely used methodology across all OPEX methodologies, followed by Lean Six Sigma and Lean, with Agile being the least utilized.

4.2. Investigating the criticality of failure factors

The sample of 249 participants was divided into two random groups using SPSS. In one of these samples (consisting of 124 participants), we performed an Exploratory Factor Analysis (EFA) while in the other sample (comprising 125 participants), we conducted a Confirmatory Factor Analysis (CFA), following procedural guidance by (Roth *et al.*, 2008). The statistical results for the EFA illustrate that all twelve CFFs were loaded onto a single factor. Subsequently, in the second sample, a CFA was conducted utilizing AMOS to validate the measurement of all variables associated with the CFFs used in our study. Notably, all the CFFs were loaded onto a single factor. The results of the CFA (Hair *et al.*, 2014a; Tabachnick and Fidell, 2007) and model fit indices are presented in Table 5.

The CFFs loadings were (>0.5), indicating convergent validity, and the overall model fit results suggested an acceptable one-dimensionality for the measures (Hair *et al.*, 2014a; Tabachnick and Fidell, 2007). The composite reliability using the standardized loadings and the measurement error of each CFF were also computed. The results showed composite reliabilities above 0.7 (Hair et al.2014). Scale validity was further confirmed by computing the average variance extracted (AVE) for the constructs. The AVE values, computed using the squared standardized loadings and the measurement error of each indicator, surpassed the recommended value of 0.50. This confirmed the validity of the scales (Hair et al. 2014; Tabachnick and Fidell 2007).

Table 5. CFA loadings and model fit

Critical Failure factors	**CFF Loading**
Lack of top management support	0.711
Poor alignment between OPEX and organizational learning	0.804
Lack of OPEX roadmap or framework for sustainability	0.64

Lack of reward and recognition system in the organization	0.544
Lack of training and education for employees	0.74
Poor Project Selection and Prioritization	0.827
Lack of employee engagement at all levels	0.661
Lack of Proper Communication	0.686
Poor Leadership	0.732
Poor organizational strategy and OPEX initiatives	0.72
Resistance to Change Issues	0.601
Poor organizational culture	0.745

Composite reliability = 0.75, Ave Variance =0.50
$\chi 2$ = 92.18 df =54 , RMSEA =0.072, SRMR =0.06
NFI =0.90, CFI=0.93, GFI =0.86, AGFI =0.82

To determine the most critical failure factors, the mean scores of all failure factors reported in the sample (n = 249) were analysed (Table 6). In order to determine the critical failure factors, the technique suggested by Adabre and Chan (2019) was used. Following this technique, first, the mean scores were calculated. Then, the normalization score was calculated as Normalized Value = (mean – minimum mean)/(maximum mean – minimum mean). The normalized value indicated that the success factor was critical (normalized ≥ 0.50) (Adabre and Chan 2019).

Table 6. Criticality of Failure Factors

	Mean	**Normalization**	**Rank**
Poor Project Selection and Prioritization (A)	3.49	1	1
Poor Leadership (B)	3.46	0.88	2
Lack of Proper Communication (C)	3.45	0.82	3
Resistance to Change Issues (D)	3.41	0.65	4
Lack of training and education to employees (E)	3.37	0.46	5
Lack of reward and recognition system in the organization (F)	3.35	0.38	6
Lack of top management support (G)	3.34	0.36	7
Poor organizational strategy and OPEX initiatives (H)	3.29	0.12	8

	Mean	Normalization	Rank
Lack of employee engagement at all levels (I)	3.29	0.12	9
Poor alignment between OPEX and organizational learning (J)	3.28	0.07	10
Poor organizational culture (K)	3.28	0.06	11
Lack of OPEX roadmap or framework for sustainability (L)	3.27	0	12

The four predominant critical factors (highlighted in bold in Table 6) were *poor project selection and prioritization, poor leadership, lack of proper communication, and resistance to change issues were the most critical failure factors.*

4.3. Comparison of CFFs across sectors, organizations and economies

In order to compare the CFFs across sectors, developed and developing countries, and across developed and developing economies, statistical analysis was conducted utilizing t-tests and ANOVA. The mean scores of the CFFs were used to investigate the differences across developing versus developed countries, by continent, and by sector. The results of the analysis, presented in Table 7, show the CFFs with significant differences.

Table 7. CFFs of OPEX across the type of sector, size of companies, across continents and developed vs developing nations

How do the critical failure factors of OPEX vary across developed and developing countries?				
CFFs	*t-test result*			
	Mean (Developed)	**Mean (Developing)**	**t-value**	**p-value**
Poor leadership in the organization	3.60	3.32	2.019	0.045**
Lack of reward and recognition system in the organization	3.48	3.21	2.079	0.039**
How do the critical failure factors of OPEX vary across Manufacturing, Services and Manufacturing & Service?				
ANOVA				
CFFs	**Mean (Manufacturing)**	**Mean (Service)**	**Mean (Both)**	**p-value**
Lack of proper communication	3.29	3.59	3.69	0.031**
Poor project selection and prioritization	3.38	3.42	3.77	0.048**
Lack of training and education for employees	3.19	3.51	3.54	0.031**
How do the critical failure factors of OPEX vary across different continents?				
ANOVA				
CFFs	**Mean (North America)**	**Mean (Asia)**	**Mean (Europe)**	**p-value**
Poor leadership in the organization.	3.85	3.40	3.30	0.027**
Lack of proper communication	3.73	3.47	3.28	0.042**
Poor project selection and prioritization	3.85	3.50	3.29	0.014**
Lack of employee engagement at all levels	3.60	3.29	3.13	0.028**
Lack of training and education for employees	3.66	3.38	3.19	0.034**
Resistance to change issues	3.71	3.43	3.25	0.008**
Poor Organizational strategy and OPEX initiatives	3.58	3.33	3 .11	0.01**
How do the critical failure factors of OPEX vary across large- and small and medium firms?				
None of the critical failure factors significantly varied with the size of the organization				

Two tailed significance (* =P<.1, ** =P<.05, *** =P<.001)

4.4. Conceptual model testing: poor project selection and other critical failure factors

The dependent variable (Poor Project Selection and Prioritization) was tested for normality using the Kolmogorov-Smirnov test. It was found that the dependent variable followed a normal distribution (Razali *et al.*, 2011). To test for multicollinearity (Table 8), variance inflation factor (VIF) analysis for all the independent variables was performed (all below 10, suggesting negligible multicollinearity concerns (Wooldridge, 2016a). The R^2 (0.560) is considered to be acceptable in cross-sectional studies (Krueger and Ashenfelter, 1992) (Wooldridge, 2016b). Furthermore, the p-value of the F-statistic was below 0.0001, indicating the regression equation is significant (Allison, 1999; Hair *et al.*, 2014a). The variables of the CFFs were visually inspected for outliers. Moreover, the Mahalanobis difference test (P. Cohen, West, and Aiken 2014; Stevens 1984) and the modified Cooks test (Cook and Weisberg 1982) using R software (Finch 2012) were performed to detect outliers. To test the hypothesized relationship between the dependent variable, i.e., poor project selection and prioritization, and the remaining 11 CFFs as independent variables, a multiple regression was conducted. The purpose was to determine the relative influence of independent variables on the dependent variable (Allison 1999; J. Cohen 1968). The analysis is outlined in Table 4, which describes which of the hypotheses outlined in Table 8 were significant or failed to be rejected.

Table 8. Multiple Regression

Model		**Beta**	**T-value**	**p-value**	**Collinearity Statistics**	
					Tolerance	**VIF**
1	(Constant)		1.976	0.049**		
Poor Organizational strategy and OPEX initiatives **(H)**		0.173	2.731	0.007**	0.461	2.167
Poor Leadership **(B)**		0.065	0.834	0.405	0.304	3.286
Lack of Proper Communication **(C)**		0.216	3.212	0.001***	0.411	2.432
Lack of employee engagement **(I)**		0.197	2.633	0.009**	0.334	2.996
Lack of training and education for employees **(E)**		0.145	2.044	0.042**	0.368	2.715

Lack of reward and recognition system in the organization **(F)**	-0.035	-0.524	0.601	0.422	2.372
Lack of OPEX roadmap or framework for sustainability **(L)**	0.137	2.103	0.037**	0.44	2.272
Poor alignment between OPEX and organizational learning **(J)**	0.056	0.635	0.526	0.237	4.218
Lack of top management support **(G)**	0.017	0.211	0.833	0.291	3.44
Resistance to Change Issues **(D)**	0.168	2.906	0.004**	0.558	1.793
Poor organizational culture **(K)**	0.06	0.858	0.392	0.386	2.592
a Dependent Variable: Poor Project Selection and Prioritization **(A)**					

Two tailed significance (* =P<.1, ** =P<.05, *** =P<.001)

The resulting regression equation predicts that poor project selection and prioritization are positively influenced by *poor organizational strategy and OPEX initiatives(H), lack of proper communication(C), Lack of employee engagement (I), lack of training and education to employees(E) Lack of OPEX roadmap or framework for sustainability (L) and resistance to change issues(D)*. Or:

A = 0.173 H +0.216 C + 0.197 I + 0.145 E + 0.137 L + 0.168 D …………….(1)

Thus, hypotheses H1, H3, H5, H6, H7 and H11 were supported (Table 2), whereas all others were rejected.

4.5. Key performance indicators (KPIs) for the failure of OPEX

To understand the key performance indicators (KPIs) for best observing the failure of OPEX, the respondents were asked which measures of OPEX initiative impact monitoring (operational, financial, environmental & social measures) are typically used for Lean/Six Sigma/Lean Six Sigma/ Agile manufacturing (Table 9).

Table 9. Measures for Failure of OPEX Methodologies

Measures of failure of OPEX Methodologies	**Lean**	**Six Sigma**	**Lean Six Sigma**	**Agile manufacturing**
Operational performances measures	3.80	3.58	3.84	3.14
Financial performance measure	3.71	3.60	3.78	3.18
Environmental performance measure	3.14	2.99	3.11	2.75
Social performance measure	3.06	2.82	2.97	2.71

Mean scores on a five-point scale

The most referred OPEX performance measures that could indicate failure were identified as operational performance and financial measures and the least referred KPIs of failure observation were determined as social performance measures. It is worth noting that the Agile methodology scored the lowest for all failure performance measures. Lean Six Sigma has shown a significant impact on financial and operational performance measures, focusing less on social and environmental performance indicators of failure. It was also surprising to observe that Lean has the most impact on social performance measures of failure. A plausible explanation for this is that many Lean programs focus on employee engagement, a focus Six Sigma and LSS initiatives in many organizations fail to address.

5. Discussion

This global study aimed to evaluate the factors that contribute to the failure of OPEX initiatives in organizations, considering their size and nature. A large number of OPEX and CI professionals participated in this two years study (approximately 249 across three continents; Asia, Europe and North America). The first task for the research team was to understand the most currently popular OPEX methodologies utilized by organizations. Six Sigma was found to be the most popular OPEX methodology employed by organizations. This may be due to the unique nature of the Six Sigma methodology's implementation, such as its parallel mesostructure, strategic project selection, leadership engagement, improvement specialists, structured method, and performance metrics that focus on customer and financial implications (Schroeder *et al.*, 2008). This was followed by determining the CFFs that are influential in the deployment of OPEX initiatives. As some empirical studies were available, the authors employed a CFA and EFA followed by normalized mean scores to derive the top factors. The results of the study suggested that poor project selection and prioritization, poor leadership, lack of proper communication, and resistance to change issues were the most critical failure factors that are required to be addressed for organisations to successfully deploy OPEX methodologies. Besides, numerous studies have reported the alignment of OPEX with corporate strategy (Antony, Sony, *et al.*, 2020; Sreedharan *et al.*, 2018). The lack of alignment of OPEX with corporate strategy will have an impact on other CFFs too. Our findings also showed a significant difference between developing and developed nations' mean scores of poor leadership and lack of reward and recognition systems. From a maturity point of view in applying OPEX, these results are expected, and the data from our research support these two aspects. None of the CFFs varies significantly between large enterprises and small and medium-sized enterprises (SMEs). As project selection and prioritization were identified as the most important CFF, the authors wanted to explore other factors responsible for the failure of project selection and prioritization (dependent variable). The CFFs such as lack of communication, lack of employee engagement, lack of training on OPEX, lack of roadmap and infrastructure required for the implementation of OPEX, resistance to change and a weak link between the OPEX strategy with corporate objectives had an impact on the project selection and prioritization.

The analysis then focused on investigating how the failure of various OPEX methodologies impacted a variety of performance indicators. Results showed that all OPEX methodologies had a greater impact on operational and financial performance than on environmental and social performance. This is not surprising, as most process improvement projects have traditionally been focused on finance and operational performance indicators, with the inclusion of environmental and social performance indicators occurring more recently.

Additionally, it was found that social performance scores were higher in developed countries than in developing ones. Lastly, it was observed that all performance indicators scored higher in North America compared to Asia and Europe, likely due to the higher maturity level of OPEX methodologies implementations in North America (Antony, Lizarelli, *et al.*, 2020b; Antony, Sony, *et al.*, 2020). We also observed that, generally, the performance indicators scored higher in manufacturing than in service companies.

The next phase of the analysis aimed at analysing the popularity of OPEX methodologies in various organizations. We found that all OPEX methodologies were more mature in developed countries, large enterprises and manufacturing-dominant settings. Learning that Lean is more popular in Europe than in North America and Asia was noteworthy. Both Six Sigma and LSS were more popular in North America. This is primarily due to the heavy Six-Sigma investments of US corporations in the late 1980s and early 1990s (Snee and Hoerl, 2003; Snee, 2010).

6. Conclusion, limitations, and directions for future research

This paper presents the results of a global study looking into the top factors for the failures of OPEX initiatives in organizations. Poor project selection and prioritisation is the most important CFF unearthed in this study. This CFF is impacted by poor organizational strategy and OPEX initiatives, lack of proper communication, lack of employee engagement, lack of training and education to employees, lack of OPEX roadmap or framework for sustainability and resistance to change issues. Though it is a generic list, however, insufficient attention has been paid to these factors by researchers. The study also examined various performance measures that were influenced by the failure of OPEX. For instance, all OPEX methodologies have a greater impact on financial and operational performance measures but less on environmental and social performance measures. Another major study finding was the significant difference between developing and developed nations' mean scores of poor leadership and lack of reward and recognition systems.

Directions for further research could focus on understanding and analysing the reasons for such differences. Our findings also showed that there was a significant difference between developing and developed nations' mean scores of poor leadership and lack of reward and recognition systems. Another interesting finding was that the application of Lean was more popular in Europe than in North America and Asia. Contradictorily, Six Sigma and LSS were more popular in North America compared to Asia and Europe. The study highlighted that organizations should focus on weaving the OPEX into the organization's fabric rather than focusing solely on the investment-to-benefits ratio.

One of the study's limitations was that the data collection involved only three continents: Europe, Asia and North America. It would be helpful to understand if similar findings are obtained from other continents. Due to the limitations of the survey, the authors will be pursuing several semi-structured interviews with selected OPEX professionals in each continent to obtain greater insights into OPEX failures. Future research might also look into developing a predictive model connecting the critical failure factors and key metrics of OPEX failures.

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