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Temporal Distance Issues and their Mitigation Strategies in GSD: An Empirical Study

*[1]Atta ur Rahman, [2]Uzair Iqbal Janjua, [3]Adeel Ahmed, [4]Tahir Mustafa Madani

Abstract

GSD has several advantages that make it easier for software companies to follow this trend, like skillful workers, lower costs, and an improved marketplace. To achieve the benefits mentioned above, distributed teams must communicate effectively. Communication is a major problem for development, especially in GSD. Communication issues are classified based on temporal, geographical, and sociocultural distances. The temporal distance problem affects more GSD operations than the other hazards combined. Organizations can mitigate these obstacles and attain the desired quality by employing mitigation strategies while adhering to budget and time constraints. The authors of this study conducted a systematic literature review to identify temporal distance issues and their respective mitigation strategies to develop a conceptual framework. Additionally, a questionnaire interview with closed-ended questions was conducted. Without an empirical study, it is difficult to determine the precise relationship between temporal distance issues and mitigation strategies. The primary objectives of this study are to experimentally evaluate the proposed conceptual framework and the effects of selected risk mitigation measures. This study identified forty-four mitigation techniques and nine temporal distance challenges with a focus on a GSD-based environment, empirical research was conducted using data collected from Pakistani software companies. The findings of this study indicate, with a p-value of 0.01, that various mitigation techniques significantly impact various temporal distance issues. Based on the findings, software organizations can employ appropriate mitigation techniques to address temporal distance issues and reduce the failure rate of software projects.

Keywords: Global Software Development, Temporal Distance Risks, Communication issue, Empirical Study, Mitigation Strategies, Mitigation Practices, Distributed Software Development, Warp PLS

1. Introduction

Most software development firms have implemented Global Software Development (GSD) alongside dispersed work sites. GSD is a term used to describe a group of geographically dispersed individuals working on separate projects. GSD team collaborates across time zones,

[1]*Department of Computer Science, COMSATS University Islamabad l attaur94@gmail.com*
[2]*Department of Computer Science, COMSATS University Islamabad l uzair_iqbal@comsats.edu.pk*
[3]*Department of Computer Science, COMSATS University Islamabad l adeelahmed.paksoft@gmail.com*
[4]*Department of Computer Science, COMSATS University Islamabad l tahir_mustafa@comsats.edu.pk*

cultures, and geographic borders [1]. In modern years, software development organizations have been in high demand in GSD, particularly in the last few years [2]. Multiple organizations utilize GSD environments for their benefit. Due to a lack of resources [1], [2], and reduced development costs [4], many businesses have profited from distributed software development's advantages. . Additionally, it enables a business to obtain a plentiful supply of resources, reducing costs, sharing experiences, and facilitating ongoing work [1][5][6]. Due to budget and time constraints, most businesses use the GSD environment to achieve the required quality [3]. China, India, Pakistan, and Thailand were among the developing nations that participated in distributed development operations. Most businesses in these developing nations provide developed software markets, such as those in the United States and Europe, with high-quality, reasonably priced software [7]. These approaches have provided organizations and businesses with a competitive advantage and stakeholders with GSD knowledge with crucial support [2]. As a result, GSD is now a common and distinctive industrial practice in the software [8] sector. In Figure 1, the benefits of GSD are shown. On the other side, there are numerous challenges and risks that global software development must overcome [1][9][10].

This study's contribution is an SLR conducted in the past [11] to recognize entirely temporal issues in GSD and its mitigation strategies. In addition, a Closed-ended questionnaire was used for interviews in this study to identify additional issues and mitigation strategies and to validate the existing issues and strategies. An empirical evaluation has determined the connection between the issue and mitigation strategies. The proposed conceptual model is analyzed on a formative basis, and the study results also indicate which issues and mitigation strategies are more significant.

There are eight (8) sections in this paper. The remainder of this paper is structured as follows. The relevant work is discussed in Section 2, whereas the study methodology is discussed in Section 3. Section 4 of the proposed conceptual model is presented. Section 5 discusses empirical analysis, whereas Section 6 discusses results and findings. The seventh section discusses the current study, while the eighth section discusses the conclusion and future research.

Figure 1: Benefits of GSD

2. Related Work

Physical isolation among virtual teams [11], time zone differences [5], physical distance [1], overlap of time [12], inadequate communication [1], [13], and delay in responses [11] are the most significant factors affecting GSD base activities. The insufficiency of synchronous communication [14], a wrong choice of technology [15], differences in languages, cultures, and time zone and, geographical distance limitations [11, 16] can all contribute to the development process of communication difficulties. These issues, including "communication," "coordination," and "control," impede GSD [1], [17], [18], [8]. The global developer community views communication as a censorious risk [19]. According to multiple studies [1, 3, 5], communication is the most significant barrier to global project development; 32.5 billion euros have been lost due to a lack of communication. In addition, 400 questionnaires have been completed, revealing that poor communication costs the average business $62.4 million annually in lost productivity [20]. Multiple studies [21], [22], [23], [24], [25], and [1] analyzed and commented on a global project that will require 2.7 times as much time to complete as Collaborative research and development. Moreover, it has been estimated that 78 percent of administrative issues in the software industry are caused by a lack of communication [26], [27], and the project's predicted quality has been sustained [28]. Therefore, poor communication is considered a significant risk factor for the failure of a GSD software project [29]. Informal communication is essential for connecting dispersed developers. Team members involved in global software development have noted difficulty communicating with team members [18]. Literature suggests that GSE is a precarious endeavor and that certain difficulties arise due to time, geographical, and cultural distances, as well as a lack of technical knowledge. Communication is a fundamental risk for GSD-based businesses [1]. Temporal, geographical, and cultural distance are the sub-factors of communication. Temporal distance risk has been identified as a significant risk [10]. According to studies [1], [15], and [30], time zone differences [12], delayed responses [13], incorrect technology selection, improper communication, synchronous communication, and minimal time discussion [1] create temporal distance risks among team members.

The study [20] suggests several mitigation strategies for these issues, but none have been empirically evaluated. The authors of [31] discussed some of the difficulties posed by temporal issues for which few mitigation strategies exist. Diverse studies [32], [33], and [34] have discussed solutions for temporal risk but not for sub-risks, and these strategies have not been empirically tested. Insufficient research has also proposed a conceptual framework for the problem, not mitigation strategies. All previously identified mitigation strategies have been implemented, and some additional mitigation strategies. Time zone difference mitigation strategies include the FTS technique [14], adjusting operating time [2], and time overlapping solutions such as advance meetings, raising overlapping sessions, etc. Strategies for dealing with late comments in response include using a robust feedback channel [15], making regular visits to for away side [3], promoting interaction [16], [35], and practices for poor equipment choices, such as utilizing rich communication channels [17] and synchronization methods of communication [1]; however, these strategies have not been tested. Numerous mitigating measures for synchronous communication have been investigated, including synchronous communication [27], [36], and the use of KABAN tools [28]. Communication guidelines address organization-wide improper communication [3]. Effective communication, groupware applications, and suitable tools are utilized [25], as well as mitigation techniques for limiting communication frequency and encouraging frequent communication [30, [37]. Most studies indicate that the temporal distance risk is the most significant communication risk relative to other risks. According to the findings of SLR [11], we could not locate any empirical research evaluating the effects of temporal distance mitigation techniques on GSD-related problems. The present study aims to fill a gap in the literature by exhaustively defining and empirically validating all of the risks and solution techniques for temporal distance in GSD sectors.

3. Research Methodology

The research approach for the present study is discussed in this section. Figure 2 displays the overall research design. The procedures necessary to conduct the study are detailed below.

3.1. Systematic Literature Review

In our earlier study [11], SLR was used to extract the temporal distance issues for communication and the relevant mitigation strategies from the literature; a closed-ended set of questionnaires were used in the interview process to determine the temporal distance issues and associated mitigation strategies in GSD. The identification of nine temporal distance issues and their respective solutions. These mitigation strategies address multiple issues simultaneously. A conceptual framework was proposed in response to competing SLRs [11].

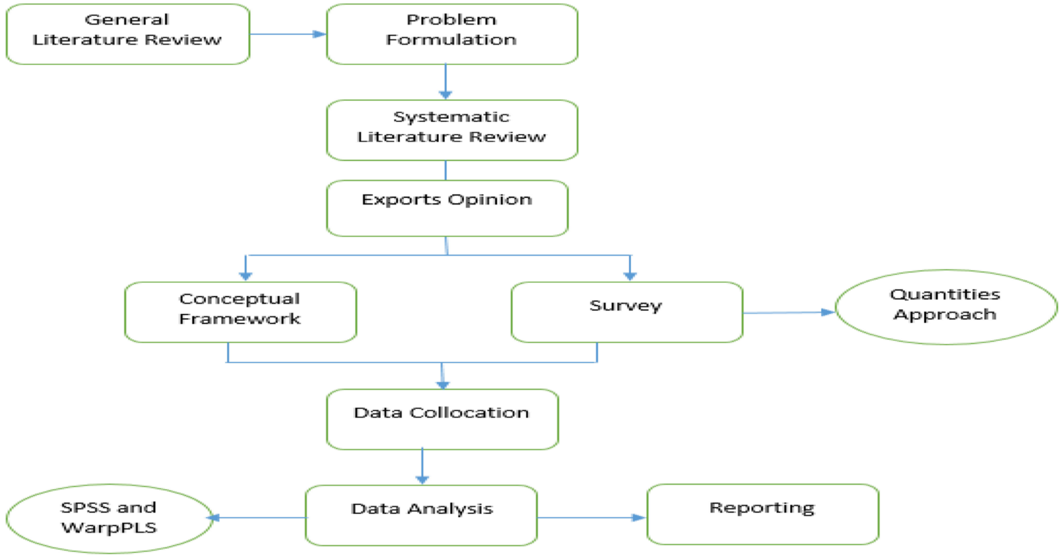

Figure 2: Research Methodology

3.2. Closed-Ended Questionnaires used for Interviews

For interviews [10] [22], closed-ended questionnaires were used to collect and analyze data using qualitative data analysis techniques. The expert's perspective helped us endorse the SLR-derived parameters and mitigation techniques, as well as pursue any missing or neglected information.

3.3 Data Collection

Collecting data from three specialists (i.e., industry experts, academic experts, and experts working in both domain areas). Table 1 demonstrates the demographic characteristics of experts.

Table 1: Demographic information of experts

Expert	Experiences	Current Position	Expertise
1	4	Lecturer	Both
2	3	Developer and designers	Both
3	3	Assistant Professor	Both
4	4	Game Developer	Industry
5	3	Developer and designers	Industry
6	6	ERSIP	Both
7	5	Developer	Industry
8	10	CEO	Both
9	7	Developer	Industry
10	6	Lecturer	Both
11	4	Project manager	Industry
12	13	Requirement engineer	Industry
13	3	Lecturer	Both

The expert interviews yielded the following challenges and mitigation strategies associated with extra GSD's temporal distance. Table 2 demonstrates the additional temporal distance issues, while Table 3 demonstrates the mitigation strategies.

Table 2: Temporal Distance Factors

Items	Factor	Expert Opinion												
		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Less availability of remote team members	N	Y	N	N	N	N	N	N	N	N	N	Y	Y
2	The remote team thinks others doing fraud or telling a lie	N	Y	Y	N	Y	N	Y	N	Y	Y	Y	N	Y

The expert interviews yielded the following challenges and mitigation strategies associated with extra GSD's temporal distance. Table 2 demonstrates the additional temporal distance issues, while Table 3 demonstrates the mitigation strategies.

Table 3: Mitigation strategies for Temporal distance issues

Items	Factor	Expert Opinion												
		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Availability of fast internet	N	N	N	N	N	N	N	Y	N	N	N	Y	Y
2	Using already-used technologies instead of new technology	N	N	Y	Y	N	N	Y	N	N	N	N	N	Y
3	Enhance Face-to-face communication	N	N	N	N	N	Y	N	Y	N	N	N	N	Y
4	Train team members	Y	N	N	N	N	N	N	N	N	N	N	N	Y
5	use collaborative tolls	N	N	N	N	N	Y	N	N	Y	N	N	N	N
6	Common language use like English.	N	N	N	N	N	Y	N	Y	N	N	N	N	N
7	Proper negotiations are needed	N	N	N	N	N	Y	N	Y	N	N	N	N	N
8	Apply Agile practices	N	Y	N	N	Y	N	Y	N	Y	N	Y	N	Y
9	Maximize response level	N	Y	N	N	Y	N	Y	N	Y	N	Y	N	N
10	To establish an appropriate communication Infrastructure	N	Y	N	N	Y	N	Y	N	Y	N	Y	N	N
11	increase overlapping time	Y	N	N	N	N	N	Y	N	N	N	N	N	Y

4. Proposed Conceptual Framework and Hypothesis Development

In this section, the proposed conceptual framework and assumptions are presented. In the conceptual framework proposed for the current research, there are nine exogenous variables. Probably an endogenous variable, the temporal distance issue in GSD (TDIGSD) is indirectly affected by these variables. Temporal distance is the dependent variable, while mitigation strategies are the independent variable.

Additionally, this research identified temporal remoteness as a formative concept in the literature. Consequently, formative measurements were utilized to experimentally test the proposed theoretical basis. The conceptual framework for the current investigation is illustrated in Figure 3.

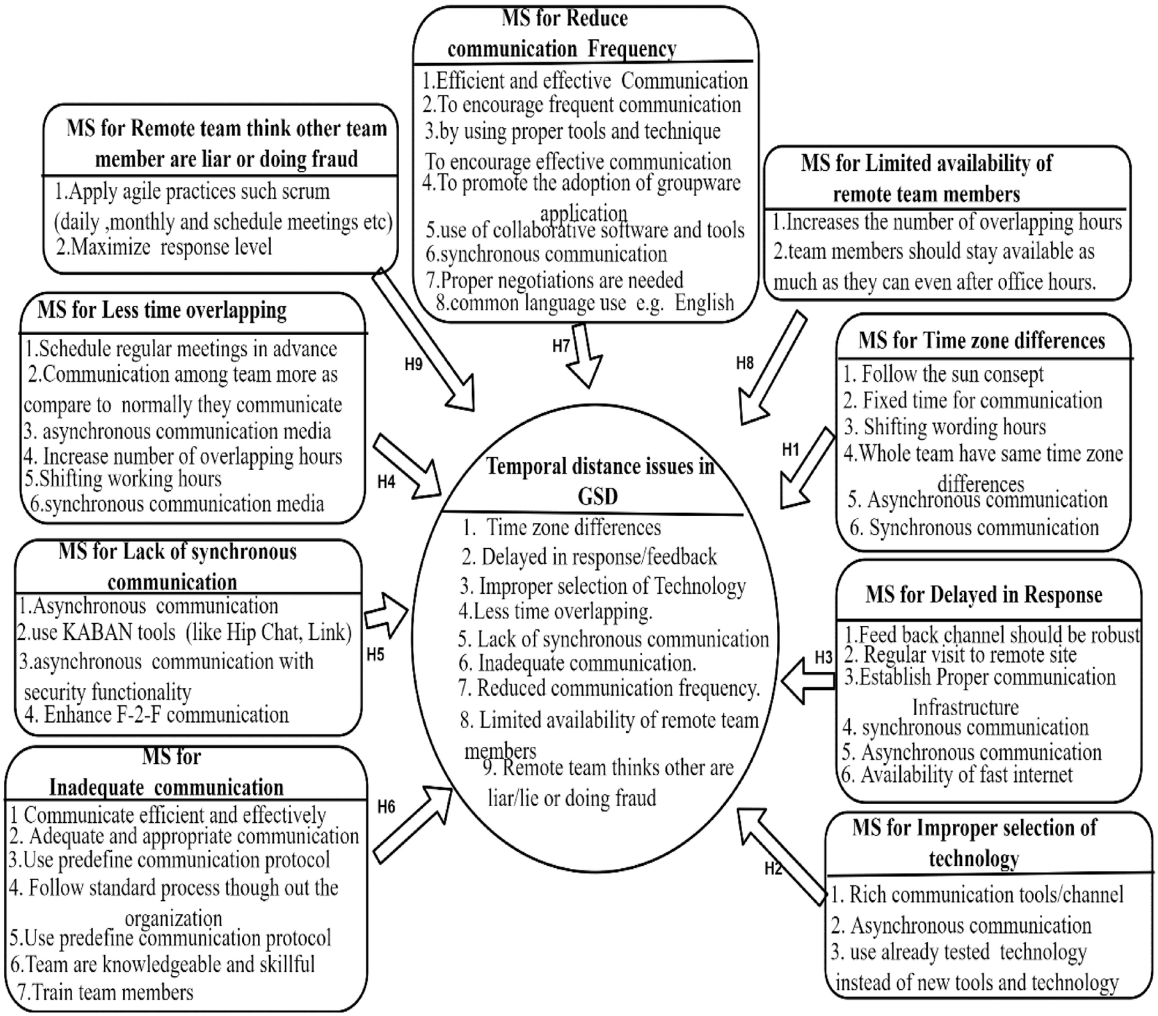

Figure 3: Proposed Conceptual Framework

4.1. Temporal Distance Issues in GSD (TDI)

Due to these issues, coordination and communication between team members are diminished when they are dispersed across multiple distant locations and have different time zones. Late responses and acknowledgements are challenging for team members at various locations [1].

4.2. Mitigation Strategies for Temporal Distances Issues (MSTDI)

In this section, all possible techniques for mitigating the temporal distance issue have been discussed in order to maximize the success rate of GSD-based projects. Various mitigation strategies are discussed in the following section.

4.3. Mitigation strategies for Time Zone Differences (MSTZD)

Sub-factors of temporal distance and, time zone differences affect GSD projects during development [1]. Due to time zone differences, the team's communication is significantly reduced, and knowledge sharing is inadequate [26]. Numerous mitigation strategies have been employed to address these problems. In previous SLR studies, all mitigation techniques have been highlighted [11].

H1: *"Less time zone differences mitigation techniques have a significant impact on temporal distance issues in GSD".*

4.4. Mitigation strategies for Delayed Response (MSDR)

The delayed response sub-factor of temporal distance influences the development of GSD projects [1]. When a message is sent during the working hours of one remote site but during the operating hours of another remote site, there is a significant difference [42]; therefore, the reply is delayed until the start of the next working time site. Several countermeasures were implemented to address the delay in response/feedback.

H2: *"Delayed in responses mitigation techniques have a significant impact on temporal distance issues in GSD".*

4.5. Mitigation strategies for Improper Selection of Technology (MSIST)

Time distance, a crucial risk factor in GSD, will also be impacted by a poor choice of communication technology. When significant jet lag occurs, it occurs between remote teams. Video conferencing and ICT such as Skype are inappropriate [1]. Therefore, it is preferable to suggest Email communication between team members [27]. One of the communication methods is electronic communication channels. Because of the time gap between teams. Team members receive it immediately. Feedback via chat, but the complexity of tone of voice without contact, this individual has lost a crucial opportunity. When using email as a communication platform, feedback is essential [18].

H3: *"Improper selection of technology mitigation techniques has a significant impact on temporal distance issues in GSD".*

4.6. Mitigation Strategies for Less Time Overlapping (MSLTO)

Less time overlap is a temporal distance sub-factor or issue that influences the GSD project's development. One of the disadvantages of less time overlap as a result of GSD time differences is the reduction of working time between sites, resulting in less work being completed [26].

Less time overlap results in a great deal of work in a short period of time and an increase in communication costs [18]. When the time zone difference is greater, there is less overlap, and the absence of overlapping hours increases the opportunity for asynchronous communication. Transmission is suitable for synchronous communication [10] Diverse Mitigation strategies have been used to mitigate this problem [11].

H4: *"Less time overlapping mitigation techniques have a significant impact on temporal distance issues in GSD".*

4.7. Mitigation Strategies for Lack of Synchronous Communications (MSLASC)

Lack of synchronous communication is a subfactor of temporal distance that negatively impacts the development of GSD projects. Using various online tools such as synchronous chat, remote teams collaborating on GSD-based projects become less communicative. [10]. Using asynchronous communication tools would make security communication difficult. The majority of the time, when communicating with team members asynchronously, such as via email, etc., few significant issues have arisen, such as emails being lost, ignored, or unnoticed. As a result, every employee is confused, leading to an increase in miscommunication and misunderstanding among team members. [5] [26]. Numerous mitigation strategies have been employed to address this problem [11].

H5: *"Lack of synchronous communication mitigation techniques has a significant impact on temporal distance issues in GSD".*

4.8. Mitigation Strategies for Inadequate Communication (MSIC)

When the time zones of members of a distributed team are different and prompt response to questions is not an essential task, there is adequate communication [13]. This issue arises as a result of infrequent communication with project team members or the transmission of insufficient detail to contributors or members. Diverse mitigation strategies have been employed to address this problem [11].

H6: *"Inadequate communication mitigation techniques have a significant impact on temporal distance issues in GSD".*

4.9. Mitigation Strategies for Reduce Communication Frequency (MSRCF)

The communication frequency decreases when team members are geographically dispersed, and it also decreases due to time intervals. This is not the case for the regularly occurring Q&A session. Similarly, crucial concerns may not be communicated in a timely manner, affecting the model and work schedule for the following days. Due to the infrequent communication between distributed teams, the following dangers exist: Incorrect communication and miscommunication will increase [1]. Communication frequency issues are affected by the distance between remote team members when there is less space between them. This issue has minimal impact on distributed development projects. Nonetheless, when the distance between team members is considerable, there is a high probability that the problem will hinder team communication. Communication frequency also influences the level of team member feedback. Diverse strategies have been employed to address this issue [11].

H7: *"Reduce communication mitigation techniques have a significant impact on temporal distance issues distance in GSD".*

4.10. Mitigation Strategies for Less Availability of Remote Team (MSLART)

Due to time zone differences, members of a remote team have limited availability. Geographical differences also contributed to this problem. This risk is frequently present when office hours differ or overlap less frequently. Due to the limited availability of team members working on various projects, some team members have completed their tasks and are awaiting the completion of project module integration by remote team members. As previously mentioned, distinct. To address these problems, mitigation strategies have been employed.
H8: "Less availability of remote team member's mitigation techniques has a significant impact on temporal distance issues in GSD".

4.11. Mitigation Strategies for Remote team Think Other Team Members Doing fraud or Telling Lies (MSRTOL)

Due to time zone differences, remote team members believe others to be liars or commit fraud. This issue arose as a result of large distances between members of a small team. Remote team members do not interact face-to-face and do not trust one another [1], [10], which is one of the most important factors for the success of projects. Occasionally, team members do not complete or even begin their assigned tasks but send a message to other team members stating that they are working. As a result, the end-time for the project is delayed, as they deceive their teammates. Typically, asynchronous communication channels are utilized during this issue. Numerous mitigation techniques have been employed to eliminate this issue [11].

H9: *"Remote team thinks other team members are liars or doing fraud mitigation techniques have a significant impact on temporal distance issues in GSD".*

5. Empirical Analysis of Conceptual Framework

The empirical analysis of the conceptual framework is presented in this part.

5.1. Measure and Procedure for Data Collection

In this quantitative study, the difficulties associated with temporal distance in GSD were investigated. A closed-ended questionnaire was used to collect data from GSD-based organizations to test the conceptual framework [38]. The questionnaire is divided into three sections. The first section focuses on the interviewee's demographic data. The second section of the questionnaire contains information about the organization, while the third section consists of communication-related questions. The items in the questionnaire are rated on a five-point Likert scale with 1 = "strongly disagree," 2 = "disagree," 3 = "neutral," 4 = "agree," and 5 = "strongly agree." The author asserts that the use of a neutral scale point is not detrimental [39]. Two GSD organizations in Islamabad (Pakistan) and Swat were sent surveys (Pakistan). Version 22.0 of the Social Science Statistics Software Package (SPSS) was used to analyze the experimental study's data. Figure 4 depicts the survey layout

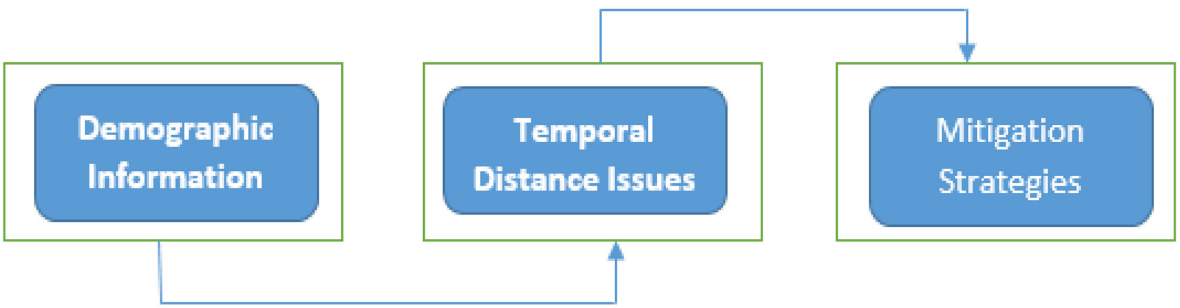

Figure 4: Survey Design

5.1.1. Participants

As a result of the pilot study, convenience sampling was applied in this investigation because not all organizations in Pakistan are GSD-based [40]. The collection of data has been limited to GSD-based groups. Between 2 December 2020 and 1 April 2021, information was collected. On the LinkedIn platform, 400 individuals were given access to the survey, of which 264 responded and completed it. 136 questionnaires were discarded because they were randomly and incorrectly completed. 248 of the 264 respondents provided accurate and comprehensive responses. The response rate for the final study was significantly high (66%).

5.1.2. “Data Analytical Approach”

As a result, the partial least squares structural equation model was utilized in this study (PLS-SEM). According to [41], [42], conceptual framework variables can be formative, so this method was chosen. PLS-SEM is a two-part multivariate analysis technique (i.e., structural and measurement models). The structural model illustrates the relationship between latent variables. The measurement model, on the other hand, illustrates the relationship between the latent variables and the survey data [43]. SEM allows you to examine the relationship between endogenous and exogenous variables simultaneously [44], rather than listing them separately. This study's sample size exceeded the recommended sample size of 200 respondents for dependable structural equation modeling results [45]. For statistical analysis, Warp PLS survey version 7.0 data collected by Kock [43] was utilized.

6. Results and Findings

The outcomes of the empirical study are presented in this section. We assessed each hypothesis and its results.

6.1. Findings of an Empirical Study

This section presents the results of an experimental examination conducted in conjunction with the present study. A survey questionnaire was administered to organizations in Pakistan that were developing globally distributed software, or GSD-based, software. The conceptual framework was analyzed using SPSS and Warp PLS for statistical measurements. In addition, each hypothesis was examined, and their corresponding outcomes were analyzed.

6.2. Demographic Profile of Respondents

A sample size of 200 or greater is recommended for PLS-SEM [43, 46, 47]. In total, 248 responses were collected for this research project. Table 4 displays the demographic information for respondents.

Table 4: Summary of Respondent's Demographics.

Demographics	Respondents	Frequency	Percentage
Gender	Male	239	96%
	Female	7	3%
Total	-	248	100%
	Developer	131	52%
	Analyst	4	1.6%
	Designer	7	2.7%
Position	Team Manager	5	1.9%
	Project manager	7	2.8%
	Tester	26	10.48%
	CEO	4	1.5%
	Other	64	26%
Total	-	248	100%

Education	High school	2	0.8%
	Diploma	1	0.4%
	Bachelors	202	81%
	Post-Graduate	40	16.3%
	PhD	3	1.1%
Total	-	248	100%
Working Experience	"1-3 years"	190	76.61%
	"4-7 years"	47	30%
	"8-10 years"	7	2.7%
	"More than 10 years"	4	1.5%
Total	-	248	100%

6.3. Organization Related Information

Using the collected data, develop an understanding of the organization's history. The table below shows the details of the project, including its kind and workforce. Table 5 contains details about the organization.

Table 5: Organization-Related Information

Organizational In-formation	Respondents	Frequency	Percentage
Nature of Project	Desktop Development	3	1.1%
	Web Development	87	35 %
	Android development	13	4.9%
	IOS/Apple Development	35	14.3%
	Others	110	44.5%
Total	-	248	100%
"Number of Employees"	"5-10 employees"	65	26.1 %
	"10-25 employees"	50	20%
	"26-50 employees"	45	18%
	"51-80 employees"	21	8%
	"80-250 employees"	31	11.7%
	"Above 250 employees"	36	14%
Total	-	248	100%

6.4. Quantitative Analysis

This study employed PLS-SEM. The construct measurement model was accessed in order to define the data's precision and validity. The importance of the connection or association among the constructs was then described utilizing the retrieved structural model. The model is evaluated using the Stable3 sampling strategy, which yields more reliable and consistent results for path coefficients [43]. The results of the evaluation are shown in Table 6 of the formative structural model.

6.4.1. Assessment of Measurement Model

More frequently advised for formative assessment is PLS Model B [48]. The PLS Model B technique was consequently used in this study. To evaluate the construct's validity, the variance inflation factor (VIF) is first used. Following that, the R-square, beta coefficient, loading, weight, and P-value were determined.

i. A VIF with a value of less than 3.3 is preferred, while a value of less than 5 is acceptable.
ii. The loading, weight, VIF, full collinearity, and significance level of the items were examined to determine the construct's reliability.
iii. If the loading value of an item is greater than 0.5, it is acceptable [43].
iv. Weights ranging from -1 to 1 are acceptable [43].
v. R-Square measures the proportion of variance in the independent variable that is attributable to the dependent variable [43], and its value is 0.70.
vi. The beta value measures the effect of each independent variable on the dependent variable. The effect increases as the beta coefficient value increases [43].
vii. A P-value less than 0.05 indicates that a correlation is significant. According to research [43], a relationship between two variables is significant if its value is equal to 0.05 and its loading is within an acceptable range.
viii. Tolerance values less than 0.989 are acceptable [43].

Table 6 displays the outcomes of the measurement model evaluation. A thorough list of each issue's potential mitigation measures is represented by the items (column). All constructs are statistically significant, according to the evaluation of the measurement model.

Table 6: Evaluation of Formative Measurement Model

Constructs	Items	Loadings	Weights	Signi-	Full	Beta	-VIF	Tol
					ficance	Collinearity		
	TZD	(0.632)	(0.239)	<0.001		0.16	1.609	0.621
	DR	(0.661)	(0.246)	<0.001			1.892	0.528
	IST	(0.512)	(0.054)	<0.001			1.431	0.699
TDI	LTO	(0.551)	(0.074)	<0.001	2.075		1.358	0.736
	LSC	(0.644)	(0.145)	<0.001			1.358	0.736
	IC	(0.700)	(0.229)	<0.001			1.598	0.625
	RCF	(0.710)	(0.262	<0.001			1.697	0.590
	LAR	(0.621)	(0.184)	<0.001			1.612	0.620
	RTOL	(0.532)	(0.147)	<0.001			1.245	0.803

	M1DR	(0.787)	(0.463)	<0.001			1.355	0.738
	M2DR	(0.716)	(0.282)	<0.001			1.394	0.717
	M3DR	(0.631)	(0.187)	<0.001			1.096	0.912
MDR	M4DR	(0.555	(0.349)	<0.001	1.56	0.09	1.183	0.845
	M7DR	(0.700)	(0.349)	<0.001			1.248	0.801
	M1TZD	(0.551)	(0.264)	<0.001			1.201	0.832
MTZD	M2TZD	(0.832)	(0.664)	<0.001	1.45		1.096	0.912
	M3TZD	(0.667)	(0.371)	<0.001			1.226	0.815
	M4TZD	(0.537)	(0.124	<0.001			1.734	0.576
MIST	M3IST	(0.811)	(0.486)	<0.001	2.960	0.10	2.341	0.427
	M2IST	(0.912)	(0.613)	<0.001			1.760	0.568
	M1LTO	(0.506)	(0.035)	<0.001		0.15	1.907	0.526
	M2LTO	(0.837)	(0.412)	<0.001			1.835	0.544
MLTO	M3LTO	(0.733)	(0.289)	<0.001	2.065		1.498	0.667
	M4LTO	(0.289)	(0.072)	<0.001			1.173	0.852
	M5LTO	(0.831)	(0.831)	<0.001			1.672	0.598
	M6LTO	(0.621)	(0.137)	<0.001			1.507	0.663
MLSC	M2LSC	(0.845)	(0.658)	<0.001	2.258	0.17	1.122	0.891
	M4LSC	(0.783)	(0.566)	<0.001			1.122	0.891
	M1IC	(0.858)	(0.212)	<0.001			2.780	0.359
	M2IC	(0.863)	(0.246)	<0.001		0.17	2.692	0.371
MIC	M3IC	(0.787)	(0.272)	<0.001	1.92		1.755	0.569
	M4IC	(0.835)	(0.213)	<0.001			2.410	0.414
	M5IC	(0.807)	(0.077)	<0.001			2.705	0.369
	M6IC	(0.833)	(0.182)	<0.001			2.835	0.352
	M2RCF	(0.806)	(0.269)	<0.001		0.17	2.035	0.491
	M4RCF	(0.773)	(0.145)	<0.001			2.088	0.478
MRCF	M6RCF	(0.893)	(0.433)	<0.001	2.12		2.400	0.416
	M7RCF	(0.893)	(0.433)	<0.001			2.049	0.488
	M8RCF	(0.733)	(-0.039)	<0.001			2.294	0.435
MLAR	M2LAR	(0.835)	(0.844)	<0.001	1.36	0.11	2.526	0.395
	M1LAR	(0.783)	(0.367)	<0.001			2.635	0.379
MRTOL	M1RTOL	(0.921)	(0.601)	<0.001	1.62	0.11	1.930	0.518
	M2RTOL	(0.901)	(0.484)	<0.001			1.930	0.518

6.4.2. Assessment of Structural Model

Evaluating the structural model and conceptual framework assumptions, Wrap PLS 7.0 can be used to calculate the path coefficient, the effect size, the value of the endogenous configuration coefficient R2 (i.e., the time interval (TDI) problem), and the T value of the path coefficient / SE can calculate the T value. The T value criterion is greater than 1.64 (or 1.96 in some cases) [43]. P 0.05 is the threshold value at the same moment. The structural model was evaluated using Wrap

3. Since it is the best appropriate for computing formative framework path coefficients [43]. The hypothesis testing, effect size-value, path coefficients, and reliability are all detailed in Table 7. The table shows that (MTZD) significantly impacted temporal distance to reduce its effect by 0.16 with a "path coefficient'. The T-value of 2.85 at P is considered statistically significant. In addition, MDR also significantly impacted at p=0.05, the endogenous construct with a path coefficient of 0.9 and a T-value of 1.95, satisfying the guidelines discussed before. The notable point is that the p-value is 0.005. Still, most literature has mentioned it as an essential issue affecting temporal distance.

This is the second-highest factor in the literature and survey; therefore, considered this hypothesis acceptable. Furthermore, MIST also significantly influenced the TDI with a T-value of 1.96 at p=0.5 [48]. Wrap PLS 7.0 is also used to produce six values of the Global fit indices for a comprehensive evaluation of the model, demonstrating that it fits the following criteria and is statistically correct. To calculate the exogenous constructs' effect size on the "endogenous construct" in this investigation. Effect size was used to evaluate the link between the constructs and was defined as "the proportion of a "exogenous latent variable's" R2 value that a "endogenous latent variable" contributes to the R1 value of an endogenous latent variable" [48]. A construct with a value greater than or equal to 0.35 will have a substantial impact. A construct with a value of 0.25 has a medium effect, but one with a value of >0.1 has a tiny influence [43]. To calculate the tolerance of every issue and mitigation strategies with their respective variable all values have shown in Table 7.

i. Average path coefficient (APC) =0.132, P<0.001 [43].
ii. Average R-squared (ARS) =0.698, P<= 5, ideally <= 3.3 [43].
iii. Average full collinearity VIF (AFVIF)" =2.133, acceptable if <= 5, ideally <= 3.3 [43].
iv. Tenenhaus GoF (GoF) = 0.673, small >= 0.1, medium >= 0.25, large >= 0.36 [43].

The concept is empirically and statistically meaningful, according to six global indicators. APC, ARS, and AARS are statistically significant when the p-value is less than or equal to 0.05 [43]. Because the p values of these three variables are all less than 0.05, the current study results indicate that "APC", "ARC", and "AARC" are statistically significant. AARS is frequently smaller than ARS, according to the accepted standard [43]. As a consequence of the current research, the AARS value is 0.686, and the ARS value is 0.698, both of which are within the acceptable criteria. In addition, AVIF and AFVIF are assessed in this research. The AVIF and AFVIF indices add new aspects to the model's interpretation and prediction, boosting its overall quality [51]. The optimum value for "AVIF" and "AFVIF", according to the suggested standard, is = 3.3, with a value of = 5 being reasonable. As a result of the current research, the AVIF and AFVIF values met the supplied requirements, namely, AVIF 2.174 and AFVIF 2.133. This means that both values are optimally acceptable. Finally, the "Tenenhaus GoF (GoF)" is examined and described to measure the explanatory power of a provided conceptual framework [43]. If the (GOF) value is >= 0.1 , the (GOF) threshold is smaller, If GOF >= 0.25, then it is average and If the GOF >= 0.36, increasing[51].

The current research results show that the (GoF) value is 0.673. The (GoF) value results reveal that the conceptual framework's predictive ability is extreme and standard. Therefore, from the previous discussion and analysis of formative models, it has been decided that the outcome and results of this study lie within the supplied criteria, as well as the structural model's evaluation, are statistically meaningful. To calculate the tolerance of every issue and mitigation strategies with their respective variable all values have shown in Table 7. The test of the "conceptual framework hypothesis" is shown in Figure 5.

Table 7: Evaluation of Formative Structural Model

Hypothesis Testing	Path Co-Efficient (B)	SE	T-value	P-value	ES	Results
H1:(MTZD) → TDI	0.16	0.056	2.85	<0.05	0.321	Supported
H2:(MDR) → TDI	0.09	0.046	1.95	$= 0.05$	0.298	Supported
H3:(MIST) → TDI	0.10	0.051	1.96	<0.05	0.192	Supported
H4:(MLTO) → TDI	0.15	0.052	2.88	<0.05	0.491	Supported
H5:(MLSC) → TDI	0.17	0.052	3.26	<0.05	0.259	Supported
H6:(MIC) → TDI	0.17	0.062	2.74	<0.05	0.278	Supported
H7:(MRCF) → TDI	0.13	0.068	1.92	<0.05	0.368	Supported
H8: (MLART)→ TDI	0.11	0.041	2.68	<0.05	0.511	Supported
H9:(MRTOL)→ TDI	0.11	0.049	2.46	<0.05	0.431	Supported

6.4.3. Hypothesis Testing and a Conceptual Framework

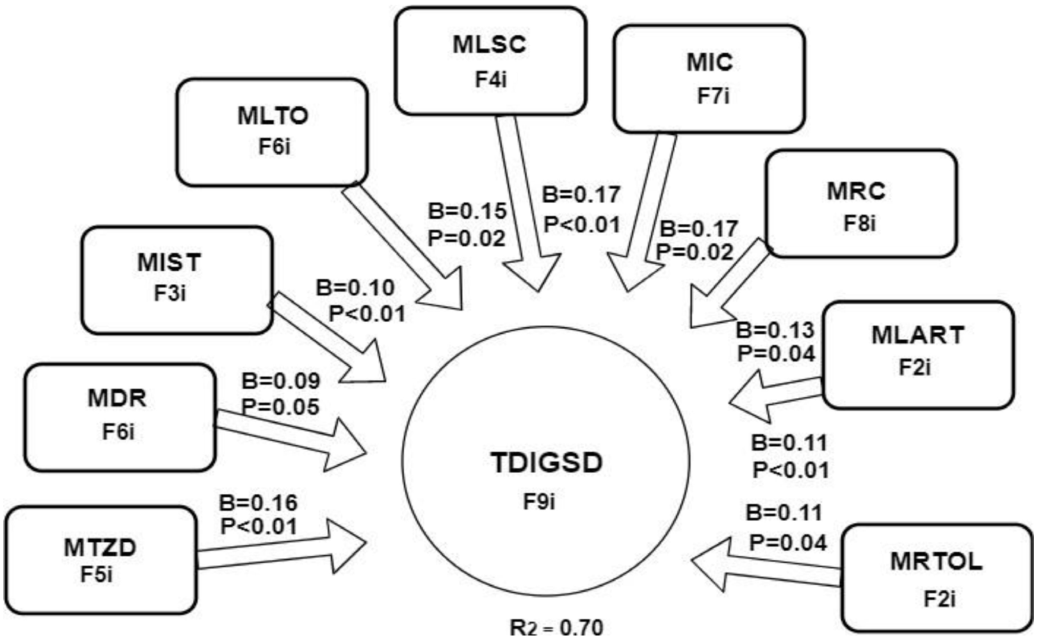

Figure 5: Hypothesis Testing and a Conceptual Framework

7. Discussion

Communication issues involving temporal distance are crucial obstacles in" GSD." Poor communication with remote team members is the leading cause of project failure, and more than half of the GSD base projects failed as a result of this thread [1]. This study identifies and analyzes all temporal distance barriers that impede communication when working collaboratively on distributed projects. Consequently, this study's main goal is to catalogue all temporal distance problems and viable mitigation measures to deal with them. Previous research identified nine temporal distance challenges and related mitigation strategies through previously published SLR and closed-ended interviews. Through SLR, seven issues were identified. One is derived solely from closed-ended interviews and the other from both; a total of 52 mitigation strategies have been uncovered. Seven were identified through interviews, three through both methods, and the remaining individuals were identified using SLR. An empirical evaluation of the framework has been developed to explain and demonstrate the impact and mitigation of these challenges. Numerous Pakistani software companies operating in a Distributed environment have been singled out for data collection. The identified influencing factors are divided into nine groups of temporal distance issues, including time zone differences, response delays, a lack of synchronous communication, less time overlap, and decreased communication frequency. Improper selection of technology, Remote team believing others to be liars or perpetrators of fraud, and Limited availability of remote team members and their respective mitigation strategies). The development and introduction of a conceptual framework to examine the influence of recognized and identified challenges and their mitigation practices. The conceptual framework's hypothesis has been empirically evaluated through quantitative analysis, which addresses the study's results.

Nine categories of mitigation strategies are (exogenous) or independent constructs, which contribute directly to minimizing the effect of endogenous (dependent) construct temporal distance issues (TDI) in GSD. The conceptual framework permits practitioners and researchers to focus on the numerous significant problems and practices associated with time zone issues in GSD. Literature reveals that the temporal distance reduces the availability of remote team members, and the remote team believes that other frauds are not empirically analyzed. The remaining issues, however, are diagnosed empirically. Still, their effect has not been adequately studied. Maximum mitigation strategies have not been empirically examined and are only mentioned in the literature to decrease temporal separation.

Consequently, this study empirically investigates and evaluates the impact of temporal risks and their mitigating practices, which serve to reduce this impact. The findings of the experimental investigation based on the industrial survey confirm that temporal risk factors directly influence the temporal distance in GSD and that its mitigation strategies have resolved these problems. The temporal distance mitigation strategies also increase, confirming the hypothesis (H1) that fewer time zone differences mitigation strategies in GSD significantly impact temporal distance mitigation strategies.

In addition, the results confirm hypothesis (H3), demonstrating that delayed response mitigation measures substantially affect the GSD temporal distance. As more and more mitigation strategies are utilized, temporal distance and feedback issues diminish. Using a different synchronous communication technique reduces these issues, according to a study [23], which supports the hypothesis (H5). The absence of measures to mitigate asynchronous communication will exacerbate the temporal distance concerns of GSD. Multiple studies have demonstrated and maintained similar outcomes. Improper technology selection techniques will directly impact efforts to reduce temporal distance issues supporting the hypothesis (H2). Studies [19] have also shown that excessive strategies for inappropriate technology selection reduce problems among distributed team members (H4). According to the findings, In GSD reduced time overlapping mitigation methods have a substantial direct impact on temporal distance problems, indicating that they are effective (H4). "In GSD challenges, mitigation strategies with less time overlap will significantly affect temporal distance. Utilizing a variety of solutions, the effects of this issue can be mitigated. The authors of [36] noted that correcting comprehension is possible if team members at both locations are appropriately, efficiently, and regularly informed.

Furthermore, empirical evidence supports Hypothesis H6, which states, "Improper communication methods have a significant impact on GSD concerns about temporal distance." Even though the study results indicate that techniques for reducing communication frequency significantly impact GSD temporal distance difficulties, hypothesis (H6) is supported (H7). Frequent use of various strategies minimizing the limited availability of team members' issues led to the resolution of temporal problems in GSD. It supported hypothesis (H8) that remote team members' major factor affecting temporal distance in GSD is the availability of mitigation techniques. Lastly, based on the empirical evaluation, various interviewees indicate that mitigation strategies for remote team members who believe other team members are committing fraud can improve time to market. Numerous methods have been employed to confirm the hypothesis (H9). From a theoretical standpoint, the present study contributes to the empirical review of nine key factors that significantly impact temporal distance risks and their mitigation strategies to mitigate their effects. In addition to this assumption, a conceptual framework was created to explain the influence of effective mitigation strategies in the GSD environment on temporal distance issues.

8. Conclusion and Future Work

In terms of temporal distance, global software development faces significant challenges. Improper communication among group members is the primary reason GSD projects have failed more than half of the time globally. In a prior study, an SLR was conducted to identify temporal distance issues and their corresponding mitigation strategies, and a conceptual framework was proposed but not empirically validated. In this investigation, an empirical analysis is conducted. Consequently, this study aims to conduct a scientific analysis of the obstacles and mitigation strategies. Small and medium-sized GSD-based organizations in Pakistan are surveyed online to collect data and validate the framework's hypothesis. From 68 selected studies, nine problems have been identified, along with mitigation strategies. Nine issues have been identified, seven of which are based on literature, one on interviews, and one on both literature and interviews. In addition, temporal distance mitigation strategies have been identified. Seven interview-based, three interview-and-literature-based, and one literature-only mitigation strategy out of 44 have been acknowledged. The findings indicate that all temporal distance challenges (as well as their mitigation measures) significantly impact temporal distance concerns.

In the future, the impact of temporal distance risks on the success rate of GSD projects can be analyzed to identify critical success factors and mitigation strategies for temporal distance. The issue's causes and negative effects can be identified using the analytical network process algorithm, and the most critical strategy and temporal distance issues can be ranked in order of importance (ANP). In addition, a study is conducted on small and medium-sized GSD groups.
As with other research, this one has some limitations. To generalize the results, it is recommended that similar research be conducted in another country. Other electronic databases can be used in SLR to find additional factors and their appropriate mitigation strategies. The survey can be repeated with participants from larger GSD organizations in the future the Analytical Hierarchical Process (AHP) method could be useful for prioritizing issues and mitigation strategies in the software industry.

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APPENDIX

Survey Questionnaire

TABLE 1: Demographic & Organization-Related Information

Section A-Demographic Information				
Email				
Gender			Male	Female
Education	High School	Diploma	Bachelors	Post Graduate
Working Experiences in GSD	1-3 Years	4-7 years	8-10 years	More than 10 years
Position	Developer	Tester	Designer	Analyst
	Team manager	Project Manager	CEO	Other

Section B -Organization Related Information				
Nature of Projects	Software Development	Web Development		If Other (please specify)
Number of Employees	Between 10-25 employee's	26-50 employees	51-80 employees	80-250 employees

Table 2: Section-C Temporal distance issues and mitigation strategies in GSD

Items	Strongly Disagree	Disagree	Agree	Neural	Strongly Agree
Temporal Distance Issues in GSD					
Lack of management of time Differences.	1	2	3	4	5
Lack of synchronous communication.	1	2	3	4	5
Lack of frequent feedback.	1	2	3	4	5
Improper selection of communication technology	1	2	3	4	5
Few overlapping hours.	1	2	3	4	5
Reduced communication frequency.	1	2	3	4	5

Lack of adequate communication.	1	2	3	4	5
Less availability of remote					
Team members.	1	2	3	4	5
Remote team think other doing fraud.	1	2	3	4	5
Mitigation strategies for time zone differences					
Follow-the-sun concept/24 hours available	1	2	3	4	5
Fixed timed for communication.	1	2	3	4	5
Shifting the working hours.	1	2	3	4	5
Whole team have same time zone/less different time zone	1	2	3	4	5
use asynchronous communication	1	2	3	4	5
Use synchronous communication.	1	2	3	4	5
Mitigation strategies for Delayed in response					
Use synchronous communication.	1	2	3	4	5
Feedback channel should be Robust.	1	2	3	4	5
To promote informal communication among the team	1	2	3	4	5
To establish an appropriate communication Infrastructure.	1	2	3	4	5
Use asynchronous communication.	1	2	3	4	5
Availability of fast internet	1	2	3	4	5
Mitigation strategies for Lack of synchronous communication					
use synchronous communication	1	2	3	4	5
use KABAN tools (like Hip					
Chat, Link).	1	2	3	4	5
Use asynchronous communication with security functionality (email, text mes-sages etc.)	1	2	3	4	5
Enhance Face-to-face communication.	1	2	3	4	5
Improper selection of technology mitigation strategy					
Use asynchronous communication (email, text messages etc.).	1	2	3	4	5
Use rich communication tools/communication channel.	1	2	3	4	5
Using already used tech nologies instead of new technology	1	2	3	4	5
Inadequate communication mitigation strategies					
Communicate efficient and effectively.	1	2	3	4	5
Adequate and appropriate communication.	1	2	3	4	5
Use predefine communication protocol.	1	2	3	4	5
Follow standard process though out the organization.	1	2	3	4	5

Team are knowledgeable					
And skillful.	1	2	3	4	5
Train team members.	1	2	3	4	5
Reduce communication frequency mitigation strategies Communicate efficient and Effectively.	1	2	3	4	5
To encourage frequent communication.	1	2	3	4	5
By using proper tools and technique To encourage effective communication.	1	2	3	4	5
To promote the adoption of groupware application.	1	2	3	4	5
Use synchronous communication.	1	2	3	4	5
use of collaborative software And tools.	1	2	3	4	5
Common language use language like English.	1	2	3	4	5
Proper negotiations are needed.	1	2	3	4	5
Less time overlapping mitigation strategies					
Schedule regular meetings In advance.	1	2	3	4	5
Communication among team more as compare to normally them communicate.	1	2	3	4	5
Use asynchronous communication media.	1	2	3	4	5
Number of overlapping hours should be increase.	1	2	3	4	5
Synchronous communication.	1	2	3	4	5
Shift work hour to increase time overlap.	1	2	3	4	5
Less availability of Remote team members mitigation strategies					
Increases the number of overlapping hours between the team members.	1	2	3	4	5
Team members should stay available as much as they can even after office hours.	1	2	3	4	5
Remote team think other doing fraud mitigation strategies					
Apply agile practices such scrum (daily and schedule meetings etc.).	1	2	3	4	5
Maximize response level.	1	2	3	4	5