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Risks and risk mitigation in global software development: A tertiary study

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ABSTRACT

Context
There is extensive interest in global software development (GSD) which has led to a large number of papers reporting on GSD. A number of systematic literature reviews (SLRs) have attempted to aggregate information from individual studies.
Objective: We wish to investigate GSD SLR research with a focus on discovering what research has been conducted in the area and to determine if the SLRs furnish appropriate risk and risk mitigation advice to provide guidance to organizations involved with GSD.
Method: We performed a broad automated search to identify GSD SLRs. Data extracted from each study included: (1) authors, their affiliation and publishing venue, (2) SLR quality, (3) research focus, (4) GSD risks, (5) risk mitigation strategies and, (6) for each SLR the number of primary studies reporting each risk and risk mitigation strategy.
Results: We found a total of 37 papers reporting 24 unique GSD SLR studies. Major GSD topics covered include: (1) organizational environment, (2) project execution, (3) project planning and control and (4) project scope and requirements. We extracted 85 risks and 77 risk mitigation advice items and categorized them under four major headings: outsourcing rationale, software development, human resources, and project management. The largest group of risks was related to project management. GSD outsourcing rationale risks ranked highest in terms of primary study support but in many cases these risks were only identified by a single SLR.
Conclusions: The focus of the GSD SLRs we identified is mapping the research rather than providing evidence-based guidance to industry. Empirical support for the majority of risks identified is moderate to low, both in terms of the number of SLRs identifying the risk, and in the number of primary studies providing empirical support. Risk mitigation advice is also limited, and empirical support for these items is low.

1. Introduction

The aim of this research is to investigate risk and risk mitigation strategies in global software development (GSD). In order to achieve this goal we have undertaken an assessment of GSD systematic literature reviews (SLRs). An SLR is a way of synthesising existing research by following a rigorous, pre-defined procedure aimed at reducing bias. They are based on aggregating the research undertaken in other studies. The aggregated studies are referred to as primary studies. Since it summarises the research undertaken in primary studies, a SLR is referred to as a secondary study. A systematic mapping study, or mapping study, is a form of SLR that aims to address a broader set of research questions in order to provide a 'map' of a particular topic area by investigating, for example, the number of papers published on the topic per year and where the papers are most frequently published [23]. Studies which synthesize data and information from a number of SLRs in a particular area are called tertiary studies.

This paper is an extended version of a paper previously presented at EASE 2012 [34]. While our initial investigation focused on mapping GSD SLR research and identifying active researchers and institutions, we now extend our earlier study to include the identification of GSD risks, and risk mitigation advice. As we are involved in research aiming to provide recommendations for GSD

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client organizations, we wish to discover if the SLRs we identified furnish enough risk and risk mitigation advice to provide a useful foundation for this work. If there is not enough detail we would need to perform a new SLR ourselves to achieve our ultimate research goals. We next provide a short overview of GSD, then briefly discuss GSD risks and conclude this section with our research questions.

1.1. Global software development

The software development paradigm is changing with improvements in telecommunications encouraging the increased use of GSD (also termed distributed software development (DSD), distributed software engineering (DSE) and global software engineering (GSE)). GSD is used to describe one of the following situations:

- When organizations shift all or part of their software development to another country (referred to as off shoring), to lower cost destinations, and/or to destinations where the required skills are more readily available. Such organizations are normally independent client companies who outsource their software development to a vendor or software supplier who then develops the software.
- When multinational organizations distribute their software development activities across multiple subsidiary sites, many of which are in different countries, e.g., IBM, Bosch, Siemens [3] and Phillips [24]. Here, the multinational subsidiary that requires the software can be viewed as the client and the subsidiaries that develop the software can be considered (in some ways) equivalent to software vendors.

The motivation for GSD is usually to achieve improvements in time-to-market efficiency, to obtain access to a larger number of resources at lower cost, and thus to gain and maintain competitive advantage [24]. The growth of GSD has been helped by the availability of well educated and technically competent software engineers in low cost areas such as Eastern Europe, Latin America, India and the Far East [5]. GSD growth means that many software engineers have to collaborate over geographic, temporal, cultural and linguistic distances [29]. However, the benefits associated with GSD will not be achievable unless project risks are managed throughout the life cycle of these projects.

1.2. Global software development risks

Despite the potential benefits there is no more promise of GSD success than there is for in-house development or domestic outsourcing and, in light of the additional risks incurred, GSD may be an uncertain undertaking [12,13]. In this context a risk denotes a particular aspect or property of a software development task, process, or environment, which, if is ignored, will increase the likelihood of project failure [30]. GSD introduces risks which may not be fully understood and hence are not properly mitigated [11]. Failure to understand and manage project risks can result in significant losses, including project failure, and this may subsequently affect the achievement of an organization's business objectives [33]. Many organizations that have undertaken GSD have discovered that off shoring to distant subsidiaries or outsourcing software development to remote software vendors is neither simple nor straightforward [5]; GSD projects are often large-scale, and global development leads to significantly increased complexity. GSD complexity leads to increased risk. Offshore projects tend to be unsuccessful, because "physical, time, cultural, organizational, and stakeholder distances negatively influence communication and knowledge exchange between onshore and offshore project team members" [14]. When a software project is carried out in multiple countries, the software development project manager must address execution risks, such as those related to project distribution, time zone differences, as well as issues related to communication, coordination and control, project context, and infrastructure [4,16,17]. In some cases organizations have found that GSD efficiency is disappointingly low with up to 50% of development effort spent on overheads such as communication and increased project management [24]. Suggestions have been made that a 50% failure rate for GSD projects is not uncommon [26].

Organizations frequently consider offshore systems development in the belief that projects can be completed at lower cost. While prices quoted by offshore vendors may be very appealing additional risks must be considered when considering offshore systems development. These risks have associated costs and typically result in additional indirect costs which add to the total payment required for the delivered system. However, such costs are seldom considered by companies at the outset of a project, yet may become painfully apparent once the project is under way [11].

All software development projects involve some degree of risk and some GSD project risks are identical to those faced by onshore developments [11]. However, as noted earlier, there are issues that need special attention in the offshore context. Building on conventional risk factors from earlier research, a survey of senior IT executives with offshore project experience [28] produced a ranking of risk factors that apply to GSD projects. Risks identified were those that (1) appeared both in on-shore and offshore projects but were exacerbated in the offshore context, and (2) those that were unique to the offshore context. Their findings suggested that the offshore context was more vulnerable to some traditional risks such as communication issues, poor change controls (scope creep), lack of business know-how, and failure to consider all costs. Communication in the offshore context can be especially risky due to the effect of language and cultural differences between the onshore client and offshore vendor: poor change control figures prominently in both contexts. What stood out in the offshore context was lack of business know-how. Client product managers found it difficult to convey to overseas vendors the business practices and competencies of a company. Factors unique to the offshore context [28] included seven risk factors specific to GSD: language barriers in project communications; cross-national cultural differences; constraints due to time-zone differences; unfamiliarity with international and foreign contract law; political instability in offshore destinations; negative impact on image of client organization; and currency fluctuations. One comment by an expert illustrated these concerns: "Doing business with a different country usually involves risks of a dispute due to different (or incompatible) laws, currency, business and accounting practices, failure of communication lines and travel, political risk, etc. Telecommunications and infrastructure issues arose because of a lack of reliable networks in some countries" [28].

To deal with the increased GSD risks the client must monitor the development closely [1,33] and an experienced project manager with an understanding of the most widespread risks can help alleviate problems before they occur. Thus the findings of our research may assist clients to recognize and understand risk factors that affect such projects, so that effective actions can be taken before the risks manifest themselves into problems that damage the project [33]. When projects go awry there can be a disinclination to investigate the real reasons, so we frequently are unable to identify which risks proved fatal. It is less embarrassing for a company to bury the project and move on, particularly if the mistakes were overarching high level management errors, e.g., without sufficient high level management support many stakeholders may not feel inclined to fully cooperate in requirements gathering [33]. Few failed projects result in litigation; of those that do, most are settled out of court and the "gag orders" imposed make it difficult to find

out what actually happened [2]. Hence, there is a danger that companies involved in GSD projects will continue making the same mistakes.

1.3. Research questions

Over the past few years there has been a considerable increase in GSD research. A large number of research papers discussing GSD issues have already led some researchers to undertake systematic reviews. Since our goal is to assess the scope of GSD research and to identify what is known about risk management in the context of GSD, we decided to perform a tertiary systematic literature review using GSD-related SLRs to provide our data. A tertiary SLR is a SLR of secondary studies [21]. We specify our research questions as:

RQ1 What GSD SLR studies have been published?
- RQ1.1 When and where were the GSD SLR research papers published?
- RQ1.2 What GSD research topics are addressed?
- RQ1.3 What are the gaps in the GSD topics addressed?
- RQ1.4 Which researchers and institutions are active in GSD SLRs?

RQ2 What is the quality of GSD SLRs and is it changing over time?

RQ3 What risks and risk mitigation advice are identified in the SLRs and what empirical support is provided for them; are the results different if we exclude low quality studies?
- RQ3.1 What are the most common GSD project risks and what empirical support do the SLRs provide for these risks?
- RQ3.2 What risk mitigation advice is proposed for the risks and what empirical support do the SLRs provide for the advice?
- RQ3.3 Do we obtain different results if we exclude low quality studies?
- RQ3.4 Which risks are the responsibility of the client and which are the responsibility of the vendor?

In the next section we discuss related work; in Section 3 we describe our research methodology; in Section 4 we present our results. Section 5 discusses the limitations of our research while Section 6 presents a discussion, conclusions and further work

2. Related work

We identified five tertiary SLRs relevant to our research [8,15,21,22,25]; three studies focus on general software engineering (including GSD) while the two most recent focus specifically on GSD [15,25]. The first of the tertiary studies, Kitchenham et al. [21], is a mapping study that investigated SLRs in software engineering. The goal was to identify how many software engineering SLRs had been published, what research topics were addressed, and the SLRs' limitations. Twenty SLRs were identified; however none were related to GSD [21]. Kitchenham et al., [22] published an extension to the first study in 2010. They contrasted the number, quality, and source of the SLRs extracted with the SLRs identified in their original study [21] and found that high quality studies were likely to be found in a targeted set of papers and conference but a complete set of papers needed a broader search. They identified a single GSD SLR. The goal of da Silva et al., [8] in 2011 was to extend and update the two previous tertiary studies [21,22]. Sixty-seven new SLRs addressing 24 software engineering topics were found; nine were related to GSD. da Silva et al., found proportionally more mapping studies than conventional systematic reviews and the authors thought the results indicated that systematic reviews are increasingly being used as an important tool in performing unbiased and comprehensive research mappings [8].

Hanssen et al's 2011 workshop paper is a tertiary review focussing on agile GSD [15]. It is a mapping study that used an automated search of ISI Web of Science and Google Scholar to find 12 GSD SLRs. All the research papers from which data were extracted were published between 2008 and 2011. Hanssen et al.'s research questions focussed on (1) interest in implementing agile methods in GSD, and (2) the application of agile methods in GSD. They found that while a number of systematic reviews focussed on GSD challenges and solutions only two reviews specifically focussed on agile development. They note that authors of several secondary studies commented that "vague or missing backgrounds" (i.e. context) in primary studies makes it hard to properly comprehend the results [15].

Marques, Rodrigues, and Conte's 2012 conference paper is a tertiary GSD mapping study [25]. The authors investigated GSD SLRs, in particular the research topics, research questions, individuals and organizations involved in SLR-based GSD research, and the limitations of systematic literature reviews in GSD. An automated search using the Scopus indexing system, without any publication period restrictions, was conducted in July 2011 and replicated in January 2012. Of the 14 SLRs identified, seven were categorized as managing distributed development; four addressed engineering process topics and the other three focussed on requirements, design and software engineering education in GSD. The authors concluded that the topic areas covered by SLRs were limited, that the majority of SLRs were focused on summarizing current knowledge concerning a specific research question, that despite the number of SLRs, the number of empirical studies is relatively small, and that there is little aggregated knowledge.

In order to provide guidance to organizations involved with GSD, and to determine if the SLRs we identify furnish appropriate risk and risk mitigation advice related to project management and problems experienced in GSD projects, we conducted a tertiary SLR. This topic is not addressed by the tertiary studies described above, although they do provide a set of studies that we can use to crosscheck our search in order to assess its completeness.

3. Research methodology

As noted earlier, guidelines for applying SLRs within software engineering have been developed [23] and a number of SLRs on software engineering and related topics have been published. The research described here is a tertiary SLR study investigating SLRs in global software development; it is a mapping study intended to provide an overview of research in GSD. However, because we ultimately wish to provide advice to GSD project managers we are interested in more than just mapping the research and also investigate GSD risks, risk mitigation strategies and the supporting evidence provided by the SLRs for the risks identified and risk mitigation strategies suggested.

An SLR of any kind is a method of "identifying, evaluating and interpreting all available research relevant to a particular research question or topic area or phenomenon of interest" [23]. The aim is to synthesize existing evidence in a fair, rigorous, and open manner. After specifying research questions a review protocol is developed; this includes definitions of: (1) the search process, including search strings and other search criteria, (2) inclusion and exclusion criteria, (3) the selection process, (4) the data extraction process, including quality assessment, and (5) data synthesis. The following subsections describe the research methods specified in our protocol which were used to conduct our tertiary study.

3.1. Search process

A broad search, combining automated and manual searches to increase coverage, was conducted (between September 2011 and

October 2011) to identify peer-reviewed articles published (or available on-line) up to October 2011. The search process used seven search engines and indexing systems, i.e., ACM Digital library, IEEE Explore, Scopus, Science Direct, Web of Knowledge, SpringerLink and Google Scholar. Manual searches of the Proceedings of the IEEE ICGSE, and Proceedings of the Conference on Evaluation and Assessment in Software Engineering (EASE) were conducted; in addition reference lists of all selected papers were scanned for additional papers (snowballing).

Search terms used were ((global OR distributed OR outsourc* OR offshor*) AND (software engineering OR software development OR software production) AND (review of studies OR structured review OR systematic review OR literature review OR systematic literature review OR literature analysis OR in-depth survey OR literature survey OR meta-analysis OR analysis of research OR empirical body of knowledge OR overview of existing research OR body of published knowledge)). Adjustments as necessary were made to fit the syntax of the search engines used. Coverage of the search terms was checked against the papers with a GSD focus included in [8,15,25].

3.2. Inclusion/exclusion criteria

Articles were included if they:

- Reported SLRs or meta-analyses in GSD.
- Were published in, or submitted to, a conference or journal or were technical reports or book chapters.
- Were written in English.

Articles related to the following were excluded:

- Masters studies not published in refereed conferences or journals.
- Informal literature surveys (i.e. literature surveys with no defined search questions, no search process, no defined data extraction or data analysis process).
- Papers discussing the process of performing SLRs, or meta-analyses.
- SLRs relating to topics such as evaluating installed systems and applications.
- SLRs dealing with open source software development.
- SLRs related to IT services, software applications and IT operations.
- SLRs related to teaching and education.
- SLRs reported only in PowerPoint slides or abstracts.

3.3. Paper selection

Papers resulting from the automated and manual searches were reviewed by the first author who, after considering the title and if required, the abstract, rejected all papers that were obviously not relevant. This resulted in 115 candidate papers. The same researcher read the abstract and conclusions of the selected papers and, based on the inclusion and exclusion criteria identified 69 papers that appeared to be relevant. Each of these papers was then read by another member of the team and only those papers that both researchers considered relevant were included. This resulted in 35 papers considered appropriate for inclusion.

We reference the papers included in our study and listed in Table 1 with an S and a study number, e.g., [S12]. Where there is more than one paper reporting the same study we follow this with a letter referring to the particular paper, e.g., [S12b]. Review of the references in the selected papers resulted in identification of two additional papers not retrieved earlier, making 37 papers in all. Though these two papers were not at that time refereed they were relevant to our research. One was a technical report [S23], and the other was a paper that had been submitted to a journal but had not at that stage been accepted [S5a].

As noted earlier we reviewed the papers we selected against those included in the previous GSD tertiary studies described in Section 2 above [8,15,25]. We found all appropriate GSD papers referenced in [8,9] and all papers in [15,25] although we rejected one paper [27], included in [25] as it dealt with GSD and education and our exclusion criteria explicitly excluded "SLRs related to teaching and education".

3.4. Data extraction

Data extraction occurred in two phases; firstly data for RQ1 and RQ2 were collected and analysed. Only then did we extract data for RQ3. As we were particularly interested in identifying SLR studies that were reported in more than one paper the first author reviewed all papers in order to identify multiple papers with similar authors reporting aspects of the same study; another researcher independently reviewed all papers written by similar groups of researchers. Disagreements were settled by discussion. We considered it important not to reject papers by the same authors reporting aspects of the same study as we are aware that space limitations for conference papers do not always allow researchers to report all their results in a single paper. When we discuss a SLR study reported in more than one paper, we extracted most data from the paper that provided the most details of the study (often a journal paper).

3.4.1. Global software development SLR study details

The title of the papers, authors' names, their affiliations, and publication venues were extracted by the first author. For other data, data extraction forms were provided (See Appendix, Table A1a, Mapping Data Extraction Form. The first author extracted data from all of the papers and data was also extracted for each paper by one of the other researchers; the results were then compared. The following details were extracted for RQ1: What GSD SLR studies have been published?

- Type of study: meta analysis, SLR, or mapping study.
- Main GSD topic and research questions explored.
- Whether the SLR was unique; i.e., whether the SLR was published as a single paper or whether the same group of authors published several papers addressing the same study.

3.4.2. Quality assessment

To answer RQ2 "What is the quality of GSD SLRs and is it changing over time?", each SLR was evaluated for quality using the York University DARE Criteria (DARE) [7]. Each study was evaluated for quality by two researchers (the first author evaluated all studies while the other four authors evaluated a quarter of the studies each). There were four disagreements between researchers that were resolved by a third researcher independently extracting the data. The quality criteria used here are the same criteria used in [21], except that we have included an additional criterion, synthesis method, as the DARE criteria were recently updated to include synthesis methods [7]. Although we collected data on the synthesis method used and discuss synthesis briefly in our results, we have omitted synthesis from our quality scores in Table 1 as we did not wish to penalize papers that were written before DARE added this criterion in 2009. At least seven of our studies (29%) and 15 of our papers (41%) were completed before this criterion was added. The criteria are based on five questions and scored as shown in Appendix, Table A1b: Data extraction form for quality.

Table 1
GSD SLR studies and papers reporting those studies.

Study and paper	No. of primary studies	Quality (max. 4)	Authors and title
[S1a]	Unknown	1.5	Ågerfalk P. J., Holmström H., Lings B., Lundell B., Conchúir E.Ó., (2005) "A Framework for Considering Opportunities and Threats in Distributed Software Development"
[S1b]			Lings B., Lundell B., Agerfalk P., Fitzgerald B., (2006) "Ten strategies for successful distributed development"
[S2]	25	1.5	Ali, N., Beecham, S., Mistrík, I., (2010) "Architectural knowledge management in global software development: A review"
[S3]	315	1.5	Alsudairi M, Dwivedi Y. K., (2010) "A multi-disciplinary profile of IS/IT outsourcing research"
[S4]	25	2.5	Costa C., Cunha C., Rocha R., Franca A., da Silva F., Prikladnicki R., (2011) "Models and tools for Managing Distributed Software Development: A systematic literature review"
[S5a]	70	3	da Silva F. Q. B., Prikladnicki R., França A. C. C., Monteiro C. V. F., Costa C., Rocha R., (2011) "Research and Practice of Distributed Software Development Project Management: A Systematic Mapping Study"
[S5b]			da Silva F.Q.B., Prikladnicki R., França A., Monteiro C., Costa C., Rocha R.,(2011) "An evidence-based model of distributed software development project management: results from a systematic mapping study"
[S5c]			da Silva F.Q.B., Costa C., França A.C.C., Prikladnicki R., (2010) "Challenges and solutions in Distributed Software Development Project Management: A systematic literature review"
[S6]	12	1.5	Ebling, T., Audy, J.L.N., Prikladnicki, R., (2009) "A systematic literature review of requirements engineering in distributed software development environments"
[S7]	24	3	Fauzi S. S. M., Bannerman P. L., Staples M., (2010) "Software Configuration Management in Global Software Development; A Systematic map"
[S8]	20	3	Hossain E., Ali Babar M., Paik H.-Y., (2009) "Using scrum in global software development: A systematic literature review"
[S9]	31	2.5	Huang H., (2007) " Cultural Issues in Globally Distributed Information Systems Development; A Survey and Analysis"
[S10a]	77	2	Jalali, S., Wohlin, C., (2011) "Global software engineering and agile practices: a systematic review"
[S10b]			Jalali, S., Wohlin, C., (2010) "Agile practices in global software engineering – A systematic map"
[S11a]	60	2.5	Jiménez M., Piattini M., Vizcaino A., (2010) "A Systematic Review of Distributed Software Development: Problems and Solutions"
[S11b]	69		Jimenez M., Piattini M., (2009) "Problems and solutions in Distributed Software Development: A Systematic Review"
[S11c]	78		Jiménez M., Piattini M., Vizcaino A., (2009) "Challenges and improvements in distributed software development: A systematic review"
[S12a]	98	2.5	Khan, S.U., Niazi, M., Ahmad, R., (2011) "Barriers in the selection of offshore software development outsourcing vendors: An exploratory study using a systematic literature review"
[S12b]			Khan, S.U., Niazi, M., Ahmad, R., (2009) "Critical barriers for offshore software development outsourcing vendors: A systematic literature review"
[S13a]	122	2.5	Khan, S.U., Niazi, M., Ahmad, R., (2011) "Factors influencing clients in the selection of offshore software outsourcing vendors: An exploratory study using a systematic literature review"
[S13b]			Khan, S.U., Niazi, M., Ahmad, R., (2009) " Critical success factors for offshore software development outsourcing vendors: a systematic literature review"
[S14]	Unknown	0.5	Kroll, J., Luis J., Audy N., Prikladnick R., (2010), "Mapping the evolution of research on global software engineering: A Systematic Literature Review"
[S15]	36	2	López, A., Nicolás, J., Toval, A., (2009) "Risks and safeguards for the requirements engineering process in global software development"
[S16]	26	2	Noll J., Beecham S., Richardson I., (2010) "Global software development and collaboration: barriers and solutions"
[S17]	86	1.5	Nurdiani I., Jabangwe R., Šmite D., Damian D., (2011) "Risk Identification and Risk Mitigation Instruments for Global Software Engineering: A systematic review and survey results"
[S18a]			Persson J S., Mathiassen L., (2011) "A process for managing risks in Distributed teams"
[S18b]	72	3	Persson J.S., Mathiassen L., Boeg J., Madsen T. S., Steinson F., (2009) "Managing Risks in Distributed Software Projects An Integrative framework"
[S19a]	30	3	Prikladnicki R., Audy, J. L. N., (2010) "Process Models in the practice of distributed software development: A systematic review of the literature"
[S19b]			Prikladnicki, R., Audy, J. L. N., Shull, F., (2010) "Patterns in effective distributed software development"
[S19c]			Prikladnicki R., Damien D., Audy J. L. N., (2008) "Patterns of evolution in the practice of distributed software development: quantitative results from a systematic review"
[S20]	9	3	Rocha R. G. C., Costa C., Rodrigues C., de Azevedo R. R., Junior I. H., Meira S., Prikladnicki R., (2011) "Collaboration models in distributed software development a systematic review"
[S21a]	59	2.5	Šmite, D., Wohlin, C., Gorschek, T., Feldt, R., (2010) "Empirical evidence in global software engineering: A systematic review"
[S21b]			Šmite, D., Wohlin, C., (2011) "A whisper of evidence in global software engineering"
[S21c]			Šmite D., Wohlin C., Gorschek T., Feldt R., (2008) "Reporting Empirical Research in Global Software Engineering: a classification scheme"
[S22]	42	2	Steinmacher I., Chaves A.P., Gerosa, M.A., (2010) "Awareness support in global software development: A systematic review based on the 3C collaboration model"
[S23]	83	2.5	Treude, C., Storey M.-A., Weber J., (2009) "Empirical studies on collaboration in software development A systematic Literature Review"
[S24]	57	1.5	Yalaho A., (2006) "A Conceptual Model of ICT-Supported Unified Process of International Outsourcing of Software Production"

3.4.3. Mapping risk and risk mitigation and their details

Table A2 (Risk and Risk Mitigation Data Extraction Form, in the Appendix), presents the data extraction form used to record the information required to answer RQ3: What risks and risk mitigation advice are identified in the SLRs and what empirical support is provided for them? The first author extracted data from all studies. To check the first author's data extraction the other four authors each extracted data from two of the SLR studies. This meant that we had eight studies where we could compare the first author's data with that extracted by the other authors (thus giving a 33% data extraction check). If the overall level of agreement had been poor then data extraction from the other studies would have been undertaken by the other four authors. This was however, not required as the data extraction check provided good agreement

between researchers. There was slight disagreement (on empirical support for 2 risks) between the first author and one of the other researchers; this was resolved by discussion. The following data was obtained:

- Risks identified in the study plus any mitigation advice suggested.
- SWEBOK [19] classification for risk and mitigation advice.
- Number of primary studies supporting the risk or risk mitigation strategy.
- Whether the mitigation strategy advice was meant for the client or the vendor.

3.5. Data synthesis

Most of the data was aggregated using simple counts and percentages. To answer RQ1.2 "What GSD research topics are addressed?", thematic analysis was used [18] and the main topic of each study was mapped to SWEBOK [19]. The first author then mapped the topics to Abdullah and Verner's outsourcing risk framework [1] and the ISO 12207 framework [32] used by Jimenez et al. [S11]. The ISO framework comprises three main lifecycle process areas (primary, organizational and supporting), with each process area having several sub-processes that comprise a number of tasks.

To answer the first part of RQ3, "What risks and risk mitigation advice are identified in the SLRs and what empirical support is provided for them?" we

- Developed two spreadsheets, one for risks and one for advice items.
- Each risk (and advice item) with explicit primary study support was extracted and stored in the appropriate spread sheet with its SLR study reference and number of supporting primary studies.
- Each risk and mitigation item was then categorized by a category and sub category obtained from RQ1.2 (see Table 5 for categories used).
- Thematic analysis [18] was then used to organize the items into appropriate themes and sub-themes.
- The risks and advice items were then sorted by theme, subtheme, and empirical support to identify the relative importance of each risk and mitigation strategy.
- If different authors used slightly different wording for the same risk we consolidated the wording into a single risk description.
- The sorted risks and risk mitigation strategy items were added to the tables based on the themes and subthemes; mitigation strategies were matched to a corresponding risk if possible.
- Because we were interested in the mapping risks and mitigation advice with the most empirical support, items with support from fewer than three primary studies, or that had an unspecified level of empirical support were excluded from the tables.

4. Results

This section reports on the results of our investigations. Section 4.1 describes what GSD SLRs have been published; Section 4.2 summarizes when and where the GSD SLRs were published; Section 4.3 investigates what research topics were addressed or not addressed by our GSD SLRs; Section 4.4 discusses which researchers and institutions are active in GSD SLRs; Section 4.5 discusses the quality of the SLRs, Section 4.6 examines GSD risks, risk mitigation advice together with their empirical support, and Section 4.7 provides a summary of the results related to risks, risk mitigation advice and their empirical support as well as differences in results should we omit support from low quality SLRs.

4.1. RQ1-What GSD SLR studies have been published?

In Table 1 we present the papers we identified. We organize the results by SLR study, and list each of the papers that describe the same study. We found 24 studies reported in 37 papers. Fifteen studies (63%) are reported by a single paper; five studies (21%) by two papers; and four studies (17%) by three papers.

4.2. RQ1.1 When and where were the GSD SLR research papers published?

The *IEEE ICGSE* is the most popular conference for this research with seven papers published between 2008 and 2010. The *Proceedings of ICEIS*, *EASE* and *APSEC* each include two papers. Though the most popular journal for this type of paper is *IEEE Software*, the papers published there provide summaries of the studies aimed at practitioners rather than providing comprehensive details of the SLR. The *Journal of Software Maintenance Evolution and Practice* has published several special issues with extended versions of the best papers from *ICGSE*. It is not surprising that *Information and Software Technology* provides a venue for SLR studies as it has a special section devoted to the topic. The rest of the journals in which the publications appear are fairly scattered, though *Empirical Software Engineering* is represented and will be publishing a special issue that will include extended versions of the best papers from *ICGSE 2012*. When we consider the year in which the (most complete) paper reporting each study was published, we obtain the results shown in Table 2; the first GSD SLR was published in 2005; research continued at a fairly low level until there was a marked increase in 2009, 2010 and 2011. Tables 3 and 4 provide details of the publication outlets for the papers describing our GSD SLR studies. Twenty papers (54%) are conference proceedings, 15 papers (41%) are journal papers, one paper appears as a book chapter, and one is a technical report.

4.3. RQ1.2 What GSD research topics are addressed?

The research topics addressed by our studies are shown in Table 5. Column 1 in Table 5 shows the main topics organized by the headings we developed using thematic analysis. When we mapped the main topic of each study against SWEBOK [19] and later PMBOK [20] we discovered that the topics addressed in our studies were difficult to fit into either framework. Kroll et al. [S13] also mapped their studies against PMBOK and SWEBOK and noted that these frameworks do not have knowledge areas appropriate for classifying some of the studies they found. Our studies fitted better into Abdullah and Verner's outsourcing risk framework [1] even though their framework was designed for outsourced software development, not specifically GSD (column 2 in Table 5). We identified Vendor Selection as a topic that should be incorporated into the Abdullah and Verner outsourcing framework; we believe that with further development this framework

Table 2
Studies by year.

Year	Number of studies	Average quality of studies by year	Standard deviation of Quality Score
2005	1	1.5	0
2006	1	1.5	0
2007	1	2.5	0
2008	0		
2009	4	2.4	0.6519
2010	9	1.94	0.7763
2011 (until October)	8	2.5	0.5774

Table 3
Publishing outlets for GSD SLRs.

Publisher	Journal/Book/Report	Number
IEEE	Software 2010, 2011	3
	Transactions on Engineering Management 2009	1
Springer	Empirical Software Engineering 2010	1
Elsevier	Information and Software Technology 2010, 2011	2
	Journal of Systems and Software 2011	1
ACM	Inroads 2010	1
Wiley	Journal of Software Maintenance and Evolution: Research and Practice, 2011	2
CLEI	Electronic Journal 2011	1
Emerald	Journal of Enterprise Information Management 2010	1
Hindawi	Advances in Software Engineering 2009	1
IGI Global	Handbook of Research on Software Engineering IGI Global and Productivity Technologies: Implications of Globalization 2010	1
University of Victoria, Canada	Technical Report 2009	1

[1] may be useful as a risk framework for GSD projects. As well as using [1], we also mapped our study topics against the ISO 12207 framework [32] used by Jimenez et al. [S11]. This framework comprises three main lifecycle process areas (primary, organizational and supporting); each process includes several sub-processes each of which comprises a number of tasks (see columns 3 and 4 in Table 5).

We found five studies that consider communication, collaboration, control and distance. The focus here is mainly (1) on the vendor environment(s); and (2) on the vendor team and interactions within the team and team sites (if there is more than one site). Five studies are concerned with the development process and again the focus is on the vendor; there is a single study on architectural knowledge management [S2] and one on configuration management [S7]. Three SLRs [S12,S13,S24] explicitly consider the client. However, the main focus of [S12,S13] is on what vendor organizations should do "in order to be competitive in the outsourcing business" [S13a].

When we consider the Abdullah and Verner outsourcing risk framework categories [1] covered by our SLRs, "project execution" (or the development process) is the most popular topics for research with seven studies in this category. Almost as popular as a research topic for GSD SLRs is "the organization environment" with six studies. "Project planning and control" comes third with four studies. We are not told which project manager is the focus of the research but the way the papers are written implicitly suggests the vendor (or supplier) project manager.

4.4. RQ1.3 What are the gaps in the GSD topics addressed?

With the main focus on the vendor environment and the development process (Table 5) we are lacking research on the users, the client organization (except for some research on vendor selection [S12,S13]) and development of an outsourcing lifecycle framework that includes the client, project complexity and the effects of several vendors, the type of contract, and cross border financial and legal implications. In several of the studies there appears to be some confusion about who is the owner of the issue discussed, i.e., the term "practitioner" was frequently used though the identity of the practitioner was vague; it was not clear if the authors were discussing issues related to the client, the vendor (including developers), or all those involved in the project.

4.5. RQ1.4. Which researchers and institutions are active in GSD SLRs?

Table 6 and Appendix Table A3 provide details of the researchers most active in GSD SLRs. It is interesting to note that a large proportion are based in Brazil (17) and that these researchers are also the most active in GSD SLRs, e.g., Prikladnicki has been involved in six GSD studies. Ireland with nine researchers and Sweden with eight researchers provide the next largest groups of researchers. Both Brazil and Ireland are important GSD destinations.

Given the importance of GSD to the US, a client country, and the software engineering research that occurs there, it is surprising that only three SLR researchers are based in the US, although many of the primary studies do involve US researchers. Appendix Table A3: Institutional Affiliation of Active Researchers, shows that almost all the researchers are based in Universities; very few authors are from industry. Of those researchers that are based in industry, three are from Denmark [S18] which is mainly a client country, so that it is not surprising that they are associated with a study focussing on managing risks in GSD projects.

4.6. RQ2-What is the quality of GSD SLRs and is it changing over time?

Table 1 includes details of our quality evaluation of the major paper reporting each of the studies and Table 2 provides average quality of the SLRs by year. Statistical analysis shows that there is no evidence that quality is improving over time; there is no significant difference between year and quality scores. The mean for journal papers is 2.5 (SD = 0.734) and the mean for conference papers is 1.92 (SD = 0.527); there is a significant difference between the quality of the journal papers and the conference papers ($p < 0.05$). Although we collected data on the data synthesis methods we did not include this in our quality score for two reasons: (1) many of the studies were done before this criterion was added to the DARE criteria, and (2) we did not consider that it was important

Table 4
Conference venues for GSD SLRs.

Publisher	Conference	Number
IEEE	International Conference on Global Software Engineering (ICGSE) 2008, 2009, 2010	7
	International Conference on Global Software Engineering (ICGSE) PARIS Workshop 2011	1
	International Enterprise Distributed Object Conference Workshops (EDOCW) 2006	1
	Conference on Software Engineering Approaches for Offshore and Outsourcing Development (SEAFOOD) LNBIP, 2009	1
Springer	Product-Focused Software Process Improvement (PROFES) LNCS 2010	1
	International Workshop on Groupware (CRIWG) LNCS 2010	1
	IFIP The Transfer and Diffusion of Information Technology for Organizational Resilience 2006	1
Austrian Computer Society	International Workshop on Distributed Software Development 2005	1
BCS/IET	Empirical Assessment in Software Engineering (EASE) 2008, 2011	2
INSTICC	AIS International Conference on Enterprise Information Systems (ICEIS) 2009, 2010	2
AIS	Americas Conference on Information Systems (AMCIS) 2007	1
	Asia-Pacific Software Engineering Conference (APSEC) 2009, 2010	2

Table 5
GSD SLR research topics categorized by thematic analysis.

Main study topic (thematic analysis)		Mapping to Outsourced risk framework [1]	ISO 12207 Mapping [32]; Lifecycle process; sub process	Constituent task
Research		N/A	N/A	
	General, what research has been done and who is doing that research [S3] Mapping the research and identifying gaps in the research [S14] Empirical studies in GSD [S21]			
Architecture		Project execution		
	Architectural knowledge management [S2]		Primary; development	System architectural design
Development process		Project execution	Primary; development	Software construction
	Scrum, risk factors and strategies [S8] Agile practices research and context for use of practices [S10] Problems and solutions, challenges and solutions, procedures, models, and strategies employed in the development process for distributed teams [S11] Key factors for DSD process models [19] Activities in the software development process [S24]			
Project management		Project planning and control	Organizational management	Review and evaluation
	Identify effective models and tools for supporting DSD management [S4] Challenges, practices, tools and models for project management [S5] Risk and risk mitigation instrument [S17] Managing Risks in distributed projects [S18]			
Requirements engineering		Project scope and requirements	Primary; development	Elicitation and analysis
	What are the main risks to RE in DSD? What methods, models, techniques, approaches and tools support RE in DSD? [S6] Which new risks and challenges are identified for RE on GSD environments? Which solutions have been proposed [S15]			
Configuration management		Project execution		
	Configuration management empirical methods, research contribution, issues, solutions major problem areas [S7]			
Outsourcing vendor selection			Primary; acquisition process	Selection of supplier
	Barriers and Influencing factors [S12,S13]			
Culture				
	Research into cultural issues [S9]	Organizational environment	Organizational; training	
Collaboration, communication, control and distance		Organizational environment	Organizational; organizational management	Infrastructure
	Opportunities and threats regarding communication, coordination, control, and geographic distance [S1] Barriers that prevent software development teams from collaborating in a global environment; solutions to addressing the barriers to collaboration [S16] Collaboration models in software development [S20] What are the awareness studies carried out to Improve the GSD scenario? Which of the 3Cs are the studies supporting [S22] Insights from empirical studies on collaboration in software development? [S23]			

Table 6
Most active GSD SLR researchers.

Name	Affiliation	Number of studies
Prikladnicki	Brazil	6
Audy	Brazil	3
Costa	Brazil	3
Rocha	Brazil	3

for a mapping study. Of the papers that do discuss a synthesis method used [6], very few provide any references to the method used.

4.7. RQ3. What risks and risk mitigation advice are identified in the SLRs and what empirical support is provided for them; are the results different if we exclude low quality studies?

We begin this section with a discussion of the data extracted related to risks, risk mitigation advice and their empirical support. Discussion of the data analysis is presented in Sections 4.6.1–4.6.4. We conclude with the answers to the RQ3 sub-questions in Section 4.7. The risk and mitigation advice formulations found in some of the studies were somewhat disappointing and some were rather cryptic. Where two or more studies discussed the same risk

we consolidated the risk description into a single entity. However, we felt it unwise to expand the risk descriptions to include material not already present in the studies. Even studies that specified how many primary studies were included in their SLR did not always specify the level of support when a risk or risk mitigation advice item was discussed. It is also not clear whether the empirical support is based on observing case studies where the risk management strategy was used and found effective, or whether support means that the authors of the paper or study participants speculated that the strategy would have helped observed problems. The SLRs that provided our empirical support did not differentiate between the two although for the purpose of this study we have included all the advice that has sufficient support.

We identified the following themes and sub-themes for risks and risk mitigation strategies:

1. *GSD outsourcing rationale*, including high level strategy and detailed strategy.
2. *Software development*, including requirements engineering, architecture, software development methods, and configuration management.
3. *Human resources* including culture and social integration, training, communication, and collaboration.
4. *Project management* including planning, risk management, coordination, and control.

As noted earlier, because we are interested in empirical support, the number of primary studies in each of the SLRs is important if we are to understand the empirical support for a risk or risk mitigation factor. Hence we use the number of primary studies in a SLR that identify an item as a risk, or as a mitigating factor, as empirical support. Table 1 lists the number of primary studies in each of our SLR studies which ranged from 9 [S20] to 315 [S3]. Two studies [S1,S14] did not make clear how many primary studies were included in their review and several SLRs (e.g. [S3,S14,S23]) did not provide any empirical support regarding risks and mitigation advice as their focus is on mapping GSD research.

Overall we identified a total of 122 risks and 98 risk mitigation advice items from the SLRs, each with support from at least one SLR and three primary studies. Categorization and thematic analysis of the risks and mitigation items was difficult as many overlapped, e.g., "In GSD differences among national cultures of the participants affect their collaboration", can be considered to be a cultural risk as well as a collaboration risk. Thus, we classified items where we felt they best fitted but other researchers may have organized them differently. Some of the items related to a specific theme also had overlaps and we have combined them into a single risk or mitigation strategy when it was appropriate. This resulted in 107 separate risks; and 77 risk mitigation strategies. We discuss our themes and sub-themes below and list the risks and advice with the most empirical support (up to 10 for each theme) in tables below. For each risk and mitigation strategy we identify (1) the supporting SLR studies, (2) number of primary studies supporting the item from the SLR, and (3) the percentage of supporting studies from the particular SLR. Of course with the variation in the number of primary studies in our SLRs the percentage support for a risk from a particular SLR will vary even if both are supported by three primary studies in the SLRs. Although some of the risk (or advice item) descriptions in the SLRs are somewhat cryptic we felt it important not to add interpretation to the risks as described by the SLR authors.

If we found 10 or fewer risks or items of advice for a sub-theme we list all items in the table; if we found more than ten items we include the 10 with the most empirical support. A complete list of risks and advice items can be obtained from the corresponding author. Of the risks without enough empirical support to be included in Tables 7–18 below, just over half were related to communication and collaboration, and the rest were related to control; and high level GSD strategy.

We have endeavoured to place the risk and its appropriate mitigation advice together in the tables when possible, ordered by the risks with the most empirical support. As each study provided a different number of primary studies we provide the percentage support for a risk or mitigation item from a particular study so that the reader is able to understand the degree of support provided for the items included in our tables. This is in line with some SLRs in the area, e.g. [S12,S13]; we felt that support from 12 primary studies where a study identified 24 primary papers overall (50%), is rather different from support from 12 primary studies when the authors identified 120 primary studies overall (10%).

We now discuss the risk and mitigation items identified under each theme and sub-theme, together with their empirical support.

4.7.1. GSD outsourcing rationale

As noted earlier, entering into a GSD project is not simple or straight forward and our SLRs have highlighted this fact with risks that need to be addressed very early in a project, i.e., when considering whether (or not) to outsource and which vendor to choose. Because of the comparatively large number of primary studies identified by [S12,S13] there is good primary study support for most items in this category. Outsourcing rationale risks and mitigation advice are found at two levels, 1) GSD high level vendor selection strategy (general considerations regarding choosing a software supplier or vendor), and 2) GSD detailed vendor selection strategy (which is more related to a specific project). Four studies [S5,S12,S16,S18] contributed 21 GSD risks with support from at least three primary studies. Five studies [S5,S12,S13,S18,S19] contributed advice items. Almost all risks should be the concern of senior management in the client organization, although as [S13] notes, successful senior vendor management must be aware of the client's selection criteria as the criteria may well provide risks for the vendor. The vendor is actually the focus of [S12] where barriers to vendor selection are extracted; vendors are told to focus on the barriers if they wish to attract clients.

4.7.1.1. High level GSD vendor selection strategy. Table 7 lists the 10 risks with the most support, addressing GSD high-level vendor selection strategy, and six mitigation advice items. This set of risks highlights preliminary factors that should be considered for vendor selection by a client organization whose senior management is contemplating GSD. Risks are extracted from four SLRs [S5,S12,S16,S18] and mitigation advice from five SLRs [S5,S12,S13,S18,S19]. The focus is mainly on issues about the country in which the vendor is located and factors that need to be taken into account before a vendor decision is made. Concerns such as culture, ethics, legal implications, distance and infrastructure are identified, as well as about what is known about a particular vendor's behaviour in the past. Risk #1 "Vendor's poor infrastructure" is supported by four SLRs. Mitigation advice for Risk #2, which focuses protection for intellectual property, has support from three SLRs. There is a reasonably good match between the risks and the mitigation advice. It may be quite difficult to gain some of the information that the client requires about a prospective vendor without actually embarking on a project; an initial small pilot project with a vendor may be good mitigation advice.

4.7.1.2. Detailed GSD vendor project selection strategy. Two SLR studies discuss vendor selection risks for a specific project [S5,S12] while mitigation advice was provided by three studies [S12,S13,S19]. Table 8 lists details of the risks and advice with the most empirical support. All eight of the risks found are under the control of the client and are focussed on vendor selection for

Table 7
High level GSD vendor selection risks and mitigation advice.

#	Risk	Study	Support level	Mitigation advice	Study	Support level
1	Vendor's poor infrastructure such as infrastructure incompatibility between sites causes problems; selection of appropriate information and communication technology is crucial for project success	[S12]	32 (33%)	Investigate the vendor's infrastructure to ensure that it is appropriate	[S13]	73 (60%)
		[S16]	7 (27%)		[S12]	25 (26%)
		[S05]	13 (19%)			
		[S18]	11 (15%)	Choose sites where it is possible to maintain high quality transmissions at low cost considering parameters such as the country's technological infrastructure and different laws and regulations	[S18]	3 (4%)
2	Lack of protection for intellectual property rights in the vendor country	[S12]	46 (47%)	Consider intellectual property and ensure effective policies for confidentiality, copyright protection, and intellectual property	[S12]	36 (37%)
		[S05]	5 (7%)		[S13]	23 (19%)
					[S5]	3 (4%)
3	Problems because of differences in legal systems such as jurisdiction, patents, and International laws	[S5]	3 (4%)			
4	Language and cultural barriers cause problems between client and vendor	[S12]	55 (56%)	Select a vendor with knowledge of the client's language and culture	[S12]	38 (39%)
					[S13]	39 (32%)
5	Vendor country instability such as political instability, corruption, peace problems, terrorism threats and uncertainty relating to trade and investment can cause project difficulties	[S12]	50 (51%)	Select a vendor in a stable country	[S12]	42 (43%)
6	A communication gap between client and vendor may lead to misunderstandings	[S12]	43 (44%)			
7	Vendor's behaves opportunistically	[S12]	27 (28%)			
8	Vendor has previous delays in delivery so may be unreliable	[S12]	22 (22%)	Select a vendor with a good track record of successful projects	[S13]	53 (43%)
9	Vendor incompatibility with client causes problems	[S12]	10 (10%)			
10	Vendor's strategic inflexibility can result in major disagreements	[S12]	10 (10%)			
				A strategy selection process that highlights the DSD-related decisions that have to be made and the reasons for selecting one strategy over another, the types of projects that will be distributed, and the tasks to be performed by distributed teams	[S19]	8 (27%)

Table 8
Detailed GSD vendor selection project risks and mitigation advice.

#	Risk	Study	Support level	Mitigation advice	Study	Support level
1	Choosing a vendor with a lack of project management skills can result in difficulties	[S12]	48 (49%)	Ensure that there is effective/efficient project management	[S12]	48 (49%)
					[S13]	47 (39%)
2	Choosing a vendor with a lack of technical capability can result in problems	[S12]	46 (47%)	Ensure that there is appropriate technical ability. Take into account the developers' skills	[S12]	46 (46%)
					[S13]	82 (67%)
					[S19]	5 (17%)
				Choose a vendor with SPI certification	[S13]	41 (34%)
3	A vendor with poor relationship management can result in problems such as lack of trust	[S12]	43 (44%)	Ensure there is efficient outsourcing relationships management	[S13]	59 (48%)
4	A vendor with poor contract management can cause problems for the client such as lack of integrity in obligations, commitments and behaviour	[S12]	42 (43%)	Select a vendor with effective contract management	[S13]	45 (37%)
					[S12]	35 (36%)
5	A vendor with poor quality of service and systems/processes can result in problems	[S12]	42 (43%)	Consider the vendor's product, service and process quality	[S13]	69 (57%)
6	Hidden vendor costs can be expensive	[S12]	37 (38%)	Ensure that there are no hidden costs	[S12]	37 (38%)
				Use GSD only when you can achieve cost savings	[S13]	89 (73%)
7	Choosing a vendor with a lack of control over a project can result in problems such as cost and schedule overruns	[S12]	33 (34%)	Ensure project is well controlled	[S12]	33 (34%)
8	Organizational challenges caused by GSD beyond distance and cultural differences, e.g., if the client organization has a large number of stakeholders, and /or the vendor organization has a number of sites	[S5]	14 (20%)			

a project although [S12] details barriers that vendors need to overcome to be attractive to clients. Issues such as the vendor technical capability, contract and project management, physical distance, as well as the number of client stakeholders and the possibility of hidden project costs are highlighted. While none of the risks is supported by more than a single SLR three mitigation items are supported by two SLRs and one item by three SLRs. Seven of the eight risks have matching mitigation advice and there are two advice items not associated with a risk; one of these, "Use GSD for a project only when you can achieve cost savings", has the most primary study support of any advice item with support from 89 primary studies. Most of the advice items are very general and few provide a defined strategy including guidelines on how they could be implemented.

4.7.2. Software development

We found 23 risks related to the software development lifecycle. The software development risks found relate to (1) require-

Table 9
Requirements engineering risks and mitigation advice.

#	Risks	Study	Support level	Mitigation advice	Study	Support level
1	National, organizational, and cultural differences of participants can cause problems like rework, loss of data, confusions, etc.	[S6]	7 (58%)			
		[S15]	4 (11%)			
2	Lack of informal communication negatively impacts relationship building	[S6]	4 (33%)	Provide for the use of direct communication channels	[S6]	3 (25%)
3	Requirements change management issues can be a problem especially if there are no defined organizational policies	[S6]	6 (50%)			
4	Lack of a common understanding of requirements leads to problems in system functionality	[S5]	6 (7%)			
5	A lack of suitable tools or methodologies available for requirements elicitation may lead to problems in obtaining the real requirements	[S15]	5 (14%)			
6	Lack of collaboration for RE between distributed stakeholders happens due to differences in culture, language distance and processes	[S6]	3 (10%)			
7	Lack of common stakeholder goals due to problems of communication and lack of common understanding of requirements	[S6]	3 (10%)			
8	Requirements information not properly shared with distributed stakeholders affecting their interaction	[S6]	3 (10%)			
9	Stakeholders located in different time zones can lead to problems in communicating	[S15]	3 (8%)			
				Apply personal domain knowledge	[S6]	3 (25%)
				Define a person responsible for requirements specification and prioritization	[S6]	3 (25%)

Table 10
Software development process risks and mitigation advice.

#	Risk	Study	Support level	Mitigation advice	Study	Support level
1	Problems caused by asymmetry in processes, policies and standards	[S5]	14 (20%)	Use and maintain common software processes among sites	[S5]	5 (5%)
		[S15]	4 (11%)			
		[S16]	11 (42%)	It is important to ensure that all sites follow a shared, agreed process and participants receive training on process elements	[S16]	9 (31%)
2	Application of agile practices causes problems in distributed development because of the degree of interaction between stakeholders and number of face-to-face meetings needed	[S5]	10 (14%)	Use continuous integration on agile development	[S8]	18 (90%)
					[S10]	12 (16%)
				Institute stand up meetings for agile development	[S8]	16 (80%)
					[S10]	18 (23%)
				Use pair programming for agile development	[S8]	14 (70%)
				Use test driven agile development	[S8]	9 (45%)
3	Lack of synchronous communication in agile development causes problems	[S8]	9 (45%)			
4	Collaboration difficulties caused by geographic distance in agile development may cause misunderstandings and conflicts	[S8]	6 (30%)			
5	Poor communication bandwidth for agile development causes problems with communication and knowledge management	[S8]	6 (30%)			
6	Lack of tool support for agile development causes problems with agile practices	[S8]	6 (30%)	Proactive resource management helps ensure that a Scrum team has the necessary tools and skills to support Scrum practices in distributed settings	[S8]	20 (100%)
7	Large teams involved with agile development can cause problems related to communication and coordination	[S8]	5 (25%)			
				To increase project members' domain knowledge and reduce cultural distance, a Scrum team gathers and performs a few initial sprints at one site before distributed development starts	[S11]	10 (33%)
					[S10]	13 (17%)
				Members of a distributed Scrum team are gathered quarterly or annually for few days. During this gathering, a Scrum team can perform scrum planning, review meetings, retrospectives, sprints and various social activities, this help cut cultural distance	[S11]	10 (33%)
					[S10]	4 (5%)
				Communication enhanced through working hours; working from home, adjusting working hours, etc. Some Scrum teams use strategies such as make the meetings short and effective, they post their three daily Scrum questions or develop a backlog before the distributed meetings	[S8]	10 (50%)

Table 11
Architectural design risks and mitigation advice.

#	Risk	Study	Support level	Mitigation advice	Study	Support level
1	Lack of well-defined modules causes problems with progressive integration	[S5]	8 (11%)	Divide the work into well defined modules and carry out progressive integration	[S5]	7 (10%)
		[S16]	3 (12%)			
2	High task coupling between task segments increases the need for inter-site communication, coordination, and integration, and it can lead to lower level of performance as well as increase the number of failures	[S18]	6 (8%)			

Table 12
Configuration management risks and mitigation advice.

#	Risk	Study	Support level	Mitigation advice	Study	Support level
1	Configuration management group awareness problems caused by the distribution of developers	[S7]	6 (25%)	All team members should agree on a common configuration management process	[S7]	3 (13%)
2	Configuration management problems cause dependency, delay and increased time is required to complete maintenance requests	[S7]	4 (17%)			
3	Working with different CM tools can cause slow and unreliable sites, lack of awareness of product changes, and problems with bug fixes between sites	[S18]	4 (6%)			
4	Working in different SCM environments leads to maintenance requests being handled at several levels in the project	[S7]	3 (13%)			
5	Problems can be caused by the lack of deployment of a configuration management system	[S5]	4 (6%)	Deploy and use a configuration management system	[S5]	4 (6%)

ments engineering, (2) the software development process, (3) architectural design, and (4) software configuration management. Many risks relating to the development process are under the control of vendor practitioners, mainly the vendor project manager, though some are appropriate for project leads, technical leads, quality assurance managers and software developers. However, it should not be forgotten that the client project manager must continuously monitor what is happening during the development process. Of course during requirements engineering both client and vendor need to be involved.

4.7.2.1. Requirements engineering. Most of the requirements engineering risks deal with communicating requirements, and collaboration, so that vendor practitioners may more easily understand exactly what the project needs to deliver. Many of the advice items deal with communicating requirements, and methods for modelling requirements. It is surprising that no one suggested introducing a formal requirements management process including an inventory of all requirements and a joint committee for requirement's change management particularly when the requirements management process used by a vendor and its compatibility with the client's methods could actually be audited prior to awarding a contract.

Table 9 lists the risks with the most empirical support. Three studies [S5,S6,S15] furnished the risks we found. There is a moderate level of support for the risks though none have support from more than two SLRs and seven primary studies. Given the criticality of getting the requirements right, and the importance of client stakeholder involvement in requirements elicitation, it is surprising that there is not more empirical support for risks related to stakeholder collaboration during requirements elicitation.

Research on failed outsourced software development projects [2] highlights the importance of good requirements. Many projects fail because the client and client stakeholders do not grasp the importance of participation in requirements elicitation. The client project manager can play an essential role in ensuring that stakeholders make themselves available when required. Without serious high level management input, client stakeholders often feel disinclined to make time for systems analysts as they do not comprehend the importance of their participation; all too frequently there is nothing in it for them except the threat that the automated system may cause them to be made redundant [33].

Only one study [S6] furnished empirically supported mitigation advice. There is not a great deal of empirical support for the advice items with none having support from more than three primary studies. In the advice provided there are overlaps with communication and project management. With so few advice items with empirical support it is not surprising that there is little mitigation advice related to the requirements engineering risks identified.

4.7.2.2. Software development process. Four studies [S5,S8,S15,S16] furnished risks related to the software development process; one SLR was specifically concerned with agile methods [S8]. We identified seven risks overall. Table 10 provides details of the risks and mitigation advice we found. Even though most of the risks were extracted from a study specifically focussing on agile methods all the risks, except for risk #2 (application of agile practices causes problems, etc.), could also apply to any software development method. Most risks are related to communication in the vendor environment.

Five studies [S5,S8,S10,S11,S16], supplied ten items of advice, and most are related to agile methods. There is some agreement on the recommendations particularly regarding tools required for agile practice support. Most advice was for (1) specific agile processes, e.g., retrospective, backlog, short iterations, etc., and (2) communication in the vendor environment. Risk #1 "Problems caused by asymmetry in processes, policies and standards" has two items of advice and Risk #2 "Application of agile practices causes problems" has 4 items of advice. We wonder if there is more interest in agile methods for GSD from the research community, thus the plethora of papers, than there is in the commercial environment. We note the comments by Fabriek et al. [14] that "the role of on-site customer seems to be unsustainable for long periods and that it is difficult to introduce agile methods into large and complex projects". Almost all the suggestions are intended for the vendor project manager, vendor project leads and programmers.

Table 13
Culture and social integration risks and mitigation advice.

#	Risk	Study	Support level	Mitigation advice	Study	Support level
1	Language differences between development sites can result in misinterpretations and unconveyed information	[S18]	12 (17%)	Choose sites in culturally similar locations, documents should be reviewed by a native speaker	[S16]	6 (23%)
		[S16]	14 (54%)			
		[S5]	11 (16%)			
		[S15]	3 (8%)			
2	Mutual trust is important but hard to obtain and lack of trust causes problems. This can be due to lack of face-to-face interaction, cultural differences, and weak social relations	[S18]	8 (11%)	Create teams with complementary skills and cultures	[S5]	3 (4%)
		[S5]	15 (21%)			
		[S16]	9 (35%)	Create a database that contains the areas of expertise of the individual project participants	[S18]	3 (4%)
3	Cultural bias may lead to erroneous decisions and insecurity about other participants' qualifications and it can have a devastating impact on communication and collaboration efforts. Cultural bias occurs when project participants consider their norms and values as universal and neglect to reflect onto what extent values, norms, and biases are founded in their own cultural background	[S18]	5 (7%)	Use liaisons to facilitate information exchange, identify expertise, mediate cultural conflicts and settle disputes	[S18]	6 (8%)
		[S5]	7 (10%)	Use cultural mediation; it is worth spending resources on reducing socio-cultural distance by means of facilitating face-to-face meetings. Have at least some people at each node who have met people at peer nodes in person. This also reduces the perceived geographical distance, if not the physical. This helps promote trust and reduce fear	[S16] [S18]	7 (27%)
		[S15]	4 (11%)	In on different cultures/instill a sense of cultural awareness	[S5]	4 (5%)
4	Cultural diversity between development sites or teams can cause misunderstandings	[S5]	36 (51%)			7 (10%)
		[S18]	3 (4%)			
5	Differences in work culture may render difficulties when sites are different in terms of team behaviour, balancing of collectivism and individualism, perception of authority and hierarchy, planning, punctuality, and organizational culture. This may lead to decreased conflict handling capabilities and lower efficiency or even paralyse the project	[S5]	12 (17%)	Investigate ways of maintaining team involvement and cohesion	[S5]	3 (4%)
		[S18]	8 (11%)			
		[S15]	4 (11%)			
6	Fear about the future of jobs and roles, erodes trust	[S16]	4 (15%)			
7	Stakeholders are less likely to commit to the project organization and its task when cultural differences and lack of face-to-face interaction makes it difficult to establish a clear project identity	[S18]	5 (7%)	Add team building exercises and social activities during visits	[S18]	6 (7%)
8	Goal distribution can lead to conflicts related to task interpretation, process principles, and problem resolution approaches and can result in site wars and low performance. Goal distribution is more likely in GSD because of faulty transfer of information and a focus on own site performance	[S18]	3 (4%)			
9	Trust among stakeholders necessary to achieve innovation, flexibility, cooperation, and efficiency in distributed environment. Since often a short life span, important to achieve mutual trust rapidly, but if trust is misplaced, entire organization may suffer	[S18]	9 (13%)			

Table 14
Training risks and mitigation advice.

#	Risk	Study	Support level	Mitigation advice	Study	Support level
1	Lack of training in communication and collaboration tools causes problems with communication	[S5]	12 (18%)	Provision of and training in collaboration and coordination tools	[S5]	10 (14%)
					[S18]	3 (3%)
				Focus on strengthening participants' collaboration and communication skills, e.g., by training in a wide variety of technologies	[S18]	5 (7%)
2	Difficulties caused by different knowledge levels or knowledge transfer problems	[S5]	11 (16%)	Assess practices and capabilities of individuals; need to know if team members have sufficient understanding of software development practices for deployment in a global perspective	[S19]	5 (17%)
3	Problems caused because team members do not share equal knowledge of the domain	[S5]	6 (9%)	Educate and train in software development technology especially participants introduced to new technology	[S18]	4 (6%)
				Training of participants and lower initial efficiency as experience with the chosen method varies. In the long run higher efficiency and fewer misunderstandings are expected	[S18]	5 (4%)

Table 15
Communication and collaboration risks and mitigation advice.

#	Risk	Study	Support level	Mitigation advice	Study	Support level
1	Limited face-to–face meetings caused by geographic distance impact trust, decision quality, creativity, and general management; knowledge creation is limited within organization. This may lead to problems in creating collaboration know-how and domain knowledge	[S15]	3 (8%)	Promote visits and exchanges among sites	[S5]	5 (7%)
		[S18]	6 (8%)			
		[15]	13 (19%)			
		[S16]	12 (46%)			
		[S11]	9 (12%)	Prioritize face-to-face meetings to develop trust and shared identity easier and faster	[S18]	7 (10%)
2	Temporal and physical distribution increases complexity of planning and coordination activities, makes multisite virtual meetings hard to plan, causes unproductive waits, delays feedback, and complicates simple things	[S5]	20 (28%)	Establish communication guidelines	[S5]	6 (9%)
		[S16]	13 (%)		[S17]	5 (6%)
		[S18]	5 (7%)			
		[S11]	5 (6%)			
3	Limited possibility for informal communication due to dispersion of sites (i.e., lack of spontaneous communication) causes problems with social integration of teams	[S16]	11 (42%)	Promote informal interactions to improve communication and collaboration	[S5]	6 (9%)
		[S5]	14 (20%)			
		[S18]	6 (8%)			
4	Lack of effective communication causes problems with knowledge management; participants may lack information about tasks, purpose, and their own contribution overall	[S5]	46 (66%)	Introduce multiple communication modes including support for face-to-face synchronous communication	[S5]	8 (11%)
		[S18]	5 (7%)		[S16]	5 (14%)
		[S11]	3 (4%)		[S18]	9 (10%)
5	Inability to communicate in real time) causes collaboration problems	[S5]	10 (14%)	Choose as rich media as possible to support social processes, collaboration and cohesion	[S18]	6 (8%)
		[S11]	7 (9%)			
		[S18]	5 (7%)			
6	Lack of team cohesiveness causes problems as some members feel isolated from other team members; participants have limited understanding of other project participants' competencies	[S5]	5 (9%)	Deploy evaluations and reward structures which encourage group related behaviour, to create cohesion – individual rewards are not advised	[S18]	6 (8%)
		[S18]	6 (8%)			
7	It may be difficult to establish effective coordination mechanisms in projects and overcome challenges such as little face-to-face interaction, problematic task coupling, different time zones, local holidays, weak social networks, and unclear communication lines	[S18]	7 (10%)	Prioritize face-to-face meetings to develop trust and shared identify easier and faster	[S18]	7 (10%)
				Collaboration can strengthen trust among global teams	[S16]	6 (23%)
8	Problems caused by poor collaboration and communication infrastructure	[S16]	7 (27%)			
9	Use of interaction media may cause problems such as jumbled messages; mix-ups and loss of contextual information. Such problems, may lead to confusion and misunderstandings among participants and lower morale	[S18]	5 (7%)	Educate and train participants in collaboration skills specific for the distributed environment	[S18]	10 (14%)
					[S5]	10 (14%)
10	Project participants have limited understanding of other project participants' competencies	[S18]	7 (10%)			
				Develop code repositories; they are rich source of information for awareness generation	[S22]	6 (27%)

4.7.2.3. Architecture. We found two overlapping risks from [S5,S16,S18] related to poor architectural design that result in problems with communication, coordination and integration (Table 11). There are some overlaps with geographic distribution and communication risks. One study [S5] provided advice about a need for good architectural design. Empirical support for the suggestions is low due to the few primary studies describing GSD architectural risks identified in the SLRs; all the advice is intended for the vendor project manager.

4.7.2.4. Configuration management. Five configuration management risks were identified originating from three SLR studies [S5,S7,S18]. Risk #1 as it stands, "Configuration management group awareness problems. . .", is somewhat vague and would be difficult to manage without more detail.

After removing all the advice related to tools and methods (mainly experimental, with little support), we found two advice items that match up with risks related to development sites using different configuration management tools and processes. Few authors who made recommendations clearly stated how much supporting evidence they found. The major recommendation is that all team members should agree on a common configuration management process which resolves a number of issues. The configuration management recommendations have some overlap with communication and project management. The advice is meant for the vendor project manager, vendor configuration manager and developers. Table 12 provides details of the configuration management risks and mitigation advice with the most empirical support.

4.7.3. Human resources

We divided the human resources risks into three sub-themes: culture and social integration, training, and communication and collaboration. Overall for this category we identified 34 risks and 29 items of advice. There appears to be an assumption all through

Table 16
Planning risks and mitigation advice.

#	Risk	Study	Support level	Mitigation advice	Study	Support level
1	Selection of inappropriate information and communication technology causes problems such as unreliable networks which may lead to frustration and low efficiency, limit exchange of sensitive information, or even cause production to stop	[S18]	12 (17%)	Ensure infrastructure compatibility among geographic locations	[S16]	13 (50%)
		[S5]	5 (7%)		[S5]	3 (4%)
					[S18]	4 (6%)
2	Lack of project planning causes problems	[S5]	8 (11%)	Make sites self-managing by establishing a system that allows participants to monitor own processes	[S18]	3 (4%)
				Perform detailed planning	[S5]	5 (7%)
				Project manager should explicitly relate distributed project organization to overall strategy, mission and vision and communicate the purpose of task	[S18]	4 (6%)
3	Poor identification of roles and responsibilities	[S5]	8 (11%)	Project manager should establish and obligate the participants to a shared project goal to develop a common identity	[S18]	6 (8%)
4	Lack of detailed planning causes problems with task allocation	[S5]	7 (10%)			
5	Not tailoring organizational structures to reduce delays in problem resolution causes difficulties and can result in site wars and reduce project cohesion	[S5]	6 (9%)			
6	Without communication protocols effective communication can be impeded	[S5]	5 (7%)	Create communication protocols	[S5]	6 (9%)
7	Poor quality management	[S5]	5 (7%)	Institute good management; global software projects should be undertaken only when potential benefits outweigh risks	[S16]	12 (46%)
		[S11]	4 (5%)			
8	Risk management including issues related to coordination, problem resolution problem resolution evolving requirements, knowledge sharing, and risk identification	[S11]	4 (5%)			
				Project manager should explicitly relate distributed project organization to the overall strategy, mission and vision and communicate the purpose of the task	[S18]	4 (6%)
					[S16]	11 (42%)
				Manage differences by taking advantage of existing expertise, create fast results, and avoid expenses from training and adaptation to new methods	[S18]	3 (4%)

Table 17
Coordination risks and mitigation advice.

	Risk	Study	Support level	Mitigation advice	Study	Support level
1	Lack of coordination causes problems such as unclear lines of communication and poor handling of deadlines and milestones	[S5]	25 (36%)	Use mentors to integrate new participants. The mentor is responsible for social adaptation and communication the project and group's history and values	[S18]	4 (6%)
2	Lack of appropriate information flow throughout the project causes problems with knowledge management	[S5]	9 (13%)	Deploy knowledge transfer mechanisms, e.g., transfer of people between sites	[S5]	5 (7%)
				Manage differences by taking advantage of existing expertise, create fast results, and avoid expenses from training and adaptation to new methods		
3	Coordination in multisite development becomes more difficult in terms of articulation of work as problems from communication lack of group awareness and complexity of the organization appear and influence the way the work must be structured	[S11]	5 (6%)	The development process must be adapted to provide team members with better awareness of project status	[S18]	3 (3%)
4	Task uncertainty represents lack of information needed to develop the software, and it can result in slow change coordination and process and relational conflicts	[S18]	4 (6%)	Temporary co-location during critical phases	[S18]	3 (3%)
				Stimulate the interaction between participants already from project start up	[S18]	4 (6%0
				Introduce shared deadlines/milestones when coordinating successive integration of individual software modules as well as handling local festivals and holidays	[S18]	3 (4%)

our SLRs that there are several development sites employing developers of different cultures using different languages, unfamiliar with each other, who will require much effective communication and cultural and social integration; thus making both the communication infrastructure important as well as training to use it. All but one of the advice items relate to identified risks. Each of the sub-themes is discussed further below.

4.7.3.1. Culture and social integration. Four studies [S5,S15,S16,S18] provide nine risks and six advice items related to culture and social integration. Table 13 lists their details. Support for the nine risks identified is relatively high, with five risks supported by two or more SLRs. Empirical support for the risks is reasonable in most cases. Problems caused by cultural diversity, difficulties with different languages, and mutual trust are the risks with the most

Table 18
Control risks and mitigation advice.

#	Risk	Study	Support level	Mitigation advice	Study	Support level
1	Problems with people management, conflict resolution, and staff turnover are caused by a lack of control	[S5]	10 (14%)	At project start up, define undisputed areas of responsibility for all participants as well as the relational roles being instituted	[S18]	6 (8%)
				People management	[S5]	6 (9%)
2	Problems with tracking and control can lead to unawareness of real project progress	[S5]	10 (14%)			
3	Poor control results in lack of effective scope and change management	[S5]	7 (10%)			
4	Disorganized task allocation leads to some work being done twice and other work omitted	[S5]	7 (10%)			
5	No process alignment, in terms of traditions, development methods, and emphasis on user involvement, will often differentiate between sites, possibly resulting in incompatibility and conflicts	[S18]	6 (%)	Institutionalize and build consensus on operating norms	[S18]	6 (7%)
6	Lack of control results in no transparency or visibility of project status to all sites involved in project	[S5]	5 (%)	Ensure visibility of work in progress	[S5]	4 (6%)
7	Poor schedule management	[S5]	5 (7%)			
8	Spatial distribution complicates project manager's ability to monitor participants and progress, increases travel budgets, limits face-to-face interaction, and weakens social relations	[S18]	5 (7%)	Have clearly defined roles and responsibilities	[S5]	3 (3%)
9	High organizational complexity, scheduling, task assignment and cost estimation become more problematic in distributed environments as a result of volatile requirements diversity and lack of informal communication	[S11]	5 (6%)			
10	Tool compatibility may prove a problem; sites are likely to prefer different programming languages, support tools, operating systems, and development tools	[S18]	3 (6%)	Standardize tools, methods and processes to create a harmonic and efficient project organization	[S18]	4 (6%)

empirical support. "Language differences between sites development can result in misinterpretations and unconveyed information." is the risk with the most empirical support (four SLRs). Empirical support for the advice is fairly low in most cases (one SLR and 3–6 primary studies except for "use cultural mediation…" which is supported by two SLRs but with fairly low primary study support). Five of the six most empirically supported risks have related mitigation advice. Culture and social integration risks are under the control of the vendor project manager and there are overlaps with communication and collaboration.

4.7.3.2. Training. One SLR [S5] provides three training risks related to practitioner education while three SLRs [S5,S18,S19] supply two training advice items. Table 14 furnishes details. All three risks are the responsibility of the vendor project manager although at times risk #2 "…different knowledge levels or knowledge transfer problems" may refer to knowledge transfer problems between the client and vendor. This will need to be dealt with by both client and vendor project managers. There are overlaps in the risk and mitigation items listed here with collaboration and coordination, and the development process. Empirical support for the risks and advice is low in most cases.

4.7.3.3. Communication and collaboration. It is very difficult to differentiate between risks and advice related to communication and collaboration so we consider the two together here. We identified 22 risks from five SLR studies [S5,S11,S15,S16,S18]. There is some agreement between the SLRs with all five identifying communication and collaboration risks resulting from geographic differences. Communication and collaboration risks potentially have two dimensions. Firstly vendor–client interaction risks in which case the risks need to be managed by both vendor and client. However, if the vendor subcontracts to other countries or has sites in different countries, the vendor must manage all vendor–subcontractor interaction risks. While the client project manager may not be able to control these risks he/she must ensure that risks in this area are monitored. Table 15 provides details of the ten most supported communication and collaboration risks and mitigation items. Four SLR studies [S5,S16,S18,S22], supply communication and collaboration advice. There is some agreement between the risks identified and several of the recommendations.

4.7.4. Project management

We divided the project management risks into three subthemes: planning, coordination, and control. Overall, we extracted 29 project management risks and 20 items of mitigation advice. We now discuss the risks and mitigation advice provided for each sub-theme in turn.

4.7.4.1. Planning. Three studies [S5,S11,S18] identified eight planning risks and three studies identified eight mitigation advice items [S5,S16,S18]. The risks and advice are all meant for the vendor project manager. The risks and advice items with the most support more or less match and focus on "infrastructure compatibility". Though most of the planning risks are not under the direct control of the client manager the client must be concerned with many of these risks that can be summarised into one risk–"vendor management practices are unable to deliver the required product to budget, schedule and/or quality"; a client risk that can only be addressed by good vendor selection based on proper auditing of vendor management and development practices, information about past projects and certification status. There is some overlap between planning risks and communication and collaboration risks. Table 16 lists details of the items with the most support.

4.7.4.2. Coordination. Three SLR studies [S5,S11,S18] provide four risks and two studies [S5,S18] provide six mitigation advice items related to coordination; this sub-category is closely tied to control as well as communication and collaboration. While there is a reasonable amount of empirical support for risk #1 (25 primary studies) "Lack of coordination causes problems…", no item is supported by more than a single SLR. There is not a great deal of primary study support for the advice recommendations (3–5 primary studies). All four coordination risks are of concern to both cli-

ent and vendor. Table 17 lists the coordination risks and mitigation advice items.

4.7.4.3. Control. Three studies address GSD control [S5,S11,S18]; 17 risks and six advice items were identified. Ten risks and six advice items are listed in Table 18. Most risks and advice relate to (1) socio-cultural distance (and hence overlap with culture and social integration), and (2) geographic distance (which overlaps with communication and coordination). Much of the risk and advice is for the vendor project manager.

4.8. Summary of results related to risks, risk mitigation advice and their empirical support

In the following three sub-sections we provide the answers to our three sub-questions relating to risk, risk mitigation and their empirical support.

4.8.1. RQ3.1 What are the most common GSD project risks and what empirical support is there for these risks?

Thirty-four of the risks we identified were related to *human resources*, and 29 were related to *project management*. The sub-theme with the most risks was *communication and collaboration* with 22 risks. Just because we have not included a particular risk does not mean that it does not exist; it simply means that we were not able to find enough empirical support to include it in our results. The single risk with the most primary study empirical support was a *high level vendor selection strategy risk*, "language and cultural barriers cause problems", which had support from 55 primary studies although the quality of the primary studies was not defined. The risks supported by the most SLRs were:

(1) A risk related to the effectiveness of communication and collaboration with empirical support from five SLRs; "Limited face-to-face meetings caused by geographic distance negatively impact trust, decision quality, creativity, & general management; knowledge creation is limited within the organization. This may lead to problems in creating collaboration know-how and domain knowledge" and
(2) Three risks with empirical support from four SLRs.

- A risk related to vendor selection infrastructure; "Vendor's poor infrastructure such as infrastructure incompatibility between sites causes problems; selection of appropriate information and communication technology is crucial for project success".
- A risk related to effects of distance on communication and collaboration; "Temporal and physical distribution increases complexity of planning and coordination activities, makes multi-site virtual meetings hard to plan, causes unproductive waits, delays feedback, and complicates simple things"
- A cultural risk related to language; "Language differences between development sites can result in misinterpretations and unconveyed information"

4.8.2. RQ 3.2 What risk mitigation advice is proposed for the risks and what empirical support is there for the advice?

We found 78 advice items supported by at least three primary studies. Overall, the strength of most of the support is quite low with a majority of advice items discarded as they were supported by only a single primary study. A large proportion of the recommendations kept were related to agile methods showing the research community's interest in this topic. The advice with the strongest support from primary studies was "Use GSD for a project only when you can achieve cost savings", advice categorized as *GSD outsourcing rationale*, and supported by 89 primary studies, i.e., 73% of the primary studies in [S13]. However, as outsourcing rationale is not a common research area; we are lacking other SLR support for much of the advice identified in this category. In addition, companies have found that, although a project may actually cost more than if it was developed locally, local development is impossible because scarce expertise is unavailable [24]. Three mitigation advice items, related to infrastructure planning, communication effectiveness and intellectual property rights, were supported by three SLR studies. The match between the risks with the most support and the most supported mitigation advice is not good as only two of the top ten risks are matched with mitigation advice. See Appendix Table A4: Top 10 risks and mitigation advice, which lists the risks and mitigation advice with the most SLR support.

4.8.3. RQ3.3 Do we obtain different results if we exclude low quality studies?

If we consider only high quality studies that scored two or more (out of a maximum of four) in our quality assessment we exclude seven studies (29%), i.e., [S1–S3,S6,S14,S17,S24]. All of these studies scored 1.5 except for [S14] which scored 0.5. [S1,S14] were automatically excluded as they did not specify the number of primary studies included in their research. Of the other low quality studies only [S6] included the number of primary studies supporting risks and mitigation strategy items. The removal of risk and risk mitigation support supplied by Ebling et al. [S6], resulted in some changes to *requirements engineering* risks and mitigation advice. These changes include less support for risk #1 in Table 9, although this risk is still included because of support from [S15]. Risks #2, #3 #6, #7 and #8 are now excluded from Table 9 as [S6] provided their only support (these risks address requirements engineering problems relating to informal communication, change management, collaboration, stakeholder goals and knowledge management issues caused by distribution of stakeholders). The only three requirements engineering risk mitigation items identified are now excluded, leaving us with no mitigation advice for this subcategory.

In summary, removal of low quality studies results in minor changes to our results. We lost nearly half of the requirements engineering risks and all three mitigation items from the risks and risk mitigation items included in our tables. However, if we consider the most commonly identified risks (as shown in Table A4) we find that the loss of support from the low quality studies results in no changes.

4.8.4. RQ3.4 Which risks are the responsibility of the client and which are the responsibility of the vendor?

Whilst many of the risks should obviously be identified and monitored by the vendor project manager, most authors did not specify who should be responsible for risk identification and mitigation. In many SLRs there is an implicit focus on software development, i.e., the vendor and developers. In many cases there is an assumption that there are many groups of developers of different cultures, all located in different time zones. The client is pretty much ignored except for items relating to GSD outsourcing rationale and requirements risks. Although risks and advice specific to the client are limited, those items tended to have greater primary study support. It is interesting to note that [S12], which provided the client risks with the greatest empirical support, was actually written with a vendor focus and was intended to give vendors advice so that they could make themselves more attractive to clients.

Most of the papers we reviewed did not discuss GSD business models or project context; nor were the risks and advice reported considered in the light of the project lifecycle. Much of the mitigation advice extracted was at the level of objectives rather than strategies. When the organizational and project context is unclear, as it is in most of our studies, it can be difficult to determine who should be controlling the risks. Hence we did not find that the ad-

vice furnished in the SLRs provides a good foundation on which to recommend appropriate risk and risk mitigation strategies and actions to organizations involved with GSD.

5. Study limitations

We may have missed some studies and hence underestimated the extent of GSD SLRs. However, as noted earlier, we checked our papers against those found in other tertiary studies; none of the authors identified any papers describing GSD SLRs fitting our inclusion criteria that we did not find. Some of the quality data we collected may be erroneous as extracting and scoring quality criteria can be rather subjective. However, two data extractors derived this data independently. For the initial paper inclusion/exclusion we settled differences by discussion, but for the quality scores, if our reviewers did not agree, we used a third extractor and in all situations found that we were able to use a majority value. For one paper we reviewed [S8], both reviewers gave a quality score of three while [8,10] gave this paper a quality score of four. However, we decided to stay with our evaluation. Several other quality scores in [10] differ from our scores, e.g. [S18,S21,S24] although in some cases where there was disagreement, we evaluated a later more extensive paper than that included in the other study e.g. [S12,S19].

Many of the SLRs had titles that included terms such as "map", "review" or "profile". The aim of most of the SLR studies we found was not to identify GSD risks or provide risk advice to industry, but rather to present a summary of the literature to researchers.

In addition there are a number of problems with the empirical support that we collected:

- We could not sum support provided by the different studies, as the primary papers referred to by the SLRs in many cases overlapped; hence we would have been counting the same empirical support twice. This made it difficult to be sure about the real degree of empirical support for many items; however, the tables in Section 4.6 supply the reader with the raw data so they can make up their own minds.
- Two primary studies could use the same company's participants so may not be independent.
- Many of the SLR studies did not provide details of the evidence supporting the risks and advice items they identified; this made it difficult to be sure about the strength of support for a number of the items we excluded. Some authors indicated a "high level" of support but did not specify what "high" meant in terms of primary studies.
- The empirical support that we have included in the tables varies in quality both between items, and within the support for a single item. Even the SLRs that defined the quality of all the primary studies they included mostly did not associate the quality of their evidence with a specific item. Just one SLR [S5], carefully defined the quality of the evidence for the risks they identified. For example, while Table 7, risk #3 ("Lack of protection for intellectual property rights"), has support from one SLR [S12] with 46 primary studies of undefined quality, it also has support from [S5] with five primary studies; one study is of high quality, and four are of average quality.
- Even when authors defined the quality of the primary studies they included, they use different quality assessment frameworks. Thus it is impossible to assign a single quality value for the support for an item without going back to all the SLRs and redefining quality for each primary study (using the same quality assessment for all the primary studies) and then associating these with each item identified.
- The support relating to the advice items that we have used may in some cases be suspect. It is not at all clear whether the advice the SLR authors extracted from their primary studies is based on observing case studies where the risk management strategy was used and found effective or whether the authors of the primary study or study participants speculated that the strategy would have helped observed problems. This means that some of the empirical support that we collected may be based partly on speculation rather than observation.
- We consider it more important for a risk or advice item to have empirical support from multiple (independent) SLRs rather than support from a larger number of primary studies listed in a single SLR. However, given the lack of research in many of the areas this is open to debate.

Some of the SLR authors did not consider context at all; in addition, the primary studies providing the primary studies for the SLRs did not always furnish adequate contextual details. Šmite et al. [S21a] comment that "The amount of studies with mixed, not described or unclear contexts is relatively high. This burdens the understanding of applicability of the results and requires additional effort from the readers. Accordingly, we encourage researchers to thoroughly describe the contexts of the undertaken studies". The authors of [S5], who included 70 primary studies, used contextual details as one of their quality criteria. Only 40% of the primary studies they identified provided all expected contextual details and 11% provided less than half the required information.

6. Discussion, conclusions and further work

There are some limitations in the papers we reviewed. We rejected a number of papers from the IS literature because their authors did not differentiate between offshore IT operations and GSD even though they frequently referenced GSD papers in their bibliographies. We read these papers very carefully, sometimes several times, and would have included them if they had provided specific details about GSD in their results. We do not believe that the risks involved with IT operations and IT development are necessarily the same and most of the IS papers did not differentiate. This view is supported by Beulen et al. [2]. There is also a problem with the set of SLRs; SLRs are supposed to comment on other SLRs covering the same or related material. However, most of the SLRs we reviewed do not reference related SLRs and so do not define their overlap with other SLRs.

We found 24 SLR studies reported in 37 papers. The earliest GSD SLR was reported in a conference paper published in 2005. SLRs in GSD began to be a focus for research in 2009 when five papers were published; the research has increased markedly since then. The quality of GSD SLR studies has not changed over time. GSD studies are most frequently reported in *ICGSE*; other conferences have only provided minor outlets. Major journals reporting GSD SLRs are *IEEE Software*, *Information and Software Technology* and *Journal of Software Maintenance, Evolution and Practice*. The number of primary studies included in our SLRs ranged from 9 to 315. When we map GSD SLR study topics the most popular areas for research are related to the development process (project execution) and the organizational environment. Significant research, risks and advice are related to agile methods, but how much agile development is actually used in a GSD client–vendor situation (when compared with multinational development with subsidiaries) is unclear.

With the main focus on the vendor environment and the development process we are lacking research on the users, the client organization (except for some research on vendor selection [S12,S13]), and development of an outsourcing lifecycle framework that includes the client [S24], project complexity and the effects of several vendors, the type of contract, and cross border financial and legal implications. Brazilian researchers authored nearly 20% of our SLRs; the largest research group is based in Brazil. The Brazilians

have been active in the area of systematic reviews since 2005 and Brazilian industry is involved in many GSD projects (as vendors). The concatenation of the two research interests probably accounts for these results.

We categorized the risks and mitigation strategies we found into four major themes, (1) GSD outsourcing rationale, (2) software development process, (3) human resources, and (4) project management, and 13 sub-themes. However, some of the risk and mitigation strategy descriptions were poorly formulated and rather cryptic. Interestingly, when we consider the GSD risk mitigation advice identified we found over 400 suggestions. However, only a quarter of them had empirical support from at least three primary studies, i.e., much advice was suggested, but little empirical support is provided. Most of such advice is a high level suggestion to do something (often the converse of the risk), but there are few details regarding how to implement it. In contrast, empirical support for the GSD risks is marginally better as 107 of our risks had empirical support based on three or more primary studies. Only five studies [S5,S12,S13,S15,S18] specifically extracted industry advice (or barriers) from their primary studies, and as noted earlier, this made data extraction much easier. [S5,S12,S13,S18] consistently made clear the strength of evidence for their recommendations.

Overall, empirical support for most risks is moderate to poor, and the quality of the evidence in most SLRs is undefined. The risk with the most empirical support (i.e., identified by the greatest number of SLRs) was a communication and collaboration effectiveness risk related to geographic distance supported by five SLRs and related to software development at vendor sites. The items of advice with the most empirical support (three SLRs) were related to the need for (1) considering vendor infrastructure site compatibility (*vendor selection*), (2) *communication* effectiveness using multiple communication modes, and (3) *vendor selection* related to intellectual property rights; the first and third items of advice are related to the client while the second is related to software development at the vendor sites.

Removal of low quality studies resulted in only minor changes to our results. We lost nearly half of the requirements engineering risks and three mitigation items from the items included in our tables. However, if we consider the most commonly identified risks (as shown in Table A4) we find that the loss of support from the low quality studies results in no changes.

Researchers in most studies do not differentiate between client and vendor perspectives nor whether or not the GSD they discuss is part of a multinational insourcing project. In several of the studies there appears to be some confusion about who is the owner of the issue discussed, i.e., the term "practitioner" was frequently used though the identity of the practitioner was vague; it was not clear if the authors were discussing issues related to the client, the vendor (including developers), or all those involved in the project. Are the communication issues all with the vendor or is there some consideration regarding communication with the client? With GSD the term project manager can be confusing as normally, both client and vendor companies will provide a project manager to oversee the development of a project. The term "vendor project manager" describes the project manager in charge of actual software development. The "client project manager", who is employed by the client company, is expected to liaise with the vendor project manager as well as monitor the software development for the client company. Vendor project managers involved with GSD may need to control multiple groups of developers with different cultural backgrounds, and coordinate multiple sites each with its own time zone (e.g. [3,16]). The client project manager will mainly deal with the vendor project manager. While a number of issues around the software development will be of direct interest only to the vendor project manager other areas, such as project scope and requirements, and project planning and control, will be of interest to both project managers. However, they will have different perspectives.

Most of the papers we reviewed did not discuss GSD business models or project context and much of the advice extracted was at the level of objectives, i.e. practitioners are exhorted to do something with little practical advice on how it could be done. Furthermore, the risks and advice reported have not been considered in the light of the project lifecycle where risk avoidance actions taken at an early stage may reduce the probability of subsequent risks occurring. For example, if a client selects a CMM level 3 vendor, the likelihood of serious problems associated with project planning should be substantially reduced. A practitioner may find the set of risks identified in this paper a useful checklist, which may help to provide some understanding of the different risks related to global projects. However, they must also consider the relative importance of risks not only in conjunction with their particular business model, but also in the context of the lifecycle stage of their own project, and in the context of any preceding management actions that may have been taken. Šmite et al. [31] note that in many cases it may be "hard to understand the context of a study", and this "makes it

Table A1a
Data extraction form.

Reviewer name Paper title Data required	Permitted values/guidelines	Comment
Type of study	SLR, meta analysis, mapping	
Main GSD topics	From title and RQs	
Research question explored and answered	Please comment if you feel that any of the RQs are not answered adequately; "We don't know the answer" is fine if the primary studies didn't provide enough information for the researchers	
Number of primary studies included in study	1 to n	
SWEBOK classification of the areas studied	There may be more than one area so please list them all. A summary of the SWEBOK major and first level headings is provided in the appendix to this document. You may feel, for the odd paper, that you need to refer to the SWEBOK document for finer detail	
Does this paper describe a unique SLR or does it report on the same SLR as another paper done by the same or a similar research group	We wish to collect data on unique SLR studies as well as the papers describing those studies. In some cases the authors may have written several papers using the same SLR but highlight different aspects of the study in different papers. This may be important as far as the GSD mapping exercise is concerned; i.e., we may have one study and several papers reporting that study. Please label the study unique if it is the only paper that reports the SLR. The authors may have used the same SLR in other papers, please provide the title of the paper that you believe provides the most complete report of the SLR	

Table A1b
Data extraction form for quality.

Criteria	Score	Comment	Score
Inclusion/exclusion criteria	Y (yes), the inclusion criteria are explicitly defined in the study, score 1 P (partly) the inclusion criteria are implicit, score 0.5 N (no), the inclusion criteria are not defined and cannot be readily inferred, score 0		
Adequacy of search	Y, the authors have either searched 4 or more digital libraries and included additional search strategies or identified and referenced all journals addressing the topic of interest, score 1 P, the authors have searched 3 or 4 digital libraries with no extra search strategies or they searched a defined but restricted set of journals and conference proceedings, score, 0.5 N, the authors have searched up to 2 digital libraries or an extremely restricted set of journals, Score 0		
Synthesis method	Y, an explicit synthesis method is named and a reference to the method is supplied, score 1 P. A research method is named but no reference to the method is supplied, score 0.5 N. No synthesis method is named; score 0		
Quality criteria	Y, the authors have explicitly defined quality criteria and extracted them from each primary study, score 1 P, the research question involves quality issues that are addressed by the study, score 0.5 N, no explicit quality assessment of individual primary studies has been attempted or authors have defined quality criteria but not used criteria, score 0		
Information provided about primary studies	Y, Information is presented about each primary study; score 1 P, only summary information is presented about papers, score 0.5 N, the results of the individual studies are not specified, score 0		
Total quality score			

hard for both researchers and practitioners to identify cases that may be of interest".

Inconsistency in terminology can impinge on our ability to judge the applicability and the transferability of research into practice when trying to understand studies with poorly described or unclear project context [31]. We intend to use the terminology described in [31] in our ongoing research. Šmite et al. [S21a], note that "most of the empirical findings"..."for GSD studies are based on intra-organizational industrial collaboration between two geographically distributed sites"; "There is a clear lack of studies about inter-organizational collaboration"; and that the number of "studies with mixed, not described, or unclear contexts is relatively high". Is the organizational focus of the GSD research a client in one country with a vendor in another (inter-organizational), or is it a company with many subsidiaries, each with software development capability, in multiple countries (intra-organizational)? The primary studies from which the SLRs extracted their data may have sometimes made this clear, but it is not at all obvious in the SLRs nor even that some authors of the SLRs were aware that there is a difference. We believe that organizational and project context is important and that different risks and different advice will be required in different contexts. If a client in country A, outsources to a vendor in Country B with a *single* site, the vendor company may need to employ a cultural liaison officer. However, after requirements have been specified, risks related to control, coordination, communication and culture, vendor site infrastructure compatibility, etc., should be low, unlike the situation where the vendor has *multiple* sites in different countries. In the situation where there is a single development site a reasonable level of communication between the client and vendor project managers will of course be required, but the vendor project manager will not have to manage developers of multiple cultures, speaking multiple languages, at different sites, in different countries.

This research contributes to our understanding of the current state of GSD research and identifies:

- The need for more research related to the actual business models used for GSD as we need to know how the business model impacts the development itself.
- That risks and risk management need to be assessed within the context of 1) the specific business model being used for a particular project 2) the context in which the project is undertaken (for example why the GSD approach was used), and 3) whether the goals of the project were met.
- That we need better primary studies that describe the business models used for specific projects, the context in which the project is undertaken, the risks monitored and observed for that project together with risk management procedures deployed, their effectiveness and the project outcome. Overall, we need less speculation and more objective evidence.
- That as far as industry is concerned the risks and advice identified here can serve as a useful checklist which may help provide GSD practitioners with some understanding of different risks relating to global projects and how to address those risks.

In conclusion, most of the GSD SLRs we investigated produced a summary of the literature and mappings for researchers. Although some studies identified industry risks, and evidence for those risks, most did not; some studies provided industry advice many did not. In most cases industry recommendations were almost a by-product. Basically the SLRs have not done a good job of aggregating the data in a useful way nor have they properly considered their

Table A2
Risk and risk mitigation data extraction form.

Reviewer name	Guidelines
1. Paper number	
For each paper there may be multiple risks and multiple items of mitigation advice	
Risk Details	
2. Main risk topic(s) category	Use SWEBOK classification Select from: • architecture • development process • project management • requirements engineering • configuration management • outsourcing vendor selection • culture • communication, collaboration, control and distance
3. Number of primary studies supporting risk/challenge	if known. If not known please enter "unknown"
4. Who is responsible for controlling the risk	***Choose from list below but there may be several*:** Vendor project manager (VPM) Client project manager (CPM) Client senior management Vendor senior management Developer Other please state

(*continued on next page*)

Table A2 (*continued*)

Reviewer name	Guidelines
5. Additional risk topic	*There may be several topics not just main topic listed above* 1. Use SWEBOK classification 2. Select from: • architecture • development process • project management • requirements engineering • configuration management • outsourcing vendor selection • culture • communication, collaboration, control and distance
6. Specific risk area and details, if provided	Select from: • architecture • development process • project management • requirements engineering • configuration management • outsourcing vendor selection • culture • communication, collaboration, control and distance
Mitigation advice details	
7. Advice topic(s)	Select from: • architecture • development process • project management • requirements engineering • configuration management • outsourcing vendor selection • culture • communication, collaboration, control and distance
8. Number of primary papers supporting advice	if known. If not known please enter "unknown"
9. Advice topic(s)	Use SWEBOK classification • Select from: • architecture • development process • project management • requirements engineering • configuration management • outsourcing vendor selection • culture • communication, collaboration, control and distance
10. Who is the advice meant for?	***Choose from list below but there may be several*:** Vendor project manager (VPM) Client project manager (CPM) Client senior management Vendor senior management Developer Other please state unknown
11. Advice sub-topic	Select from: • architecture • development process • project management • requirements engineering • configuration management • outsourcing vendor selection • culture • communication, collaboration, control and distance
12. Specific advice area and details, if provided	Select from: • architecture • development process • project management • requirements engineering • configuration management • outsourcing vendor selection • culture • communication, collaboration, control and distance

Table A3
Institutional affiliations of active researchers.

Country*	Institution*	Researcher[a]
Australia (4)	University of NSW, 2	Hossain Paik
	NICTA, 2	Bannerman Staples
Brazil (17)	Faculdade Integrado de Campo Mourao	Chaves
	Federal University of Pernambuco (UFPE), 10	Costa (3) Cunha da Silva (2) de Azevedo Franca (2) Junior Meira Monteiro Rocha (3) Rodrigues
	Federal University of Technology Parana	Steinmacher
	Pontifica University Catholica do Rio Grande do Sul (PUCRS), 4	Audy (3) Ebling Kroll Prikladnicki (6)
	University of Sao Paulo	Gerosa
Canada (5)	University of Victoria, 5	Damian (2) Nurdiani Story Truede Weber
Denmark (4)	Aalborg University	Persson
	Systematic Software Engineering Aarhus	Madsen
	Trifors A/S Aarhus, 2	Boeg Steinson
Finland	Jyvaskyla University	Yalaho
Germany	Software Systems Scientist, Heidelberg	Mistrik
Ireland (9)	University of Limerick, 9	Agerfalk Ali Ali-Babar Beecham (2) Conchuir Fitzgerald Holmstrom Noll Richardson
Latvia	University of Latvia	Šmite
Malaysia	Universiti Teknologi Mara	Fauzi
Pakistan	National University of Science and Technology, Rawalpindi	Ahmed (2)
Saudi Arabia	King Saud University	Alsudairi
Spain (6)	University of Castilla-La Mancha, 2	Piattini Vizcaino
	Technology Innovation Centre, Albacete; Alhambra-Eidos	Jimenez Lopez
	University of Murcia, 3	Nicolas Toval
	Blekinge Institute of Technology, 6	Feldt Gorschek Jalali Jabangwe

Table A3 (*continued*)

Country*	Institution*	Researcher[a]
Sweden (8)		Šmite (2)
		Wohlin (2)
	Skovde University, 2	Lings
		Lundell
United Kingdom (3)	Keele University, 2	Khan (2)
		Niazi (2)
	Swansea University	Dwivedi
United States	Fraunhofer Center for Experimental Software Engineering, Maryland	Shull
(3)	Georgia State University	Mathiassen
	Pennsylvania State University	Huang

* One researcher unless otherwise stated.
[a] one study unless otherwise stated.

results in the context of previous related studies. Much of the advice we extracted was at the level of objectives rather than providing risk mitigation strategies but, to be useful to a project manager on a specific project, risk mitigation strategies need to be based on business model and project context. As most of the studies provided little in the way of evidence to support the risks and advice provided, we believe that more research into GSD risks and mitigation strategies is required. For a particular GSD project we need to understand the relative importance of risks in conjunction with its context including the business model employed and lifecycle stage of the project, together with any preceding management actions that may have been taken. Evidence furnished for the risks and advice identified by our SLRs, though mostly undefined with regard to quality, provides a start, but more GSD research is required. However, the research must include a consideration of the project context, and business model, as well as the quality of the supporting evidence.

Further work includes using the results of this tertiary study as a basis for conducting an extensive GSD SLR, with a specific focus on primary studies investigating client-oriented risk. We are involved in a new independent study but will use the primary studies referenced in the SLRs identified here as a checklist. We are interested in investigating how GSD business models and project context affect risk in GSD projects and to identify risk and risk mitigation strategies and practices as they relate to the project context and business model employed. As noted earlier researchers in most studies do not differentiate between client and vendor perspectives nor if the GSD they discuss is part of a multinational insourcing project. We are not convinced that the risks in an outsourced (client–vendor) GSD project are necessarily the same as those in an insourced (multinational) GSD project. An understanding of the variations of the GSD business model will provide the foundation for a better understanding of risks, risk mitigation strategies and practices, and the strength of supporting evidence as it relates to a particular GSD project.

Table A4
Top 10 empirically supported risks and mitigation advice.

#	Risk	Study	Support level	Mitigation advice	Study	Support level
1	Communication and collaboration – effectiveness: Limited face-to-face meetings caused by geographic distance negatively impact trust, decision quality, creativity, and general management; knowledge creation is limited within organization. This may lead to problems creating collaboration know-how and domain knowledge	[S15]	3 (8%)			
		[S18]	6 (8%)			
		[S5]	13 (19%)			
		[S16]	12 (46%)			
		[S11]	9 (12%)			
2	Vendor selection – infrastructure: Vendor's poor infrastructure such as infrastructure incompatibility between sites causes problems; selection of appropriate information and communication technology is crucial for project success	[S12]	32 (33%)	Planning – infrastructure: Ensure infrastructure compatibility among geographic locations	[S16]	13 (50%)
		[S16]	7 (27%)		[S5]	3 (4%)
		[S5]	13 (19%)		[S18]	4 (6%)
		[S18]	11 (15%)	Vendor selection – infrastructure: Consider the vendor's infrastructure	[S13]	73 (60%)
					[S12]	25 (26%)
3	Communication and collaboration – distance: Temporal and physical distribution increases complexity of planning and coordination activities, makes multisite virtual meetings hard to plan, causes unproductive waits, delays feedback, and complicates simple things	[S5]	20 (28%)			
		[S16]	13 (%)			
		[S18]	5 (7%)			
		[S11]	5 (6%)			
4	Culture – language: Language differences between development sites can result in misinterpretations and unconveyed information	[S18]	12 (17%)			
		[S16]	14 (54%)			
		[S5]	11 (16%)			
		[S15]	3 (8%)			
5	Communication – effectiveness: Lack of effective communication causes problems with knowledge management; participants may lack information about the task, its purpose, and their own contribution to overall task	[S5]	46 (66%)	Communication – effectiveness: Introduce multiple communication modes including support for face-to-face synchronous communication	[S5]	8 (11%)
		[S18]	5 (7%)		[S16]	5 (14%)
		[S11]	3 (4%)		[S18]	9 (10%)

(*continued on next page*)

Table A4 (*continued*)

#	Risk	Study	Support level	Mitigation advice	Study	Support level
6	Culture – trust: Mutual trust is important but hard to obtain and lack of trust causes problems due to lack of face-to-face interaction, cultural differences, and weak social relations	[S18]	8 (11%)			
		[S5]	15 (21%)			
		[S16]	9 (35%)			
7	Communication – social integration: Limited possibility for informal communication due to dispersion of sites causes problems with social integration of the teams	[S16]	11 (42%)			
		[S5]	14 (20%)			
		[S18]	6 (8%)			
8	Process – standards: Problems caused by asymmetry in processes, policies and standards	[S5]	14 (20%)			
		[S15]	4 (11%)			
		[S16]	11 (42%)			
9	Culture – conflict: Differences in work culture may render difficulties when sites are different in terms of team behaviour, balancing of collectivism and individualism, perception of authority and hierarchy, planning, punctuality, and organizational culture. This may lead to decreased conflict handling capabilities and lower efficiency or even paralyse the project	[S5]	12 (17%)			
		[S18]	8 (11%)			
		[S15]	4 (11%)			
10	Communication – effectiveness: Lack of synchronous communication or interaction (i.e. inability to communicate in real time) causes collaboration problems	[S5]	10 (14%)			
		[S11]	7 (9%)			
		[S18]	5 (7%)			
				Vendor selection – intellectual property rights: Consider intellectual property and ensure effective policies for confidentiality, copyright protection, and intellectual property	[S12]	36 (37%)
					[S13]	23 (19%)
					[S5]	3 (4%)
				Vendor selection – technical ability: Ensure that there is appropriate technical ability, i.e., take into account the developers' skills	[S12]	46 (46%)
					[S13]	
						82 (67%)
				Vendor selection – project management: Ensure that there is effective/efficient project management	[S12]	48 (49%)
					[S13]	47 (39%)
				Vendor selection – contract management: Select a vendor with effective contract management	[S13]	45 (37%)
					[S12]	35 (36%)
				Vendor selection – culture: Select a vendor with knowledge of the client's language and culture	[S12]	38 (39%)
					[S13]	39 (32%)
				Development process – agile development: Institute stand up meetings for agile development	[S8]	16 (80%)
					[S10]	18 (23%)
				Development process – agile development: Use continuous integration in agile development	[S8]	18 (90%)
					[S10]	12 (16%)

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Appendix A

See Tables A1a–A4.

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