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An exploration of high performance computing cloud contract for SMEs: A systematic literature review

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An exploration of high performance computing cloud contract for SMEs: A systematic literature review

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Abstract

Purpose - High performance computing (HPC) is used to solve complex calculations that personal computing device are unable to handle. HPC offers the potential for small and medium size enterprises (SMEs) to engage in product innovation, service improvement and the optimization of resource allocation (Borstnar and Ilijas, 2019). However, the expensive infrastructure, maintenance costs and resource knowledge gaps that accompany the use of HPC can make it inaccessible to SMEs. By moving HPC to the cloud, SMEs can gain access to the infrastructure without the requirement of owning or maintaining it, but they will need to accept the terms and conditions of the cloud contract. This paper aims to improve how SMEs access HPC through the cloud by providing insights into the terms and conditions of HPC cloud contracts.

Design/methodology/approach - This paper adopts a systematic literature review by implementing a four-step approach. A comprehensive search was undertaken, and results synthesised to enable our objectives to be met.

Findings - This paper proposes that SMEs could gain competitive advantage(s) by understanding their own needs, improving their contract negotiation abilities, service management skills and risk management abilities before accepting the terms and conditions of the cloud contract. Furthermore, a checklist, service-level agreement (SLA), easily ignored elements and risk areas are presented as guidance for SMEs when reviewing their HPC cloud contract(s).

Originality – While HPC cloud contracts are a niche research topic, it is one of the key factors influencing the ability of SMEs to access HPC through the cloud. It is, however, by no means a level

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3 playfield with SMEs at a distinct disadvantage due to not influencing the writing up of the HPC cloud
4 contract. The added value of the paper is that it contributes to our overall understanding of the terms
5 and conditions of HPC cloud contracts.
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10 **Keywords** High Performance Computing, Cloud Computing, Cloud Contract, Systematic Review,
11 SMEs
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14 **Paper type** *Review paper*
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An exploration of high performance computing cloud contract for SMEs: A systematic literature review

1. Introduction

High performance computing (HPC) is a cluster of computers carrying out parallel process work at teraflop or petaflop processing speeds as it aggregates multiple central and graphics processing units (Maayan, 2020). HPC, therefore, has the potential to resolve complex problems at greater speeds than personal computers cannot compete with, particularly when applied to product innovation, responding time and the optimization of resource allocation etc. (Borstnar and Ilijas, 2019). However, HPC mainly depends on in-house hardware and infrastructure (Monteiro et al., 2015), it is expensive to purchase and maintain (Sajay and Babu, 2016), especially for SMEs (Botelho and O'Gorman, 2021). In addition, due to limited resources, those SMEs considering the large investment cannot afford the infrastructure to be either underutilized or overloaded (Mauch et al., 2013). On the other hand, SMEs can benefit from accessing HPC through the cloud (Gašperlin et al., 2019) in terms of improving performance, expanding business and sustaining their development (Botelho and O'Gorman, 2021) as the providers could provide pay-as-you-go costing options for SMEs, faster corresponding time, greater efficiency and unlimited storage space (Sajay and Babu, 2016) without owning the infrastructure (Gašperlin et al., 2019). In order to save cost and improve performance, SMEs are exploring the potential of accessing HPC through the cloud (Monteiro et al., 2015). HPC cloud market was worth \$4.3bn in 2020 and it is anticipated to grow at an annual rate of 17% (Shah, 2021) which gives the huge incentives for SMEs to explore the possibility of accessing HPC through the cloud.

In order to access cloud HPC, the SMEs needs to agree to the HPC terms and conditions of the cloud contract which are normally complex and prepared by and favour cloud providers (Lundqvist, 2019). The contract imposes considerable restrictions onto SMEs (Burden, 2014). Due to their flawed understanding of the contract and their inability to clarify the associated risks to the business emanating from the contract, the understanding of a cloud contract can be an issue for SMEs (EC2IT, 2017). The

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3 European Commission has published a study regarding the unfair and unbalanced cloud contract for
4 SMEs (EuropeanCommission, 2019). It indicated that the core of the problem arises from the SMEs'
5 lack of knowledge on how to use cloud services, lack of attention during signing the contract, lack of
6 transparency of cloud issues and unbalanced liability between the SMEs and the cloud providers
7 (EuropeanCommission, 2019) Furthermore, additional damage could be imposed onto SMEs due to the
8 contract-related problems, such as unsatisfied availability, low speed of service, forced updates that
9 remove a necessary function and service discontinuity (EuropeanCommission, 2019) More than half of
10 the SMEs that participated in their study implied that they needed clear guidance on how to tackle the
11 contract-related problems (EuropeanCommission, 2019), contributing that those challenges that can be
12 alleviated by negotiating a cloud contract (Opara-Martins et al., 2015).
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25 The state-of-art research of HPC cloud contract for SMEs is in its initial stage. With limited
26 skills, reduced maturity and fewer resources than large organizations (Bochicchio et al., 2011), SMEs
27 require clear guidance when reviewing HPC cloud contracts (EuropeanCommission, 2019) which
28 would identify the requirements, check the policy (Reantongcome et al., 2020), offer the optimized
29 deployment and pricing mechanism (Asthana et al., 2019, Wang et al., 2013, Dierks et al., 2019), take
30 precautionary measures to counteract risks (Lin et al., 2018, Cho et al., 2017) and provide penalty
31 measures if violations happens (Hwang et al., 2020). In the case of HPC cloud adoption by SMEs, the
32 cloud contract has barely been investigated before. This paper aims to fill in this gap by conducting a
33 systematic literature review of HPC cloud contract related publications with the aim of answering the
34 following research questions:
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46 RQ 1: How can SMEs be better prepared prior to signing HPC cloud contract?

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49 RQ 2: What cloud issues can SMEs focus on during a HPC cloud contract review?
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52 This paper is structured as follows: the systematic review methodology is discussed in Section
53 2. Section 3 and 4 answers the two research questions, namely: How can the SMEs be better prepared
54 prior to signing the HPC cloud contract? And what cloud contract issues can SMEs focus on during a
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HPC cloud contract review? Conclusions and areas for future study avenue are then discussed in the final section of the paper.

2. Methodology

The paper follows the systematic literature review method with the aim to provide robust evidence to answer the research questions by covering the majority of the relevant papers (Snyder, 2019). The systematic approach is carried out through a series of steps: comprehensive search, quality assessment, data extraction, synthesis and write up (Tranfield et al., 2003). The process of the systematic review is presented in Figure 1.

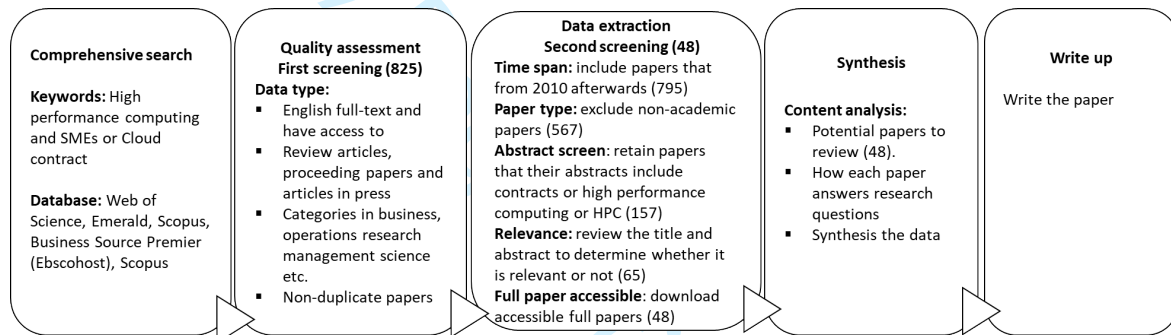


Figure 1: The literature review process

This review starts by creating a search query for papers in all fields with the keywords “high performance computing and SMEs” or “cloud contract. In the case of this paper, the chosen databases are EBSCOhost, Emerald, Web of Science and Scopus as they cover the majority of the relevant papers aligned with the topic under investigation. Next, a twofold screening process was applied. The first screening identifies preliminary restrictions before the search. The authors restrict data to English full texts that the researchers had access to and the papers have to be peer-reviewed journal articles and proceeding papers. As this study focuses on the business instead of technology, the categories are limited to multidisciplinary sciences, operations research management science, law, management, business, economics, business finance, art, humanities multidisciplinary and social science. Apart from Emerald, the search query is applied to the other three database. As the Emerald database has a very broad search algorithm, the results numbered more than 5000 which has significantly difference from the 400 articles from Web of Science, 327 articles from EBSCOhost and 34 articles from Scopus.

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3 Therefore, the search query was amended slightly in the case of Emerald where we searched in all fields
4 by the following keywords: “high performance computing and SMEs” and “cloud contract”. This
5 produced 209 results – when the different results are combined, a total of 970 publications had been
6 identified. After removing the duplicate articles and incomplete information articles (such as, no article
7 titles, no abstracts), 825 were left for further analysis.
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14 The second screening stage applies additional filter requirements to the remaining articles such
15 as the publication year being 2010 or after (resulting in 795 articles), elimination of conference papers
16 (narrowing the results to 567 articles) and checking the abstracts to include ‘cloud contract’ or ‘high
17 performance computing’ (or HPC) (resulting in 157 papers for analysis) (Ahmed et al., 2021). Irrelevant
18 papers are then removed by reviewing the title and abstracts (Mohamad Suhaili et al., 2021), resulting
19 in 65 full papers to be subsequently downloaded. Out of those, 17 papers were removed due to
20 containing incomplete information such as the author affiliation or the full versions not being accessible,
21 resulting in 48 papers to use for further analysis.
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32 Of the 48 papers, only 7 papers specifically investigate HPC in cloud, with the rest generally
33 discussing cloud contract issues. Furthermore, in the 7 papers, only one paper indirectly answers the
34 research question (Wu et al., 2017). What became evident is that SMEs have similar concerns when
35 moving conventional work to the cloud as to when moving HPC to the cloud (Shah, 2021). For example,
36 from the 1960s onwards, companies considered moving their conventional workload to the cloud as it
37 was too expensive to maintain in-house and they had the same concerns in terms of cost, lack of control,
38 lock-in issue and availability (Waddell, 2019) – these are similar to the concerns faced when moving
39 HPC to the cloud. There are only a handful of papers that discuss HPC cloud contract from a business
40 perspective and SMEs have the similar concerns as when moving conventional work to the cloud and
41 moving HPC to the cloud. Therefore, this study mainly reviews papers that discuss general cloud
42 contracts and does not specifically talk about HPC cloud.
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55 Of the 48 papers identified, 45% papers were published from 2019 onwards with the number
56 of publications peaking in 2021 (Figure 2). Even though there was a slight increase in the number of
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publications in 2015, it fell back in 2016 and remained low until 2018. This suggests that the topic is of growing interest in recent years.

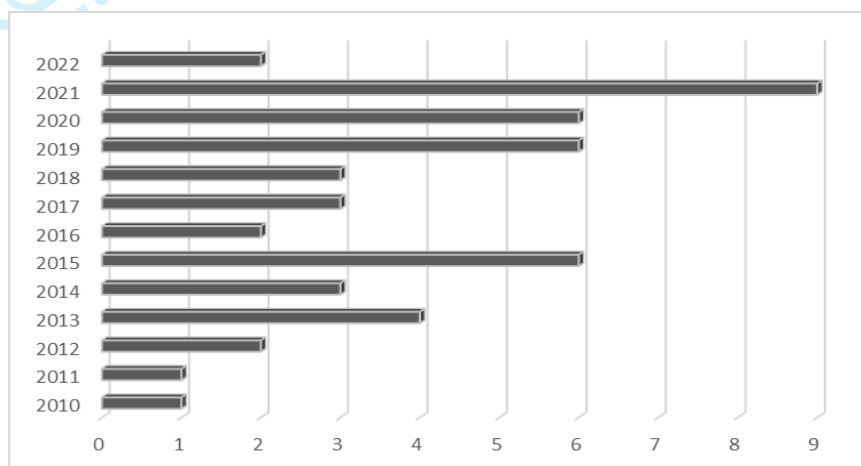


Figure 2: Year of publication

In order to illustrate co-authorship network, the countries of the co-authors are analysed using VOSviewer (Martinho, 2021). VOSviewer is a bibliometric analysis software that provides visual graphical mapping tools (van Eck and Waltman, 2010). It is a link-based analysis tool (Orduña-Malea and Costas, 2021) which can be used in academic research using databases (Ding and Yang, 2020), and in this case is used to provide a clear visual illustration of which countries are more likely to research on this topic cooperatively (Figure 3).

The results show that there are five clusters of countries engaged in collaborative joint research (Figure 3). In the USA cluster, researchers from the USA, China, Singapore and Canada are linked together; the UK cluster connects researchers from UK, Switzerland, France and Netherlands; while the Germany cluster links researchers from Germany, Greece and Yemen. In the Iraq cluster and Portugal cluster, researchers from two counties are connected in each of the clusters, respectively from Iraq and Iran, and Portugal and Spain.

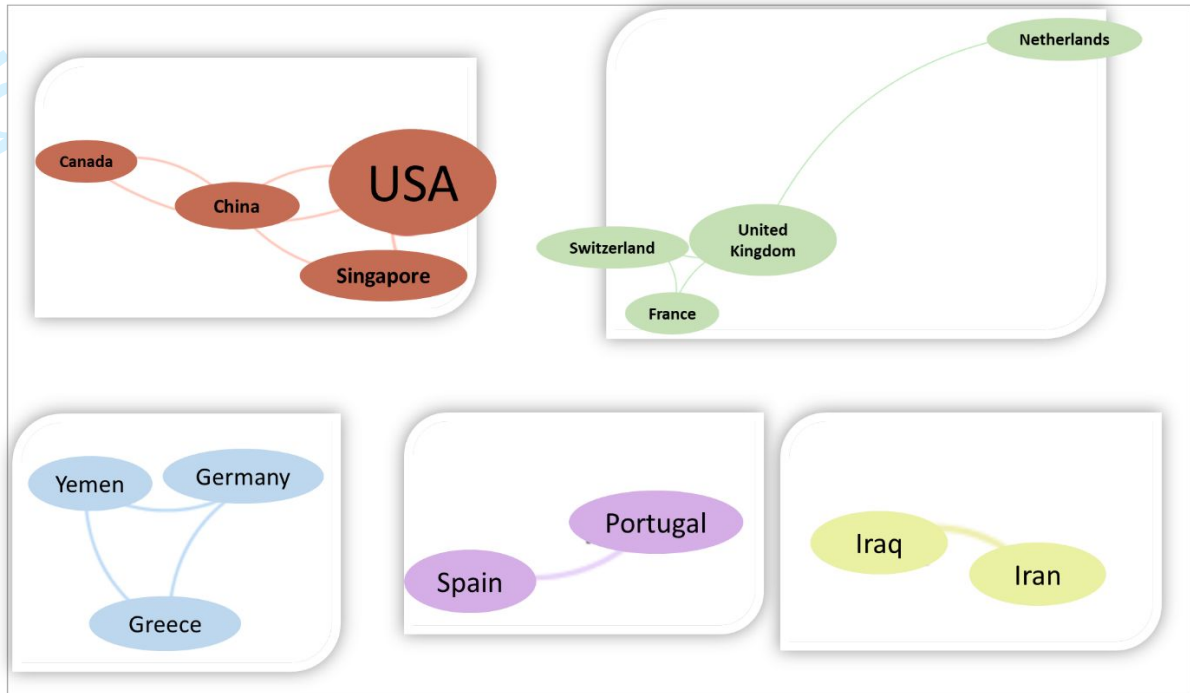


Figure 3: Five clusters of countries that cooperated

The 48 papers were published in 36 different journals, of which 8 published more than 2 papers (Figure 4). The journal that published the most papers (5 papers) is the *Computer Law and Security Review*, which has an impact factor of 2.98. The other 7 journals published 2 or 3 papers on the topic, of which the *Future Generation Computer Systems* has the highest impact factor with 7.19. Among the 8 journals, the *Information Systems Research*, *Expert System with Applications* and *Digital Policy, Regulation and Governance* are rated as 4*, 3* and 1* respectively by the Chartered Association of Business Schools (ABS) list.

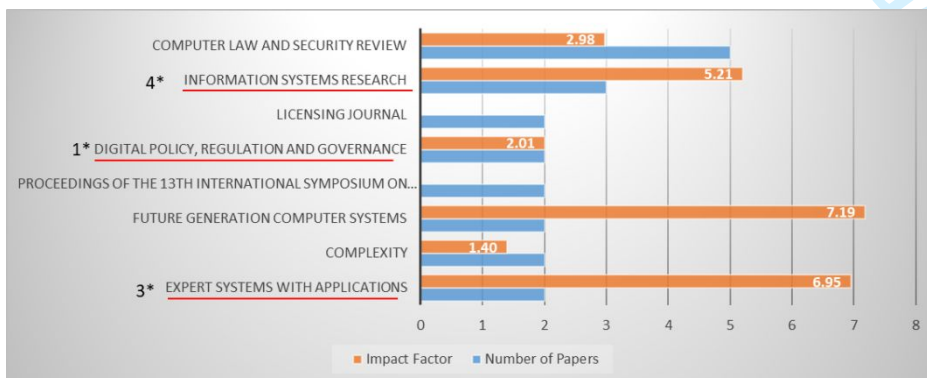


Figure 4: Journals that published papers in the investigated topic

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3 After reviewing the 48 papers, one additional duplicate paper that was not previously found –
4 due to different titles being used - was identified. The remaining 47 papers were categorised into four
5 groups depending on whether they answer research question 1, research question 2, both or neither.
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10 24 papers answer neither of the two questions but they are more or less related to SMEs
11 adoption of HPC or cloud contract as they addressed the benefits or the challenges of SMEs accessing
12 HPC through the cloud or the challenges associated with cloud contract (Gašperlin et al., 2019, Borštnar
13 et al., 2015, Besednjak Valič et al., 2021, Botelho Junior and O’Gorman, 2021, Overly, 2017). Some of
14 them discussed cloud contracts from a legal perspective such as copyright (Savelyev, 2014), cost
15 sharing or cost deferral (Chen et al., 2019, Goldstein, 2020) or treating cloud contract as a digital asset
16 (Banta, 2014). Some of the papers investigated cloud computing resource provision, such as designing
17 an auto-scaling mechanism to reduce violation, proposing a multiple stage programme to optimize
18 resource allocation (Yadav et al., 2022, Bülbül et al., 2021), while others focused on the technological
19 aspects such as how to design a smart contract using blockchain (Aguilera et al., 2021, Dorsala et al.,
20 2020, Xu et al., 2020), or algorithm issues in the cloud contract (Tiganoia et al., 2019, Taylor et al.,
21 2018).
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36 **3. How can SMEs be better prepared prior to signing HPC cloud contract?**

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38 The remaining 23 papers answer either research question 1, 2 or both of them. 12 papers answer research
39 question 1, 15 papers answer question 2 and 4 papers answer both questions. The key points of the 12
40 papers that answer question 1 can be found in Table 1. Overall, there are four competences that SMEs
41 should improve to find themselves in a more desirable position when agreeing to the terms and
42 conditions of the HPC cloud contract.
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49 *Understand the SMEs' need*

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51 First and foremost, SMEs need to know what they need (Wu et al., 2017) and prioritise these issues
52 (Gold, 2015). Hon and Millard (2018) interviewed legal professionals, business specialists and IT
53 security professionals from those banks that adopted cloud, cloud providers, advisers and financial
54 services regulators to ascertain the contractual issues arising from the preliminary stage of the
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3 contracting. They propose that improving awareness by strengthening the basic knowledge of cloud
4 work is vital for cloud users. Wu et al. (2017) believe that SMEs were increasingly requiring hardware
5 and software systems for large volume data and the algorithms that calculate and analyse complicated
6 data.
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12 The awareness improvement refers not only in-house members in SMEs but also external
13 lawyers, policy makers etc. as, on occasion, the management team and regulators may be overly
14 cautious about cloud HPC due to their ignorance (Hon and Millard, 2018). Due to their size and markets
15 in which they operate, SMEs do not need all of the services that cloud HPC operators provide. There
16 are seven major cloud HPC providers in the market who are able to provide different services ranging
17 from Infrastructure as a Service (IaaS) and Platform as a Service (PaaS) to Software as a Service (SaaS).
18 The providers are Amazon Web Services, Google Cloud Platform, Azure, IBM Cloud, Sabalcore,
19 Oracle Cloud and Penguin on Demand (Maayan, 2020). All provide detailed webpages and professional
20 customer service team to help SMEs to understand their needs and the services that they provide.
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32 *Improve contract negotiation ability*

33 SMEs may have lots of requirements, such as specified bandwidth, cloud provision at certain times and
34 latency requirements. Cloud HPC providers are able to provide a tailored service, but this requires
35 negotiation ability on the part of the SME (Shojaiemehr et al., 2019) as poorly executed negotiations
36 may cost more for both parties in the deployment stage later on (Yigitbasioglu, 2015). It is important
37 for SMEs to improve their negotiation abilities due to their limited budget. Shojaiemehr et al. (2019)
38 proposed that the negotiation strategy should consider negotiation time, negotiators' preference, and
39 opponents' behaviour. They also listed four parameters for negotiation, namely: price, response time,
40 availability and reliability (Shojaiemehr et al., 2019). Additionally, Gold (2015) noted that SMEs should
41 clearly specify the service level agreement before signing the contract. A good SLA should meet three
42 criteria, that is, it needs to be measurable, authentic and controllable. He also provided detailed steps
43 on how to specify the SLA. Finally, SMEs should establish a value target that both parties strive to
44 achieve which cannot leave the issue after signing the contract (Gold, 2015). Furthermore, as 75% of
45 outsourcing relationships experience some form of renegotiation (James, 2017), Huang et al. (2021)
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3 provided renegotiation decision model, indicating that the renegotiation decision depends on the
4 renegotiation cost, monitoring cost and vendor's bargain power.
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8 Therefore, in order to win the bargain power and improve negotiation ability, SMEs could
9 establish a value target at the beginning to avoid disappointment in the later deployment stage, select
10 suitable negotiation strategy, carefully design the SLA by adopting the criteria and balance the
11 renegotiation and monitoring decision by considering the renegotiation cost, monitoring cost and
12 vendor's bargain power.
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18 *Improve service management skills*

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20 Signing the HPC cloud contract does not mean everything occurs. The SMEs that use cloud computing
21 still have some contract-related issues after signing the contract (EuropeanCommission, 2019)..
22 Therefore, service management is vital for SMEs as it includes all the processes and activities that help
23 SMEs to align service resources with strategy, which should be carefully deployed before signing the
24 contract.(Michael et al., 2019) As SMEs do not have the capability to established an all-included service
25 management system (Michael et al., 2019), the simplified service management skills that incorporate
26 some key points are required by the SMEs. Rodrigues et al. (2012) propose a number of service
27 management targets. Firstly, the SMEs should maintain good interoperability with providers; secondly,
28 they should establish a dynamic negotiation system that both parties are involved; thirdly, the SMEs
29 could gain access to SLA data to better monitor performance; and finally, SMEs should work with
30 providers to develop a transparent audit system. On the other hand, Wang et al. (2013) discussed the
31 pricing model of cloud resources that is able to satisfy both parties. They mentioned that the contract
32 time and the trade-off between a single purchase and multiple purchases could influence the price.
33 However, Radhika and Sadasivam (2021) addressed the cloud providers' selection by proposing a Multi
34 Criteria Decision-Making (MCDM) model.
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53 Therefore, the service management skills could cover setting management targets (Rodrigues
54 et al., 2012), paying attention to contract time and price, comparing single and multiple purchases
55 (Wang et al., 2013) and choosing cloud providers (Radhika and Sadasivam, 2021). Other than retaining
56 a dynamic interaction with cloud providers, the SMEs should be aware that the contract time will affect
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3 the final price (Wang et al., 2013). Normally, the price will increase when more is used due to the pay-
4 per-use method. However, sometimes providers offer a contract price that enables unlimited usage
5 during a specific contract period. This can be as long as three years (Wang et al., 2013). Therefore, the
6 SMEs could optimise the price structure by combing the price offers. Additionally, as different cloud
7 providers meet different requirements, SMEs may need more than one provider to achieve their target(s).
8 Hence, multiple cloud service purchases might be needed. Normally, the multiple purchase option is
9 cheaper than a single purchase (Wang et al., 2013). Finally, choosing a service provider is also an issue
10 that should be tackled. Cloud performance, cloud availability, cost and whether the provider could offer
11 a scalable and reliable service are key considerations when choosing cloud providers (Radhika and
12 Sadasivam, 2021).

Improve risk management ability

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25 No matter what kind of benefits the cloud HPC can bring, risks always exist (Ryan and Loeffler, 2010).
26 Risk management is another important ability for SMEs to develop and improve before signing the
27 HPC cloud contract (Hon and Millard, 2018) as the switching cost is too high (Shah, 2021) and provides
28 SMEs with the ability to survive and overcome uncertainty (Ferreira de Araújo Lima et al., 2020).
29 Several approaches had been suggested by researchers. D'Onfro (2022) defined relationships between
30 cloud users and providers as bailment, which is the law of entrusting things to other people. If any
31 violation happens, the doctrine of bailment would protect the victims. Secondly, Hon and Millard (2018)
32 suggested that customers should ensure they have the freedom to choose business operation methods
33 and use of multi-cloud to avoid over dependency, which is a potential risk for SMEs. Ryan and Loeffler
34 (2010) believed that pre-contract evaluation is vital to manage risk, especially analysing the potential
35 uses of the cloud in terms of the business model, applied technology and regulation. Before signing the
36 contract, SMEs should evaluate the contract to weigh up the benefits and potential risks to determine
37 whether or not to join and how to join. Haibach (2015) emphasized that the most important aspect of
38 the evaluation is that what regional law can be applied if a violation happens. For example, a customer
39 in the UK uploads data to a US cloud HPC provider whose servers are located in the Netherlands. If a
40 violation happened, which country's laws would apply? The law can be agreed by both parties in the
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3 contract. Finally, Kamarinou et al. (2016) pointed out that the contract should specify the privacy policy
4 in terms of how the data is collected, used and shared. Additionally, the automatic adjustment should
5 be paid attention to and evaluate the impact it may have (Gold, 2015) as forced updated may remove
6 some necessary function (EuropeanCommission, 2019).
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12 Therefore, defining the relationship between the SMEs and the cloud provider is the foundation
13 of risk management as it relates to the law that could apply. After clearing the relationship, the pre-
14 contract evaluation is the key to protect the rights of SMEs in terms of the guarantee for SMEs to freely
15 choose the business model as well as the resources needed. During the pre-contract evaluation stage,
16 the law and the impact of automatic adjustment should be agreed and assessed. In addition, privacy
17 coverage plays an important role in the risk management as it contains details of how the data is
18 collected, stored, accessed and shared.
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28 In summary, the SMEs could prepare themselves before signing a HPC cloud contract by
29 understanding what they need and improving their negotiation skills, service management and risk
30 management abilities.
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34 **4. What cloud issues can SMEs focus on during a HPC cloud contract review?**

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37 Among the 47 papers identified, there are 15 papers that discuss cloud contract issues. Some of these
38 papers overlap with the papers that answer question 1. The key points regarding the question 2 can be
39 found in Table 2.
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44 The concerns that SMEs have when they access HPC through cloud are similar with those
45 previously expressed when they moved their traditional workload to the cloud (Shah, 2021). Therefore,
46 the cloud contract issues are also similar. The following sub-sections provide an extension to the
47 discussion surrounding research question 1, providing more details regarding the terms and conditions
48 of cloud contracts.
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Checklist

The checklist that the cloud contract issues should focus on can act as a reference for SMEs when reviewing their HPC cloud contract. Five papers were identified that provide a checklist to review cloud contracts. Hon and Millard (2018) provided a checklist from a bankers' perspective, including issues such as data protection and location, contract complexity, termination, service changes and liability. Similarly, Wilson and Bray (2013) provide a contract checklist in light of data protection and regulation which are measures to prevent the unauthorised access of data, policies to delete all copies of data which are required by the customer, policies to allow customers to access their personal data, audit process, where and how personal data will be processed and back-up procedures. Furthermore, Ryan and Loeffler (2010) offer a more comprehensive checklist covering 12 different areas. These range from service cost, service failure performance, security, clear entities that could receive service, process to changes, termination, restrictions on data's ownership, breach of contract, the management of subcontractors to the impact of disputes and bankruptcy. Joint and Baker (2011) also list 9 elements to check when comparing between cloud computing and traditional IT outsourcing contracts. Rodrigues et al. (2012) similarly propose 8 item checklists for cloud contracts.

Even though the checklists are diverse, they generally discuss five aspects. The most common issue that is discussed in these papers is contract termination. In the event of termination, the SMEs should guarantee that the providers can return data (Joint and Baker, 2011). Wilson and Bray (2013) agreed with this suggestion and added that they should also destroy data during the termination process. Joint and Baker (2011) and Ryan and Loeffler (2010) both mentioned that the providers should provide assistance to help customers transfer to their next service provider. Hon and Millard (2018), however, discussed the notice period for contract termination. They stated that normally a notice period of 30 days without reason should be given in the event of termination and this should be stipulated in the contract. Another common issues that is discussed in these papers is security. Ryan and Loeffler (2010) believed that the customers should be aware of the location of the data. In contrast, Hon and Millard (2018) argued that the location may be important but more attention should be given to accessing and processing data. No matter where the data resides, the more pressing problem is how easily the data can

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3 be accessed. Regarding security, Wilson and Bray (2013) noted that measures should be stipulated in
4 the contract regarding how to prevent unauthorised access to data and the policies governing deletion
5 of personal data. The other common elements that are discussed in the papers are service
6 performance/scope, penalties for any violation and service changes.
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10 11 12 *Service level agreement*

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14 A service-level agreement (SLA) is formulated in the cloud contract to ensure that the service level is
15 consistent with the agreement in terms of the price, resource allocation, penalty rate etc. (Kuo et al.,
16 2017). In all, 5 papers discussed SLA. Yigitbasioglu (2015) explored why organizations adopt or not
17 cloud computing and found that one of the concerns for cloud adoption is the poor SLA which is derived
18 from the ignorance of the technology(s) being used and their own requirements. Kuo et al. (2017)
19 studied the optimal cloud contract design and proposed a model of the decision of pricing and resource
20 allocation that is constructed by different contracts with different SLA. Yuan et al. (2018) addressed
21 the resource back-up, penalty determination and penalty deferred pricing issues and found that the SLA
22 parameters significantly interacted with resource back up. Kumar and Kumar (2021) proposed a toolbox
23 and a negotiation model to minimize the violation of SLA under certain service qualities. Lu et al. (2016)
24 explored the SLA automated management by proposing an actor system model.
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39 Therefore, the SLA is the key consideration that SMEs should be focused on before and after
40 signing the contract as it provides the fundamental service agreement such as the contract duration,
41 speed, bandwidth, storage space, service availability and compensation if providers do not fulfil the
42 service (Kuo et al., 2017, Yuan et al., 2018). Among the literature identified, SLA violation had been
43 addressed by several authors. For example, Yigitbasioglu (2015) proposed that algorithms can
44 automatically detect the violation of SLA. Furthermore, Yuan et al. (2018) proposed three solutions in
45 the event of SLA violation which were the allocate resource optimally for backup data, price-penalty
46 schedule for the settlement and the penalty deferral strategies for retaining customer. Similarly, in order
47 to reduce the risk of SLA violation, Kumar and Kumar (2021) proposed a SLA negotiation process and
48 SLA work flow framework. Lu et al. (2016), however, design an SLA management system from
49 computational perspective where violations are automatically detected.
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Elements that are easily ignored

There are some elements which cannot be measured directly, with the consequence that they are easily ignored in the contract, such as the usability, elasticity and security (Shojaiemehr et al., 2019). For example, Lewis (2019) developed the system usability scale, the usability metric for user experience (UMUX) and the computer system usability questionnaire (CSUQ) to measure the perceived usability. Shawky and Ali (2012) proposed an equation to measure the elasticity, including the parameters of system's response to change, the average bandwidths before and after scaling up or down. Shaikh and Sasikumar (2015) build a trust-based evaluation model to assess cloud security and identified several parameters to evaluate cloud security. They are specific attacks, frequency of attacks, loss of data protection or data leakage and improvements in technology. Meanwhile, the service schedule need to be confirmed by setting up the start date and end date and the service quality can be measured by delay, jitter, bandwidth and packet loss (Rodrigues et al., 2012). These easily ignored elements should be discussed during the negotiation process (Shojaiemehr et al., 2019).

Another easily ignored important element is latency. Latency is the transmission time from providers to customers and it is especially important in cloud computing during the early adoption of cloud services (Hinton et al., 2012). It is important as it impacts on the users' experience, service quality assessment and the service continuity. Hinton et al. (2012) suggested that the IT and legal departments should work together to stipulate the potential latency in the contract and identified possible factors that may influence it.

Risk areas

Risk areas are provided as a reminder for SMEs to pay special attention to them. Hunt (2015) proposed several risk areas and some of them may be overlapped with the contract checklists discussed above. The difference from the checklists noted above are regulation access and service availability. In regards to the regulation access, as different cloud providers may be under different doctrine of cloud codes, such as the *Telecommunications Consumer Protection Code*, *Content Service Code* and *Approved Vendor Trust Marque* etc., therefore SMEs should be aware of them in the contract; Service availability

refers to the ability to transition serviced, choice of law and jurisdiction and breach notification. They should also be cautious in contract. Gray (2013) agreed that jurisdiction should be clearly stated in a cloud contract. In addition to the jurisdiction, Wilson and Bray (2013) pointed out that compliance with data protection must be clearly allocated in the contract. In particular, some other details should be specified in the contract such as the security measurement process, the returning data condition and the obligations for suppliers to facilitate customers to access data. Meanwhile, Jahandideh et al. (2020) emphasized the numbers of simultaneous users and the resource allocation should be clearly stated in the contract as the price, the cost and the resource allocation will be different with different number of simultaneous users.

5. Conclusion and further research

This paper discusses HPC cloud contract and its role when SMEs adopts HPC infrastructure through the cloud by using the systematic literature review method. More specifically, this paper sought to identify what SMEs can do prior to accepting the terms and conditions of HPC cloud contracts. Through the review process, 825 papers from four databases were identified. After two rounds of data screening, 47 full papers published since 2010 were reviewed and categorised into four groups based on their link to the two research questions. During the literature search, a clear gap in the literature emerged that reflected the limited number of papers that discussed HPC cloud contracts. Most of them only generally discussed cloud contracts. Moreover, there are similarities between moving traditional IT workload to the cloud and moving HPC to the cloud (Waddell, 2019) . Researchers review the papers discussed about the cloud contract as customers also share the similar concerns between general cloud contracts and HPC cloud contracts (Wu et al., 2017). Therefore, the result of the literature review can be as the reference for the HPC cloud contract. This is the first contribution of this paper to the knowledge of cloud HPC from the cloud contract perspective.

The second contribution of this paper is that it proposes four areas where the SMEs can prepare before signing of the HPC cloud contract. They are to understand the needs of the SMEs, improve their contract negotiation abilities, service management skills and risk management capabilities. This paper also identifies four aspects that could help SMEs adopt cloud based HPC from a contractual perspective.

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3 SMEs could prepare themselves by focusing on the four aspects. It also gave the policymakers some
4 thoughts on how to improve the cloud HPC adoption rate in the SMEs. For example, some training and
5 support could be provided for SMEs to help them understand their needs of the cloud HPC. Mandatory
6 audit of cloud contract can be required by the policymakers before SMEs sign the contract. Negotiation
7 support from big law firms can be allocated to SMEs which will be paid by government.
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14 The third contribution of this paper is that it answers the question of what cloud issues should
15 be focussed on by providing the checklist, SLA, identifying elements that are easily ignored and risk
16 areas. The most common issues in the checklist are termination, security, service performance/scope,
17 penalties for any violation and service changes. Most attention when discussing SLA is on how to
18 automatically detect violation of SLA and what can be done after the violation. The elements that are
19 easily ignored are usability, elasticity, security and latency. The riskiest areas are the jurisdiction and
20 the law that applied.
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30 The final contribution of this paper is that it provides information for further researchers on
31 which countries normally work together to do the research and which journals most likely to publish
32 papers in the area. It provides a clear idea on what the current stage the research on at this topic.
33 Researchers in this topic could easily find partners to work with and targeted journals to publish research
34 output.
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41 This paper provides guidance for SMEs from the cloud contract perspective on how to make
42 the best of cloud based HPC to obtain access to the advantages provided by the technology. Further
43 research could explore on each section deeper. For example, a contract negotiation model can be
44 designed computationally. A platform or system can be designed for service management and risk
45 management. A comprehensive checklist can be proposed which can be validated by interviews or
46 questionnaires. The HPC cloud contract design computationally can be further studied to achieve
47 automation.
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Table 1: Key points of 12 papers that answer research question 1

Authors and Year	Key points regard RQ1
Haibach (2015)	<i>Improve risk management ability:</i> confirmed jurisdiction and applicable law prior to sign the contract
Radhika and Sadasivam (2021)	<i>Improve service management skills:</i> discussed how to choose cloud service provider (CSP) and proposed a service management index (SMI) which include five factors as the parameters to select CSP. The five factors are: performance, cloud availability, cost, scalability and reliability
Wang et al. (2013)	<i>Improve service management skills:</i> mentioned that multiple purchase is cheaper than single purchase and reminded that the contract time will affect the final price
Kamarinou et al. (2016)	<i>Improve risk management skills:</i> analysed 20 cloud providers' term and privacy policy to give a clear information in terms of what a privacy policy cover, how data were collected and used and how the personal data were shared between different actors
Rodrigues et al. (2012)	<i>Improve service management skills:</i> proposed four actions for multiple providers service management. They are: (I) to foster client and service provider interoperability; (II) to manage network service contracts, promoting the dynamic negotiation between parties; (III) to access and query SLA/SLSs data on an individual or aggregated basis to assist service provisioning in the network; and (IV) to sustain service monitoring and auditing.
Shojaiemehr et al. (2019)	<i>Improve contract negotiation ability:</i> proposed TPO (negotiation time, preferences of negotiators, and opponent's behaviour) negotiation strategy and considered four negotiation parameters which were price, response time, availability and reliability.
Gold (2015)	<i>Improve contract negotiation ability:</i> SLA is an important element that should be negotiated carefully before sign the contract. This paper proposed three criteria for setting SLA which can be objectively measured without difficulty, truly reflect the performance and within the control of the service providers if their performance was measured. This paper also outlined nine key points to set SLA which were : <i>a</i> , establish metric categories; <i>b</i> , establish measurement systems; <i>c</i> , set metric level; <i>d</i> , determine financial consequences; <i>e</i> , decide how to handle infrequent occurrences; <i>f</i> , avoid agreements to agree; <i>g</i> , carefully formulate automatic adjustments; <i>h</i> , use comprehensive reporting; <i>i</i> , tailor each SLA to its services
Hon and Millard (2018)	<i>Understand the SMEs' need:</i> This paper pointed out that awareness should be improved if customer wanted to get access to cloud service. Even the challenges of access cloud exist, they can always find a way to overcome obstacles. <i>Improve risk management ability:</i> The paper reminded that the cloud risk management should be included in the overall risk governance.
Ryan and Loeffler (2010)	<i>Improve risk management ability:</i> This examine the contract issues related with cloud computing. It emphasized that the evaluation before sign the contract was necessary when weighing the trade-off between the benefits and risks.

Wu et al. (2017)	<i>Understand SMEs' need:</i> This paper provided a computational framework for SMEs to facilitate real-time sensing, monitoring and prognosis and prognosis for HPC from the technological perspective. However, it elaborated the need for SMEs to access the HPC through cloud. What the SMEs need were the hardware and software systems for large volume data and algorithms that calculate and analyse complicated data.
Huang et al. (2021)	<i>Improve contract negotiation ability:</i> This paper aims to address information asymmetry and uncertainty by providing a decision framework between renegotiation and monitoring. The decision is moderated by renegotiation cost, monitoring cost and vendor's bargain power.
D'Onfro (2022)	<i>Improve risk management ability:</i> This paper believe that the cloud storage is a bailment relationship which would be governed by the doctrine of bailment. Consideration of the relationship between customers and cloud providers as bailment could improve the customers risk management ability as most cloud contract's disclaimers for liability for lost data are inconsistent with the duty of the law of bailment.

Table 2: Key points of 15 papers that answered research question 2

Authors and Year	Key points regard RQ2
Kuo et al. (2017)	<i>SLA</i> : This paper proposed a model to compare the profit performance between a dual contract and a single contract. The results showed that different resource capacities fitted different optimal contracts. The optimal contracts mainly focused on the SLA which gave the guarantee of available resource and the penalty if violation happened.
Joint and Baker (2011)	<i>Checklist</i> : This paper provided a checklist for cloud contract which derived from the comparison between traditional IT outsourcing and cloud computing. It gave 9 elements that the cloud contract was different from traditional IT outsourcing which were service performance, compliance with applicable laws, limits on liability, exclusion of losses, confidentiality, service levels, audit, termination and policies/standards/security.
Yigitbasioglu (2015)	<i>SLA</i> : This paper explored the reason why organizations adopted or not adopted the cloud contract from the external auditors' perspective. It also mentioned that cloud providers have the possibility to provide less quality SLA. Therefore, algorithms can play external auditors to detect the SLA violation.
Jahandideh et al. (2020)	<i>Risk areas</i> : This paper mentioned that cloud contract should be in the form of SLA instead of units of resource and the contract guarantee should design by the simultaneous users at each time instead of aggregated users. It also reminded that some cost may happened out of scope in the contract due to the unexpected users. Organisations should be carefully about it as it may influence the latency experience by the exit users.
Lundqvist (2019)	<i>Elements that are easily ignored</i> : This paper mentioned two elements that may be easily ignored which may be violate the unfair competition rules, especially for SMEs. They were lock-in clauses and non-assert clauses.
Gray (2013)	<i>Risk areas</i> : This paper mentioned that as the cloud computing is an international activity, there were different rules can be applied which rise the risk of disadvantage when breach of contract happened. Therefore, it would be better to determine the jurisdiction in the contract.
Yuan et al. (2018)	<i>SLA</i> : This paper contributes to the knowledge of SLA by providing three solutions for violation of SLA. They were optimally allocating backup resource for SLA to manage the risk of violation, providing a price-penalty schedule for better settlement when violation happened and presenting a penalty deferral strategy to keep the customer for longer relationship after the violation of SLA.
Kumar and Kumar (2021)	<i>SLA</i> : This paper provided a SLA negotiation process and a SLA work flow for both the customers and the providers to reduce the risk of SLA violation.
Hinton et al. (2012)	<i>Elements that are easily ignored</i> : This paper mainly focused on latency, and it was prominent in cloud computing for the initial adoption of cloud service. It can be easily ignored. Therefore, it was suggested by the researcher that the IT teams and lawyers should work together to reduce the latency by articulating the latency issue in the contract.
Rodrigues et al. (2012)	<i>Checklist</i> : This paper provided questions that should be answered during checking the contract from both the customers' and the providers' perspective. It also gave a checklist for a cloud contract which were scope, traffic classifier, traffic conditioner, performance guarantee, reliability, service schedule, monitoring and type of service.

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4	Shojaiemehr et al. (2019)
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7	Hon and Millard (2018)
8	<i>Checklist:</i> This paper provided a checklist for the cloud contract which were the data protection and data location, layered cloud and contract complexity, termination, service change and liability.
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11	Lu et al. (2016)
12	<i>SLA:</i> This paper proposed a SLA management system from computational perspective to achieve the automated management, mainly focusing on the negotiation, monitoring and violation stages.
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14	Ryan and Loeffler (2010)
15	<i>Checklist:</i> This paper mentioned a checklist for contractual issues. It included a clear articulation of fees, performance metrics and remedies, security, privacy and audit commitments, clear definition of the service receiver, service change, termination, business continuity, ownership, customer's right and requirements, resource allocation for the risk of breaches of contract, subcontractors, resolution and impact of disputes and bankruptcy
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21	Wilson and Bray (2013)
22	<i>Checklist:</i> This paper mentioned a checklist for cloud contract. It included personal data process, security, destroy personal data on expiry contract, confidentiality, obligations, privacy, responsibilities in the event of data breach, measures to prevent unauthorised access to data, policies and procedures to delete personal data, audit process, back-up procedures.
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Table 1: Key points of 12 papers that answer research question 1

Authors and Year	Key points regard RQ1
Haibach (2015)	<i>Improve risk management ability:</i> confirmed jurisdiction and applicable law prior to sign the contract
Radhika and Sadasivam (2021)	<i>Improve service management skills:</i> discussed how to choose cloud service provider (CSP) and proposed a service management index (SMI) which include five factors as the parameters to select CSP. The five factors are: performance, cloud availability, cost, scalability and reliability
Wang et al. (2013)	<i>Improve service management skills:</i> mentioned that multiple purchase is cheaper than single purchase and reminded that the contract time will affect the final price
Kamarinou et al. (2016)	<i>Improve risk management skills:</i> analysed 20 cloud providers' term and privacy policy to give a clear information in terms of what a privacy policy cover, how data were collected and used and how the personal data were shared between different actors
Rodrigues et al. (2012)	<i>Improve service management skills:</i> proposed four actions for multiple providers service management. They are: (I) to foster client and service provider interoperability; (II) to manage network service contracts, promoting the dynamic negotiation between parties; (III) to access and query SLA/SLSs data on an individual or aggregated basis to assist service provisioning in the network; and (IV) to sustain service monitoring and auditing.
Shojaiemehr et al. (2019)	<i>Improve contract negotiation ability:</i> proposed TPO (negotiation time, preferences of negotiators, and opponent's behaviour) negotiation strategy and considered four negotiation parameters which were price, response time, availability and reliability.
Gold (2015)	<i>Improve contract negotiation ability:</i> SLA is an important element that should be negotiated carefully before sign the contract. This paper proposed three criteria for setting SLA which can be objectively measured without difficulty, truly reflect the performance and within the control of the service providers if their performance was measured. This paper also outlined nine key points to set SLA which were : <i>a</i> , establish metric categories; <i>b</i> , establish measurement systems; <i>c</i> , set metric level; <i>d</i> , determine financial consequences; <i>e</i> , decide how to handle infrequent occurrences; <i>f</i> , avoid agreements to agree; <i>g</i> , carefully formulate automatic adjustments; <i>h</i> , use comprehensive reporting; <i>i</i> , tailor each SLA to its services
Hon and Millard (2018)	<i>Understand the SMEs' need:</i> This paper pointed out that awareness should be improved if customer wanted to get access to cloud service. Even the challenges of access cloud exist, they can always find a way to overcome obstacles. <i>Improve risk management ability:</i> The paper reminded that the cloud risk management should be included in the overall risk governance.
Ryan and Loeffler (2010)	<i>Improve risk management ability:</i> This examine the contract issues related with cloud computing. It emphasized that the evaluation before sign the contract was necessary when weighing the trade-off between the benefits and risks.

Wu et al. (2017)	<i>Understand SMEs' need:</i> This paper provided a computational framework for SMEs to facilitate real-time sensing, monitoring and prognosis and prognosis for HPC from the technological perspective. However, it elaborated the need for SMEs to access the HPC through cloud. What the SMEs need were the hardware and software systems for large volume data and algorithms that calculate and analyse complicated data.
Huang et al. (2021)	<i>Improve contract negotiation ability:</i> This paper aims to address information asymmetry and uncertainty by providing a decision framework between renegotiation and monitoring. The decision is moderated by renegotiation cost, monitoring cost and vendor's bargain power.
D'Onfro (2022)	<i>Improve risk management ability:</i> This paper believe that the cloud storage is a bailment relationship which would be governed by the doctrine of bailment. Consideration of the relationship between customers and cloud providers as bailment could improve the customers risk management ability as most cloud contract's disclaimers for liability for lost data are inconsistent with the duty of the law of bailment.

Table 2: Key points of 15 papers that answered research question 2

Authors and Year	Key points regard RQ2
Kuo et al. (2017)	<i>SLA</i> : This paper proposed a model to compare the profit performance between a dual contract and a single contract. The results showed that different resource capacities fitted different optimal contracts. The optimal contracts mainly focused on the SLA which gave the guarantee of available resource and the penalty if violation happened.
Joint and Baker (2011)	<i>Checklist</i> : This paper provided a checklist for cloud contract which derived from the comparison between traditional IT outsourcing and cloud computing. It gave 9 elements that the cloud contract was different from traditional IT outsourcing which were service performance, compliance with applicable laws, limits on liability, exclusion of losses, confidentiality, service levels, audit, termination and policies/standards/security.
Yigitbasioglu (2015)	<i>SLA</i> : This paper explored the reason why organizations adopted or not adopted the cloud contract from the external auditors' perspective. It also mentioned that cloud providers have the possibility to provide less quality SLA. Therefore, algorithms can play external auditors to detect the SLA violation.
Jahandideh et al. (2020)	<i>Risk areas</i> : This paper mentioned that cloud contract should be in the form of SLA instead of units of resource and the contract guarantee should design by the simultaneous users at each time instead of aggregated users. It also reminded that some cost may happened out of scope in the contract due to the unexpected users. Organisations should be carefully about it as it may influence the latency experience by the exit users.
Lundqvist (2019)	<i>Elements that are easily ignored</i> : This paper mentioned two elements that may be easily ignored which may be violate the unfair competition rules, especially for SMEs. They were lock-in clauses and non-assert clauses.
Gray (2013)	<i>Risk areas</i> : This paper mentioned that as the cloud computing is an international activity, there were different rules can be applied which rise the risk of disadvantage when breach of contract happened. Therefore, it would be better to determine the jurisdiction in the contract.
Yuan et al. (2018)	<i>SLA</i> : This paper contributes to the knowledge of SLA by providing three solutions for violation of SLA. They were optimally allocating backup resource for SLA to manage the risk of violation, providing a price-penalty schedule for better settlement when violation happened and presenting a penalty deferral strategy to keep the customer for longer relationship after the violation of SLA.
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Shojaiemehr et al. (2019)	<i>Elements that are easily ignored:</i> This paper reminded that the security, elasticity and usability were three parameters that were easily ignored during the negotiation process.
Hon and Millard (2018)	<i>Checklist:</i> This paper provided a checklist for the cloud contract which were the data protection and data location, layered cloud and contract complexity, termination, service change and liability.
Lu et al. (2016)	<i>SLA:</i> This paper proposed a SLA management system from computational perspective to achieve the automated management, mainly focusing on the negotiation, monitoring and violation stages.
Ryan and Loeffler (2010)	<i>Checklist:</i> This paper mentioned a checklist for contractual issues. It included a clear articulation of fees, performance metrics and remedies, security, privacy and audit commitments, clear definition of the service receiver, service change, termination, business continuity, ownership, customer's right and requirements, resource allocation for the risk of breaches of contract, subcontractors, resolution and impact of disputes and bankruptcy
Wilson and Bray (2013)	<i>Checklist:</i> This paper mentioned a checklist for cloud contract. It included personal data process, security, destroy personal data on expiry contract, confidentiality, obligations, privacy, responsibilities in the event of data breach, measures to prevent unauthorised access to data, policies and procedures to delete personal data, audit process, back-up procedures.

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