EVALUATION OF MULTI-CLOUD STRATEGIES AND CHALLENGES IN SMALL SCALE ORGANIZATIONS

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EVALUATION OF MULTI-CLOUD STRATEGIES AND CHALLENGES IN SMALL SCALE ORGANIZATIONS

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Dedication

To my fellow researchers and industry colleagues, whose collaboration, discussions, and shared insights have enriched our understanding and propelled our research forward. Your intellectual camaraderie and collective pursuit of knowledge have been inspiring. This research paper reflects the collaborative efforts that have shaped my academic endeavors.

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ABSTRACT
EVALUATION OF MULTI-CLOUD STRATEGIES AND CHALLENGES IN SMALL SCALE ORGANIZATIONS

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2024

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Multi-cloud computing is emerging as a promising paradigm for providing abundant computation resources for medium and large-scale organization. While most cloud providers provide similar functionality, performance and/or cost may vary significantly. A customer who wants to take advantage of such differences will naturally want to solve the multi-cloud configuration problem given a workload, which cloud provider should be chosen, and how should its nodes be configured to minimize runtime or cost.

This research is being conducted to explore and understand how certain large and medium scale organization achieved success through multi-cloud business strategies. The goal is to analyses data from interviews conducted with senior leaders in the IT industry and business leaders. The Leaders have influence over storage, cloud, and/or data management technology decisions in their organization. obtaining details about how they are utilizing cloud infrastructure to promote innovation while also limiting cloud costs and evaluating the resulting business advantages for future start-ups. In the same space to increase their chances of leveraging multi-cloud computing and getting the most out of each cloud service in order to increase productivity, provide exceptional customer service, and scale their business to the next level. In general, the multi-cloud strategy for small business success.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I:

INTRODUCTION

The rapid advancements in information technology have revolutionized the way organizations operate, with cloud computing emerging as the backbone of the modern business world (Wang & Edy, 2020). Cloud computing has enabled organizations of all sizes to leverage powerful computing resources without the burden of managing and maintaining complex infrastructure(Mahesh et al., 2011).

As the demand for cloud services continues to grow, the cloud computing landscape is undergoing a transformative shift towards a multi-cloud approach(Hayes, 2008). The ever-increasing volume of data generated by organizations has outpaced the capabilities of single cloud providers, necessitating a collaborative effort among multiple resource providers to fulfill the growing demand for cloud services(Wan, 2018).

The transition to a multi-cloud environment presents both challenges and opportunities for organizations.(Srivastava & Sudhish, 2015) On one hand, it allows for greater flexibility, scalability, and redundancy, enabling organizations to leverage the unique strengths of different cloud providers(Hayes, 2008). However, this shift also introduces a new set of legal, contractual, and security concerns that organizations must navigate.(Hourani & Abdallah, 2018)

To address these challenges, Information Technology professionals are evolving - rapidly evolving, delivering more powerful and agile cloud compute, richer software, better analytics, mobility, and sensors. The cloud computation world is transforming in expectation and technological advancement of practically every organization on the planet. Small, medium and large organizations equally profit from the cloud since they no longer

have to worry about storing and managing company data. As a result, cloud computing has established itself as the backbone of the modern business world.

Information Technology has been rapidly evolving, delivering more powerful and agile cloud compute, richer software, better analytics, mobility, and sensors. The cloud computation world is transforming in expectation and technological advancement of practically every organization on the planet. Small, medium and large organizations equally profit from the cloud since they no longer have to worry about storing and managing company data. As a result, cloud computing has established itself as the backbone of the modern business world. In practice, we know that no datacenter has infinite resources. Resources from multiple resource providers must collaborate, inter-communicate, and work collaboratively and in coordination to expand the flexibility or capacity of cloud service providers and fulfil the ever-increasing demand for services. Also, we aware that the amount of significant information produced by an organization today in one day is about equivalent to the amount produced in twenty days a few decades ago. To address the ever-increasing demand, a single cloud framework is insufficient. Given the current trend of organizational computational development, it is apparent that the future is multi-cloud.

In practice, we know that no datacenter has infinite resources. Resources from multiple resource providers must collaborate, inter-communicate, and work collaboratively and in coordination to expand the flexibility or capacity of cloud service providers and fulfil the ever-increasing demand for services. Also, we aware that the amount of significant information produced by an organization today in one day is about equivalent to the amount produced in twenty days a few decades ago. To address the ever-increasing demand, a single cloud framework is insufficient. Given the current trend of organizational computational development, it is apparent that the future is multi-cloud.

However, the body of empirical research multi-cloud strategy of small and medium size businesses (SMB) is very limited. This study aims to expand the current body of empirical research on multi-cloud computing is very limited. This study aims to examine the strategy and challenges faces by SMB.

Finding from this study shows that SMBs can maximize the benefit of multi-cloud environments by adopting industry best practices and by focusing on unified management, automation, security, cost optimization, and adherence to interoperability standards, organizations can overcome the inherent challenges of multi-cloud strategies.

Apart of the lack of empirical research on multi-cloud strategy for SBMs, managers of SBMs struggle to find empirical research that would guide their cloud strategy. This research also intends to address that. Figure 1 shows multi-cloud abstract view.

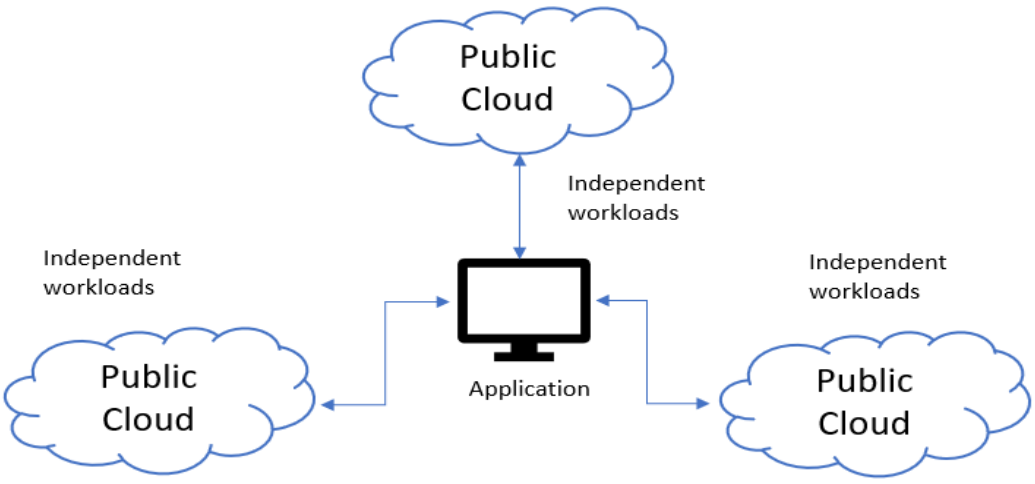

Figure 1: Multi-cloud technology abstract view

Figure 1 shows the fundamental principle of Multi-cloud computing. It shows that multi-Cloud is founded on the collaboration of several cloud service providers. The use of multi-cloud computing IT strategy has increased in many organizations. Multi-cloud computing provides many benefits in terms of optimizing costs and accessibility of data in constraints like different geo-locations legal considerations. For example, the business organization needs to operate on a single cloud but requires a different cloud to legally store data. In addition, some organizations pursue 4 multi-cloud strategies to select different cloud services or features from different provides. However, the approaches are quite diverse and are not widely used, due to complex architecture, they add more cost and risk but they may generate more business value. Also, multi-cloud necessitates a completely new security strategy to ensure that all elements of the chain, spanning multiple cloud providers, are safe. Authentication and access control are two multi-cloud security challenges. “Common challenges across all multi-clouds are providing seamless access to cloud services to users based upon their default credentials, maintaining least privilege access across all clouds, and keeping up with risk assessments and vetting of additional cloud services” (Violino, 2020).

This Literature review aims to provide an overview of the current state-of-the-art and to identify some key metrics that can improve the chances of success for small businesses through profitability and sustainability by leveraging multi-Cloud computing.

1.1 Research Background and Scope

The increasing adoption of multi-cloud environments by small-scale organizations is a critical area of research due to the potential benefits they offer in terms of flexibility, cost-effectiveness, and resilience (Alkhalil et al., 2016). However, the complexities and

challenges associated with managing multiple cloud providers present unique obstacles for these organizations (Forell et al., 2011)(Willcocks & Lacity, 2018)(Carcary et al., 2014).

One of the primary challenges in adopting a multi-cloud strategy is the lack of suitable adoption frameworks specifically tailored for small and medium-sized enterprises (SMEs)(Carcary et al., 2014). Existing cloud adoption models are primarily designed for larger organizations and may not adequately address the unique requirements and constraints of smaller entities (Carcary et al., 2014). Further, the extent of impact and benefits realized from cloud adoption in small-scale organizations is often overlooked in the current research landscape (Adam & Alhassan, 2015). Despite these challenges, the potential of cloud-based infrastructure for small business development is significant (Kamal, 2012). Small-scale organizations can leverage multiple cloud providers to meet their diverse IT requirements, such as scalability, cost optimization, and disaster recovery (Forell et al., 2011). However, effectively managing these shared resources and services across multiple cloud platforms is a critical requirement that demands new management architectures and strategies (Forell et al., 2011).

Addressing the complexities of multi-cloud strategies for small-scale organizations requires a multifaceted approach. Developing cloud adoption frameworks that cater to the specific needs of small and medium-sized enterprises, while also exploring the impact and benefits of multi-cloud adoption in these organizations, is a crucial step forward (Carcary et al., 2014)(Adam & Alhassan, 2015). Furthermore, exploring new cloud management architectures that can handle the scale, dynamism, and federation inherent in multi-cloud environments is essential for enabling small-scale organizations to realize the full potential of a multi-cloud approach (Forell et al., 2011).

1.2 **Research Objectives**:

The specific objectives of this research study are:

1. To assess the motivations driving small-scale organizations towards adopting multi-cloud strategies.
2. To identify the key challenges and barriers faced by small-scale organizations in implementing and managing multi-cloud environments.
3. To evaluate the impact of multi-cloud strategies on organizational performance, security, and cost management.

Research Background and Scope

Expected Contributions:

This research aims to contribute by providing practical insights into the drivers behind adopting a multi-cloud approach within small scale organizations as well as shedding light on common challenges faced during implementation. The findings may offer valuable recommendations for improving the effectiveness of these strategies within similar organizational contexts.

Ethical Considerations:

There were no ethical issues associated with this research. Participants confidentiality was strictly maintained throughout the research process. Informed consent will be obtained from all participants prior to conducting interviews ensureng that they understand the purpose of the study along with their rights regarding participation.

1.2 Research Problem

The main problem that this research aims to address is the limited empirical research on multi-cloud ecosystems usage. This study provides empirical evidence on the use of multi-cloud ecosystems, which is a challenge both for industry professionals and academics

(Aldahwan & Ramzan, 2022; Nzanywayingoma & Yang, 2017; Coccia & Roshani, 2022). There are many significant contributions that are inevitable and innovative for the IT industry, irrespective of whether it is a small-to-medium-sized business (SMB) or a large-scale industry(Morgan & Conboy, 2018). Considering the top three pioneers in cloud space, the research objective is to address the below challenges & opportunities in multi-Cloud in the small-scale business and increase revenue with customer experience leveraging using multi-tier cloud approach strategy.

1. Data Architecture think at scale
2. Disaster Recovery and Failover
3. Vendor Lock In
4. Cloud Manageability and complexity
5. Multi-cloud Could Security approaches and challenges
6. Cost Management in the cloud ecosystems
7. Minimizing data related costs

Multiple industry verticals are represented, including technology, manufacturing, communications and media, and business services among others. The respondents live in Australia, Canada, India, New Zealand, Singapore, the United Kingdom, and the United States.

1.3 Purpose of Research

The purpose of this research is to conduct qualitative research in order to develop a multi-cloud strategy and to evaluate multi-cloud challenges in order to adapt and provide better rewards for small scale organizations. The primary goal of this research is to determine whether a multi-cloud approach is an efficient and cost-effective method for organizations

looking to implement cloud computing solutions. The multi-cloud approach should be part of a hybrid cloud (private and public), but it can also be used as a standalone strategy.

The objective of the current study is to provide a comprehensive review of literatures and industry practices in relation to constraint analysis and outline a conceptual framework for constraint management. Particularly, the study has the following sub-objectives.

1.4 Significance of the Study

The significance of this study lies in its potential to bridge the gap and empower start-ups and small-scale businesses to harness the power of multi-cloud technology. By providing a comprehensive review of the constraints typically found in multi-cloud environments and examining the industry's best practices, this research aims to equip enterprises with the necessary insights to optimize costs, improve accessibility, and scale their business more effectively.

One of the key contributions of this study is its examination of how adopting a multi-cloud strategy can bring substantial benefits to large and medium-sized organizations. This is particularly relevant given the limited academic research available on the practical experiences and challenges faced by enterprises utilizing multiple cloud providers concurrently. The high level of expertise among the respondents further underscores the depth and relevance of this study within the academic discourse on multi-cloud technologies.

This research also recommends steps that can be taken to increase the adoptability of multi-cloud in small-scale industries. This is crucial as previous studies have shown that when small firms are able to effectively leverage information technology, they can experience faster growth compared to their non-adopting counterparts. However, the

inability to fully utilize technology has been a significant obstacle, highlighting the importance of this study's findings.

The results of this study will be invaluable to industry practitioners and software providers alike, providing them with a comprehensive understanding of multi-cloud best practices and guiding them towards achieving higher multi-cloud maturity, ultimately leading to better business outcomes

Below are the significance factors to consider in this study

- To provide a comprehensive review of sources and characteristics of constraints typically found in multi-cloud.
- To review current industry best practices and researches in regards to multi-cloud eco-system.
- Examine how adapting and leveraging multi-cloud computing provides many benefits in terms of optimizing costs, accessibility of data and scale their business to the next level.
- To study the perceived value of adopting a multi-cloud strategy in large and medium-sized organizations.
- To recommend the steps that can be adopted to increase the adoptability of multi-cloud in small scale Industry.

The result of this study will be valuable to the industry practitioners as well as related software providers in adopting multi-cloud best practice’s and to achieve higher multi-cloud maturity leads to better business results.

1.5 Research Purpose and Questions

In this section of the thesis, questions will be outlined to provide clarity on the objectives of the study and the specific inquiries that will be addressed. This aims to guide in understanding the focus and direction of the research, helping the key areas that will be explored and analyzed in the thesis.

S. No	Research Objective	Research Methodology	Primary data collection
1	What are the key features to look for in a multi-cloud management platform?	Exploratory & Qualitative research	Survey / Interview
2	What are the main challenges for multi-cloud application developers and operators?	Exploratory & Qualitative research	Survey / Interview
3	What are the main security risks and mitigation strategies in multi-cloud applications?	Exploratory & Qualitative research	Survey / Interview
4	What are the promising trends in multi-cloud application design, development, and operation that can be identified?	Exploratory & Qualitative research	Survey / Interview
5	How to tackle the roadblocks on your way to multi-cloud success	Exploratory & Qualitative research	Survey / Interview
6	How difficult is it to monitor the performance and availability of multiple clouds?	Exploratory & Qualitative research	Survey / Interview
7	Auto-scaling difficulties and challenges in scaling up multi-cloud components	Exploratory & Qualitative research	Survey / Interview

	for load balancing across multiple clouds		
8	How to effectively manage costs when deploying and scaling up the multi-cloud strategy	Exploratory & Qualitative research	Survey / Interview
9	What common mistakes should avoid when adopting Multi Cloud?	Exploratory & Qualitative research	Survey / Interview

Table 1: Multi-cloud challenges survey questions

CHAPTER II:

REVIEW OF LITERATURE

The literature review serves as a critical component of academic research, offering a thorough examination and synthesis of existing knowledge, research findings, and theoretical frameworks related to the topic at hand. By delving into the literature, can identify gaps in current understanding, analyze trends and patterns, and build a strong theoretical foundation for their own study. In the context of the multi-cloud study, the literature review will provide insights into the challenges, benefits, best practices, and emerging trends in multi-cloud adoption and management, setting the stage for the subsequent analysis and discussion of findings. Chapter 2 provides an inclusive literature review on multi-cloud, to explore and understand how certain large and medium scale organization achieved success through multi-cloud business strategies. The goal is to analyze data from interviews conducted with founders in the IT industry and create a theoretical framework for future start-ups in the same space to increase the chances of leveraging multi-cloud computing and getting the best of each cloud service to increase

their productivity, provide exceptional customer service, and scale their business to the next level. In general, the multi-cloud roadmap to small scale business success.

2.1 Multi-cloud

2.1.1. Multi-cloud infrastructure

A multi-cloud infrastructure aggregates any combination of two or more public or private cloud environments (Velmurugan, 2019). Multi-cloud also refers to using more than one cloud platform for hosting your application, website, or server. It can be as simple as one private cloud environment plus one public cloud platform, or it can combine multiple public cloud platforms. Multi-cloud environments, on the other hand, are simply environments with two or more clouds (chakraborty, 2022).

2.1.2. Requirement for Multi-cloud

There are numerous reasons why services and resources from multiple Clouds are required. Multi-cloud simply means that an organization may use a single Application Programming Interface (API), which is a software intermediary that allows two applications to communicate with one another or common interface to access services from several cloud service providers. A multi-cloud approach offers hardware, software, and infrastructure redundancy and route traffic between different partners as the fastest possible parts of the network. In addition, some organizations pursue multi-cloud strategies to select different cloud services or features from different provides. This is helpful since some cloud environments are better suited than others for a particular task. For example, some cloud providers handle a large number of requests per unit time, requiring small data transfers on average, while a different cloud platform might perform better for a smaller number of requests per unit time involving large data transfers. Some

cloud providers also offer more big data analytics tools or other specialized capabilities, such as machine learning, than their competitors. (gartner, 2020) According to Gartner, 81% of organizations are working with two or more public cloud providers. A multi-cloud strategy gives companies the freedom to use the best possible cloud for each workload.

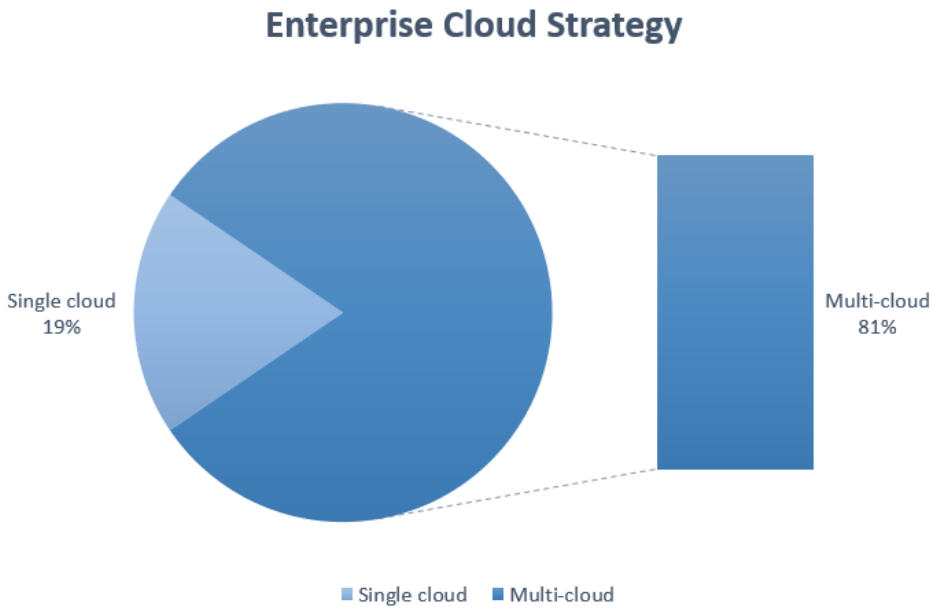

Figure 2: Enterprise Cloud Strategy

2.1.3. Application Ecosystems

Multi-cloud is frequently used by organization to deploy application ecosystems that include numerous apps and/or tools, rather than a single application. (Roe, 2021) For example, a business may use Azure Windows Virtual Desktop (WVD) with its Office 365 subscriptions to guarantee safe access to the corporate environment owing to a geographically distributed (or work-from-home) staff. Once on that virtual desktop, a corporate Enterprise Resource Planning system like Oracle E-Business Suite, SAP, or JD Edwards is accessed by Virtual Private Network or private connection, which might be on-premises or hosted by a private cloud provider. For HR data, that Enterprise Resource

Planning system might be linked to a SaaS solution like Workday or ADP, which would then combine with a data lake constructed with AWS Lake Formation and AWS Quick sight for dashboards and visualizations.

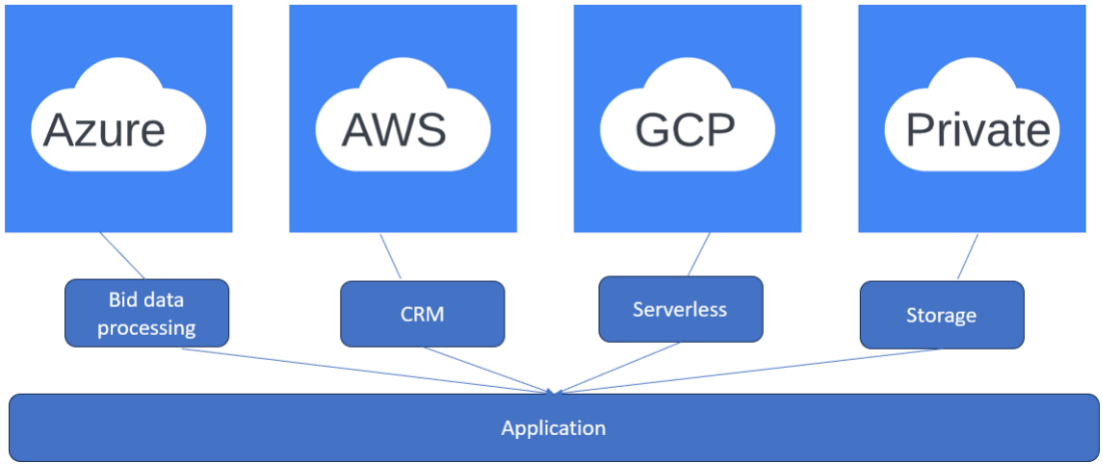

Figure 3: Multi-cloud Ecosystems

2.1.4. Avoiding Vendor Lock In

A vendor lock-in makes customers reliant on a vendor's proprietary product, service, or technology (Pellegrini et al., 2017). Customers and developers want depth in cloud services but don't want to be locked into a single cloud environment. Above all, they want choice when it comes to spinning up infrastructure for new applications, lift-and shift projects or maintaining consistency across them on premises, public cloud and edge environments. In terms of cloud services, it is accomplished by providing and developing platform-independent services using proprietary technologies, interfaces, or formats. This can be a significant barrier to adopting cloud services because customers are locked into specific vendors, preventing portability via proprietary or a limited set of interfaces. If an organization cloud vendor's technology is based on open standards, they will avoid proprietary technologies that lock you in as a customer. Multi-cloud allows organization

to switch to another cloud provider if their offerings are more attractive services (Vergilio et al., 2022, January 20) which greatly mitigates the risk of vendor lock-in, giving cloud consumers the ability to compare and combine individual offers from providers to create the most appropriate and preferred configuration. Should changes in prices or service level agreements render it advantageous to do so, resources may be easily and seamlessly transferred between clous service providers. Companies that place data at the center of everything they do are almost always successful at scaling. Data-centric multi-cloud methods are the most mature approach.

2.1.5. Disaster Recovery and Failover

A company's or organization's data is critical to its survival. High availability and disaster recovery protection software are also required for business-critical workloads (Suardika et al., 2021). Therefore, it becomes risky when an organization uses a single cloud platform to manage all of its resources. Potential incidents that could result in data loss, sometimes known as a disaster, need to be taken into account. With climate change, data centers are becoming more vulnerable to floods, fires, and loss of connection due to power outages caused by extreme weather events. Most people forget the fact that at the end of the data cloud, there is a real data center in a building someplace that is vulnerable to a variety of threats. Because of these rising, businesses must adopt a multi-cloud approach.

Catastrophic breakdown of cloud-based systems events are unpredictable phenomena. The largest cloud service provider in the world, Amazon Web Services, suffered a significant outage on November 26 in its US-EAST-1 data center as a result of a "very small addition of capacity" to the Amazon Kinesis real-time data processing service. Just over two weeks later, a significant failure in the quota management system on Google's Cloud Platform

significantly reduced the capacity of its authentication system. (Zuo, 2021). In either case, a multi-cloud strategy might have prevented the failures from causing significant service disruption. Multi-cloud computing offering a fail-safe architecture for an organization. One of the most significant benefits of running a multi-cloud system is the ability to establish redundancy and prepare for disaster recovery in a cloud-native deployment (Recovery, 2022).

2.1.6. Data Architecture think at scale

The cloud promises elasticity, but in order to achieve it, we must architect across the entire stack. The pace of digital transformation shows no signs of slowing. Whatever is currently on our mind, multiply it by at least 10 and, more likely, 100 in our experience with large organizations, an annual doubling of transaction and data volumes barely covers it. It doesn't take long for mission-critical, data-intensive applications to run into scalability issues (Farzin et al., 2022). So, think big picture and choose multiple cloud solutions that optimizes your performance and matches your revenue model. The most crucial advantage of multi-cloud, in my opinion, is flexibility. Every organization is unique, and adopting a multi-cloud strategy means that your infrastructure can be customized to your specific needs rather than being one-size-fits-all. Because of this, some firms are multi-cloud by chance, as various services were embraced by different portions of the business as and when they suited their needs. Making multi-cloud a strategic goal can optimize the advantages.

One example is a firm that employs a small section of one cloud to store or transfer papers, another private cloud for sensitive company data, and yet another for data analysis. In this case, each cloud may have different Service-Level Agreements, costs, and levels of

consumption by the company. Multiple clouds imply that you, not your provider, decide which technologies to employ.

Table 2 shows highly efficient way to summarize and compare key data points, strategies, challenges, and solutions. Below is an example of how to convey critical information about multi-cloud environments.

Aspect	Strategy A	Strategy B	Strategy C
Cost Optimization	Cost-effective for high compute workloads	Moderate cost with balanced performance	High initial cost with long-term savings
Performance	High performance for data-intensive applications	Balanced performance across all services	Optimized for low-latency requirements
Security	Strong security features with customizable policies	Built-in compliance with industry standards	Advanced security features with AI-driven threat detection
Scalability	Easily scalable with automated resource management	Manual scaling with flexibility	Scalable with real-time adjustments based on demand
Vendor Lock-in	Low risk with multi-vendor support	Moderate risk with some vendor-specific services	High risk but mitigated by robust migration tools

Data Management	Centralized data management with cross-cloud capabilities	Distributed data management with redundancy	Hybrid approach with on-premises and cloud integration
Compliance	Comprehensive compliance support for global standards	Focused on regional compliance requirements	Advanced compliance management with automated reporting
Integration Complexity	Low complexity with API integrations	Medium complexity requiring custom middleware	High complexity needing dedicated integration platforms
Reliability	High reliability with failover and disaster recovery	Moderate reliability with periodic maintenance	Extremely reliable with multi-zone redundancy
Case Study Example	E-commerce platform handling peak traffic	Financial institution ensuring data integrity	Healthcare provider maintaining patient data security

Table 2: Comparison of Multi-Cloud Strategies

2.2. Understanding the Risks and Challenges of Multi-Cloud

While leveraging a multi-cloud architecture solution, there are couple of things that are important to consider. First, the risks are really around the complexity and cost.
we have so many resources that are accessible to us that provision on demand, however, that comes at the expense of complexity and the number of potential attacks will also increase (Achar et al., 2022). Different providers will have different security rules or different protocol standards, making it complex to monitor security policies in composite

services. Another important consideration in a multi-cloud environment is cost. Migration from one service to another will incur additional economic costs that must be considered during the design process. Costs include the hardware and resources required for migration, as well as the cost of training application users.

2.2.1. Manageability

When you are using multiple clouds, the complexity of your environment increases dramatically. Every one of those clouds has its own interface and its own security tools to learn and manage (Rajeshwari et al., 2022). The more clouds, the more tools you must learn. And to do it right, each one of those clouds is going to need a firewall, security incident and event management, micro-segmentation, identity and access management, endpoint security and more. Each one of these tools becomes a place for you and your team to make a mistake that the bad guys can exploit.

2.2.2. Security

When utilizing multiple services increases your security vulnerability and of course it's important to have good security behaviors in place but using more than one provider means that you do have increased disaster recovery and have spread your risk of attack across more than one service (Sandesh et al., 2022). According to the Gartner report, 99% of cloud security failures will be the fault of the customer by 2025 (Panetta, 2019). If we have good control of our security and governance, for example, staff that are trained on avoiding security failures and reacting to breaches and data loss, multi-cloud can be a security benefit not a threat. Cloud security for multi-cloud service providers is a complex and ever-changing issue. Despite the benefits, service providers must be aware of the unique security challenges that come with this type of distributed environment. To keep

data and applications safe, service providers must carefully plan and implement security measures at each stage of the multi-cloud journey.

2.2.3. Costs

Important factor to consider is if multi-cloud is more expensive or makes budgeting more complex. It's a good idea to have an internal team to consolidate expenses and analyze the advantages of your cloud infrastructure in an enterprise organization; but, in a smaller firm, you're unlikely to have these resources. It's possible that just the IT and/or finance departments are keeping track of expenditures. This is where multi-cloud management may require more work, but it is critical to closely monitor cloud cost (Georgios et al., 2021). As previously said, if you have an unintentional multi-cloud setup, excellent monitoring is much more vital, and it may discover areas of savings if you can transition to a strategic set-up. Monitoring expenses are one area where suppliers may assist in lowering the barriers that prevent enterprises from shifting across clouds. Organizations want a simpler approach to analyze cloud spending and estimate future expenditures (Ritter et al., 2021). They need complete pricing transparency and do not want to be paid for ingress, egress, or underutilized systems.

The management complexity and operational hassles increase exponentially, with each cloud you add to your environment. That is why it is critical that you are proactive about managing the complexity that crops up from leveraging multiple clouds.
organization should leverage a set of multi-cloud universal services that will enable you to manage and optimize cost and performance from every cloud in a single interface. These kinds of services need to account for managing things like network, security controls, cost, operations, provisioning, automation, orchestration and compliance. If done properly,

these services can dramatically increase the effectiveness of your operations team and their workload day to day.

2.2.4. Bridging the Skills Gap

Many firms need to adopt a multi-cloud approach for flexibility, however increased complexity of monitoring numerous cloud services, containers, APIs, etc. other Processes can be frightening. The standardization of operations across numerous cloud services might thus constitute a significant impediment to multi-cloud. There is also a knowledge and talent gap to deal with.

The available manpower is simply not keeping up with technological improvements and business requirements. Siloing of existing information or a lack of collaboration inside firms might further aggravate multi-cloud fear and unfamiliarity.

Enterprises face a critical knowledge gap. Many IT workers lack both basic and specific expertise about multi-cloud. For example: Not understand how to efficiently use new services (e.g., serverless architectures), or how to Integrate or organize various processes to operate in tandem.

(Chelliah and Surianarayanan, 2021) provides the following critical drivers for the multi-cloud paradigm below.

- Fast-paced cloud journey
- Fast-paced cloud tool ecosystem
- Varied cloud service offerings that are value-adding
- Powerful platforms for cloud environments
- Smart networks
- Affordability
- Distributed and decentralized computing models

- Breakthrough digital technologies

Furthermore, the implementation comes with the challenges by (Chelliah and Surianarayanan, 2021), and the possible solutions as shown in Table 3.

#	Challenge	Solution approaches
1	Interoperability and portability(Nogueira, E et al., 2016)	(i) Open APIs and Standards (ii) The Open Cloud Computing Interface (iii) Automation (iv) DevOps through CI/CD pipeline (v) Infrastructure as Code (IaC) (vi) Microservices Architecture (vii) Spinnaker for Multi-Cloud Software Delivery (viii) Containerization (ix) Serverless computing and management across Multiple Clouds (x) Service Resiliency Frameworks and Libraries for Multi-Clouds (xi) Service mesh orchestration
2	Application & data integration(Senda Romdhani, 2019)	Application and Data Integration Platforms
3	Multi-cloud orchestration(Ming Lu et al., 2018)	(i) intelligent brokers (ii)Container Clustering and Orchestration Platforms
4	Multi-Cloud Monitoring, Measurement and Management(E. Rios et al., 2016)	(i) Multi-Cloud Management and Governance Platforms (ii) Multi-Cloud Monitoring and Measurement Tools (iii) AI-Inspired Log and Operational Analytics Platforms for Multi-Clouds
5	Identity and Access Management(I.Indu et al., 2018)	(i) Next-Generation Identity and Access Management (IAM) Solutions (ii) Edge Cloud Integration with Traditional Clouds (iii) Multi-cloud security

Table 3: (Chelliah and Surianarayanan, 2021) - Challenges in multi-cloud and respective solution approaches

2.3. Summary of the Literature Review

While multi-cloud environments have many advantages for small businesses, there are also potential roadblocks that organizations must overcome. Keeping track of multiple providers can be difficult, and these tools must be properly implemented in order to work together. Moving into these environments is also a significant undertaking, and many smaller organizations lack the resources to do so effectively. Also, small business must be cautious of possible potential security and interoperability challenges too.

Through the literature review we discussed the current state of multi-cloud and we can conclude that a multi-cloud strategy allows organization the flexibility to cherry pick and take advantage of the finest services from various cloud providers. They can take advantage of the marketplace's revolutionary new features rather than being tied to and relying on a single cloud vendor's plan and the associated risks for a business.

The research aims to mitigate this risk by looking to answer key questions about the journey taken by existing businesses and creating a framework for small businesses that follow.

CHAPTER III:

METHODOLOGY

In the research methodology section, we will outline the process and techniques used to collect and analyze data for this study. Research methodology refers to the systematic approach that a researcher follows in conducting their investigation. According to Leedy and Ormrod (2014), research methodology encompasses the overall strategy, action plan, and tools employed in carrying out a study. This chapter starts with summarizing the research problem, purpose, and questions. It then delves into the research design. The chapter then highlights the limitations of the research design and concludes with a summary of the chapter.

3.1 Overview of the Research Problem

The research problem in this context is the limited knowledge and understanding among start-ups and small-scale businesses regarding the benefits and potential of using multi-cloud environments. Many businesses may be hesitant to adopt multi-cloud strategies due to concerns about cost, performance, security, reliability, and flexibility.

These concerns can stem from a lack of awareness or understanding of how multi-cloud environments work and how they can be effectively utilized. As a result, many businesses may miss out on the advantages that come with leveraging multiple cloud service providers.

By conducting research on this topic, the aim is to bridge this knowledge gap and provide insights that will help start-ups and small-scale businesses make informed decisions about adopting multi-cloud strategies. The research will explore various factors such as cost savings, performance improvements, enhanced security measures, increased

reliability through redundancy across different cloud providers, and greater flexibility in terms of workload distribution.

Additionally, the research will identify any challenges or limitations associated with implementing a multi-cloud environment for these businesses. It will investigate best practices for selecting compatible cloud service providers, managing data integration across multiple platforms efficiently, and ensuring seamless interoperability between different cloud services.

Overall, the goal is to provide actionable recommendations that enable start-ups and small-scale businesses to leverage multi-cloud environments effectively and realize their full potential in terms of cost optimization, reliability improvement, and overall business efficiency

3.2 Operationalization of Theoretical Constructs

Operationalizing theoretical constructs in multi-cloud challenges involves translating abstract concepts into measurable variables for practical application. In the context of multi-cloud challenges, this process typically involves identifying key theoretical constructs relevant to the situation, determining how to measure or observe these constructs in a multi-cloud environment, and then developing specific metrics or indicators to assess the impact or effectiveness of these constructs within the multi-cloud setting.

Some common theoretical constructs in multi-cloud challenges include issues such as performance optimization, resource allocation, cost management, security and compliance, interoperability, and scalability. Operationalizing these constructs may involve defining specific KPIs (Key Performance Indicators) for each construct, establishing data collection methods, implementing measurement tools or frameworks,

and analyzing the data gathered to evaluate the performance of multi-cloud solutions against these constructs.

Overall, the operationalization of theoretical constructs in multi-cloud challenges is essential for practical problem-solving, decision-making, and performance evaluation in complex cloud environments. By clearly defining and measuring these constructs, organizations can better understand and address the unique challenges and opportunities associated with multi-cloud deployments.

3.3 Research Purpose and Questions

The distinct purpose of this study is to explore the multi-cloud strategies that can help the growth of small businesses and to leverage the multi-cloud and help to save a lot of money, improve performance, reliability, security and flexibility.
Some potential research purposes in multi-cloud could include:
1. Assessing the advantages and disadvantages of using multiple cloud providers.
2. Analyzing the performance and scalability of applications deployed across multiple clouds.
3. Exploring the impact of vendor lock-in and interoperability issues in a multi-cloud environment.
4. Investigating cost optimization strategies for managing resources across multiple clouds.
5. Examining security and privacy concerns associated with distributing data among different cloud providers.
Once the research purpose is defined, develop specific research questions that guide their investigation and provide a focused direction for this study.

S. No	Research Objective	Research Methodology	Primary data collection
1	What are the key features to look for in a multi-cloud management platform?	Exploratory & Qualitative research	Survey / Interview

2	What are the main challenges for multi-cloud application developers and operators?	Exploratory & Qualitative research	Survey / Interview
3	What are the main security risks and mitigation strategies in multi-cloud applications?	Exploratory & Qualitative research	Survey / Interview
4	What are the promising trends in multi-cloud application design, development, and operation that can be identified?	Exploratory & Qualitative research	Survey / Interview
5	How to tackle the roadblocks on your way to multi-cloud success	Exploratory & Qualitative research	Survey / Interview
6	How difficult is it to monitor the performance and availability of multiple clouds?	Exploratory & Qualitative research	Survey / Interview
7	Auto-scaling difficulties and challenges in scaling up multi-cloud components for load balancing across multiple clouds	Exploratory & Qualitative research	Survey / Interview
8	How to effectively manage costs when deploying and scaling up the multi-cloud strategy	Exploratory & Qualitative research	Survey / Interview
9	What common mistakes should avoid when adopting Multi Cloud?	Exploratory & Qualitative research	Survey / Interview

Table 4: Research objective, methodology and data collection

3.4 Research Design

Th research design uses a mixed Qualitative approach, combining historical data analysis, simulation, and statistical analysis to arrive at meaningful conclusions and recommendations for the multi-cloud. Th study was conducted in five stages: (1) a survey based on the current multi-cloud challenges. (2) Data analysis on the independent variables. (3) building the multi-cloud strategy and best practices. (4) Examine multi-cloud eco-system of various business. (5) interpretation of results.

3.5 Population and Sample

Qualitative:

The aim of the qualitative aspect of this study to gather in-depth insights and opinions from participants regarding their knowledge, experiences, and perceptions of using multi-cloud environments in start-ups and small-scale businesses. A questionnaire will be designed to collect qualitative data from 100 participants.

The questionnaire included open-ended questions that allow participants to provide detailed responses and share their thoughts on various aspects related to multi-cloud adoption. The questions may cover topics such as.

3.5.1. Current cloud usage

As a mean of obtaining information on participants current cloud usage, participants were asked about their current cloud usage, including the number of cloud service providers they are working with, the types of services utilized, and any challenges they have faced.

3.5.2. Awareness and understanding

In order to obtain information about participants awareness and understanding of multi-cloud environment, participants were asked about their level of awareness and understanding of multi-cloud environments. This includes questions on what they know about multi-cloud strategies, any misconceptions or concerns they have, and how confident they are in implementing a multi-cloud approach.

3.5.3. Benefits

To obtain information about the participants perceived benefit of multicloud environment, participants were asked about their perceptions of the potential benefits of using multi-cloud environments for their businesses. This includes questions on cost savings, performance improvements, reliability enhancement, security measures, and flexibility gains.

3.5.4. Challenges

Participants were encouraged to share any challenges or limitations they foresee when implementing a multi-cloud strategy within their organizations. This could include concerns related to cost management, data integration issues, vendor lock-in, and potential conflicts between different service providers.

3.5.5. Recommendations

Participants were also invited to provide recommendations for start-ups and small-scale businesses considering adopting a multi-cloud approach. These recommendations included suggestions for selecting compatible cloud service providers, best practices for managing data integration efficiently, and strategies for ensuring seamless interoperability between different platforms.

3.5.6. Data Analysis

The responses gathered through the qualitative research went under thematic analysis. The researcher identified recurring themes, patterns, and insights within the

dataset. The researcher also examined similarities, differences and trends among participant responses. Through this analysis, the key findings and recommendations for leveraging multi-cloud environments were derived.

3.6 Participant Selection

Participants for this study were selected using a combination of purposive and convenience sampling methods. Purposive sampling will be employed to target individuals and organizations with expertise and experience in managing multi-cloud environments. This approach ensures that participants have relevant insights to contribute to the study. Additionally, convenience sampling may be used to include participants who are easily accessible and willing to participate, thereby enhancing the diversity of perspectives in the research. The selection criteria prioritized individuals with substantial experience in implementing and utilizing multi-cloud architectures to gather comprehensive and insightful data for the study. This study used a random sample of IT and Cloud professional. To participate in the study, participants had to be active in the cloud and IT industry. To control for industry effect, participants were restricted to IT and cloud professional belonging to 5 categories.

1. IT Engineers
2. Cloud Engineering Managers / Product Owners
3. Cloud Leaders
4. IT leaders / IT product owners
5. General Technology Leaders

3.7 Instrumentation

The design of the questionnaire was based on a review of the literature and previous studies. Developed own questions to ensure that they were tailored specifically to the research objectives and the subject matter.

The questionnaire was divided into three main sections:

1. General Information: This section gathered demographic data such as age, gender, educational background, and professional experience in cloud computing.
2. Multi-Cloud Adoption: This section focused on assessing factors influencing multi-cloud adoption, challenges encountered during implementation, and perceived benefits of multi-cloud strategies.
3. Performance Metrics: This section included questions about performance measurement criteria used for evaluating multi-cloud environments.

   The questionnaire comprised a total of 15 questions, which were a mix o multiple-choice and open-ended questions. Additionally, a Likert scale rangin from 1 (strongly disagree) to 5 (strongly agree) was utilized to gauge respondents' agreement with certain statements.

Before finalizing the questionnaire for distribution among participants, pilot testing was conducted with a small sample group to assess its clarity and validity. Following feedback from this pilot test, minor revisions were made to improve the comprehensibility of certain questions.

Overall, careful consideration was given to designing an instrument that could effectively capture key insights related to multi-cloud adoption while ensuring ease of completion for survey respondents.

Instrumentation in multi-cloud environments presents several challenges that study will address. Some of the key challenges include:

3.7.1. Heterogeneity

Multi-cloud environments typically involve different cloud providers with their own unique monitoring tools, APIs, and data formats. This heterogeneity makes it challenging to collect, aggregate, and analyze instrumentation data from multiple sources.

3.7.2. Data integration

Aggregating and integrating data from different cloud providers into a unified view can be complex due to variations in metrics, terminology, and data formats. Need to develop mechanisms or frameworks to harmonize this disparate data for effective analysis.

3.7.3. Scalability

Multi-cloud environments are often large-scale distributed systems with numerous services running across multiple clouds. Instrumenting such environments at scale requires efficient methods for collecting and processing large volumes of monitoring data without affecting system performance.

3.7.4. Security and privacy

Instrumentation involves collecting sensitive information about cloud resources, applications, and user interactions. Ensuring the security and privacy of this instrumentation data is crucial to protect against unauthorized access or misuse.

3.7.5. Interoperability

Interoperability between different monitoring tools or platforms is essential for seamless integration across multiple clouds.Rresearchers can explore standardization efforts like OpenTelemetry that aim to provide a consistent set of APIs, and protocols for instrumenting applications, making it easier to collect telemetry data from diverse sources.

3.7.6. Resilience & fault tolerance

Managing instrumentationin a multi-cloudenvironment requires ensuring the resilience and faulttolerance of monitoring systems. Itinvolves dealing with challenges like failover, redundancy, capacity planning and loadbalancing to ensure the monitoring capability is available across multiple regions or cloud providers.

3.7.7. Cost management:

The ability to manage costs associated with instrumentation is vital as monitoring across multi-cloud can result in higher costs due to greater network traffic and estimation of resource usage. Instrumentation should be designed in the most cost-effective way while ensuring the needed level of visibility in to the performance and security of multi-cloud systems

Addressing these challenges requires ongoing research in areas such as scalable monitoring architectures, data integration techniques, data standardization approaches, fault tolerance mechanisms, and secure instrumentation practices. Also need to consider real-world use cases, application-specific requirements, and business objectives when designing solutions for instrumentation in multi-cloud.

3.8 Data Collection Procedures

Data used for this study was collected thriouch survey. The survey was distributed to a sample small business in India to the adoption of cloud computing among small and medium enterprises (SMEs). The survey instrument was designed to assess the key factors influencing cloud computing adoption, including technological, organizational, and environmental considerations.

In addition to the survey, the research team conducted a series of in-depth case studies with select startups and small businesses that have successfully leveraged multi-cloud environments. These case studies provided rich, qualitative data on the specific strategies, challenges, and best practices employed by these organizations.

The case study approach allowed for a deeper understanding of the nuances and complexities involved in multi-cloud adoption, which may not have been fully captured through the survey data alone. By combining the quantitative survey data with the qualitative case study insights, the researcher was able to develop a more comprehensive and actionable set of findings to support startups and small businesses in their multi-cloud journeys.

3.9 Data Analysis

Qualitative

For data analysis, survey data responses to be converted to categorical data for the dependent variables and then apply linear regression and clustering for building the framework.

3.10 Research Design Limitations

It is important to note that the research design for this study has certain limitations to consider when interpreting the findings. The data used for the study is limited to the survey responses on multi-cloud challenges and benefits from the relevant industry data practitioners and simulation based on the response groups. Though it is across various data practitioners and industry experts, the results of this study may need to be more consistent when tested on other IT Software areas or other groups.

The research design attempts to eliminate the sample and look-forward bias by training the model and using the data based on the survey response.

However, the results may vary when applied in certain situations due to issues such as the research design attempts to understand how the small, medium, and enterprise IT enabled organization and the architecture they use, the executive leaders' data-driven business decisions, etc.

The research design uses a survey for IT enabled industry experts and business leaders. The research design can be leveraged for any industry; however, it is important to consider that the subject areas for each multi-cloud may vary.

3.11 Conclusion

This chapter provided an overview of the research problem with multi-cloud eco-system and comprehensive analysis has highlighted the complexity of managing, monitoring, and securing applications spread across multiple cloud platforms. By employing a systematic methodology, we aimed to provide a structured approach to understanding and mitigating these challenges.

The first, second, and third objective is to evaluate multi-cloud challenges and benefits. Achieving these three objectives is by simulating the data based on the survey data responses by a strategic grouping of parameters with each objective.

The chapter also discussed the research design limitations. The data is limited to the multi-cloud eco-systems and may not be consistent with other multi-cloud subject areas. The study eliminates sample and look-forward bias by strategic sampling, but the results may vary due to different multi-cloud subjects. More importantly, it equips business leaders with specific steps they can take today to navigate the mix of clouds in a way that controls data costs and accelerates innovation. The survey reveals that following these

steps results in tangible benefits: companies that score high on multi-cloud maturity see greatly improved valuations, faster time to market, and the ability to beat revenue goals.

As multi-cloud environments continue to grow in complexity and prevalence, ongoing research and development in instrumentation and monitoring techniques are crucial. Future advancements in AI, machine learning, and edge computing hold promise for further enhancing multi-cloud management. Standardization efforts will also play a pivotal role in improving interoperability and reliability across diverse cloud platforms.

CHAPTER IV:

RESULTS AND FINDINGS

4.1 Introduction

This chapter outlines the results and important findings of the study. It is broadly divided into multiple parts –

- Research survey details
- Descriptive Analysis
- Factor Analysis
- Chi-square testing
- Regression Analysis

4.2 The Research Case

This section provides an overview of the users of single cloud and multi-cloud companies who were chosen for the study, their professional backgrounds, and some context about the multi-cloud environment. This information serves as a lens through which the rest of the study can be viewed and understood.

4.3 Descriptive Study

Overall, a set of 100 responses have been collected. the questionnaire was designed to capture insights from participants with various roles in the organization, including team leaders, cloud architects, software developers, IT managers, CTOs, and CIOs. This approach aimed to gather diverse perspectives on multi-cloud adoption and its implications across different organizational levels.

By including participants from various roles within the organization and industries, sought to gain a comprehensive understanding of factors influencing multi-cloud adoption

decisions and how they impact different stakeholders. This approach allowed us to assess challenges and benefits from both technical and managerial viewpoints.

A descriptive study of the responses is elaborated below.

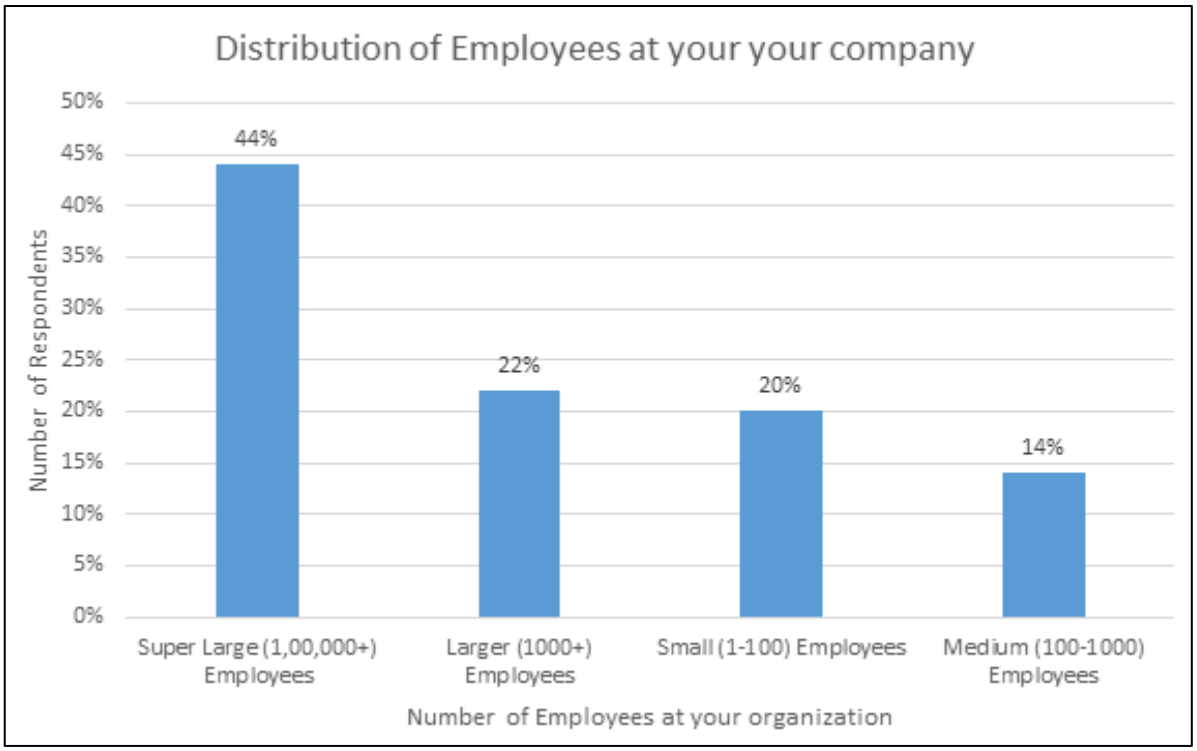

Figure 4: Distribution number of employees by organization

The majority of participants in this study from super-large (1,00,000+) and large (1000+) enterprises. Input from participants in super-large and large enterprises, as their experiences with multi-cloud adoption can provide insights into the unique challenges and opportunities that arise at scale. Their perspectives can shed light on the specific considerations and strategies that are relevant for organizations of this size.

By gathering input from these experienced decision-makers within super-large and large enterprises, aim to capture a comprehensive view of how multi-cloud strategies

are planned for and executed at an organizational level. This will enable us to provide practical insights and recommendations for organizations looking to adopt or optimize their own multi-cloud approaches.

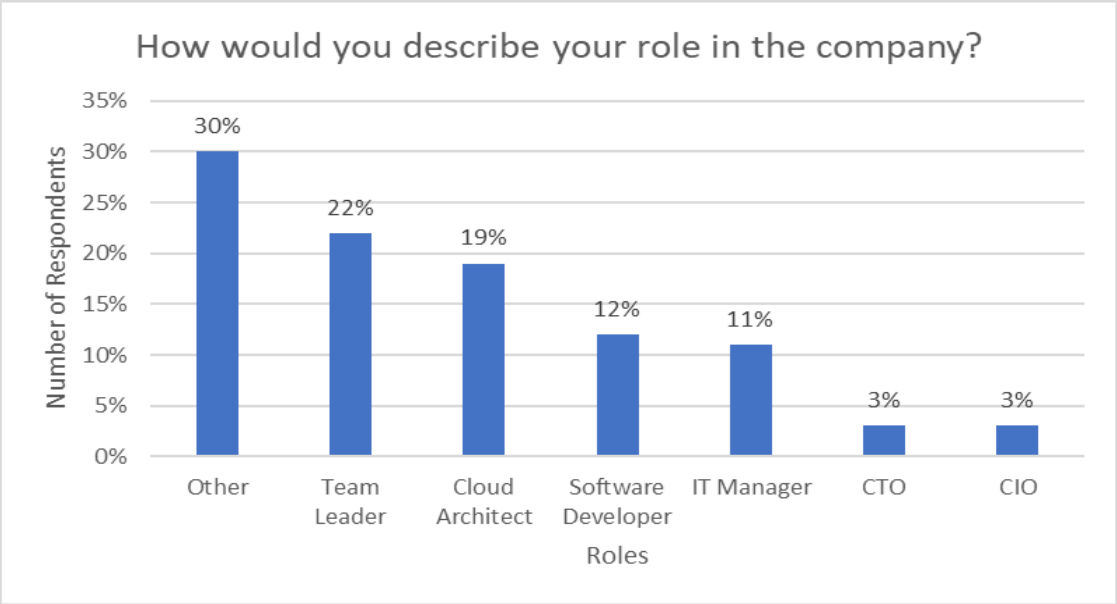

Figure 5: Multi-cloud challenges grouped by role

The questionnaire included in this sections that specifically targeted the responsibilities and perspectives of each role. From figure 5 shows most of the respondents are at leadership level. There are a few CTO/CIO respondents as well.

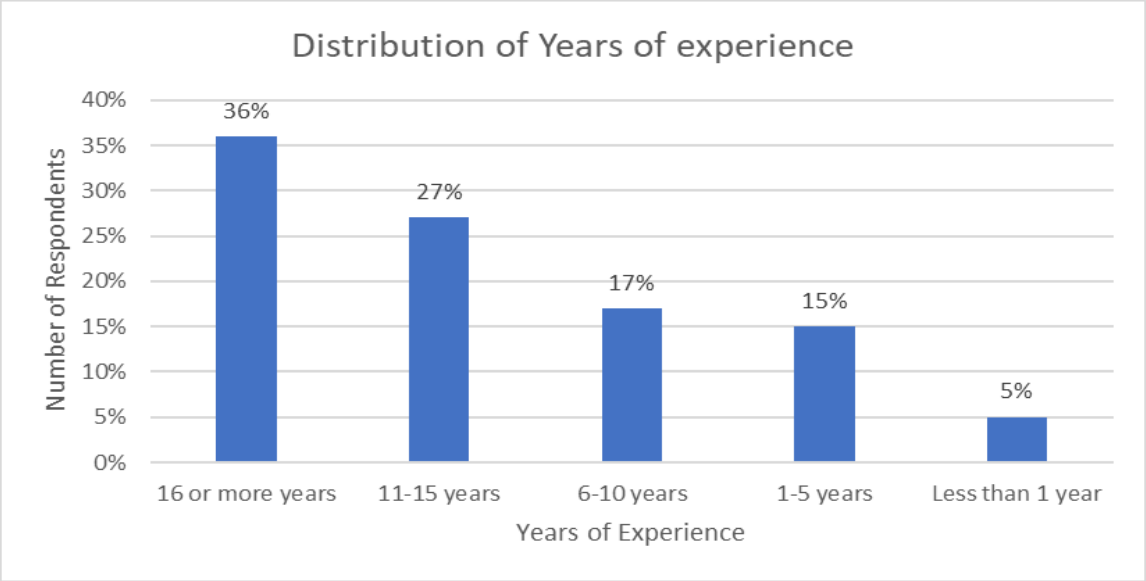

Figure 6: Multi-cloud challenges grouped by years of experience

From figure 6, the respondent experience levels are also pretty high 36% indicating that they are the decision makers of the enterprises where they work in. The high experience levels of the respondents in this study suggest that they are likely decision-makers or key stakeholders within their respective enterprises. This is significant because it means that their perspectives and insights reflect the strategic decisions and considerations made by organizations when adopting multi-cloud approaches.

Having decision-makers participate in the study allows us to gain a deeper understanding of the motivations, challenges, and strategies behind multi-cloud adoption at an organizational level. These individuals can provide valuable insights into the business drivers for pursuing a multi-cloud strategy, such as achieving cost savings, enhancing flexibility and scalability, improving resilience, or harnessing specialized services from different cloud providers.

Their experience also implies that they have firsthand knowledge of the complexities involved in managing multiple cloud environments simultaneously. They can shed light

on issues related to governance, security, integration, compliance with regulations across different clouds, as well as vendor management and relationship management with cloud service providers.

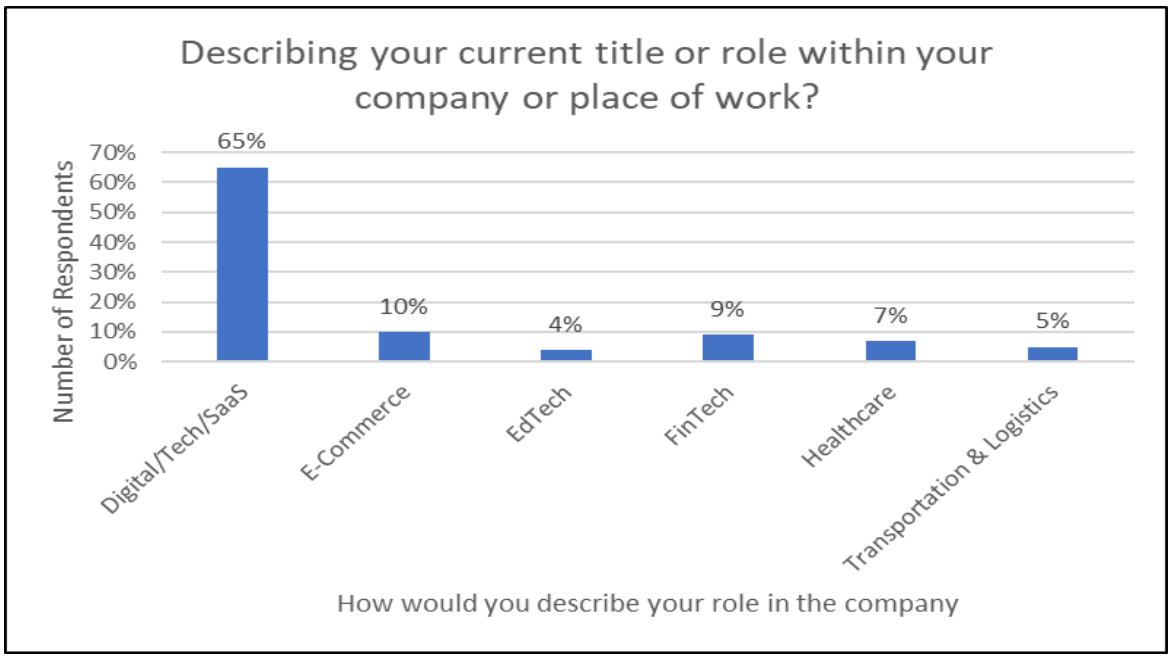

Figure 7: Multi-cloud adoption grouped by organization type

The majority of digital/tech and SaaS enterprises are heavily invested in multi-cloud strategies due to their reliance on advanced technology and data infrastructure. This suggests that these industries recognize the benefits of using multiple cloud providers for their specific needs.

The anticipated change in cloud strategy is distributed as below:

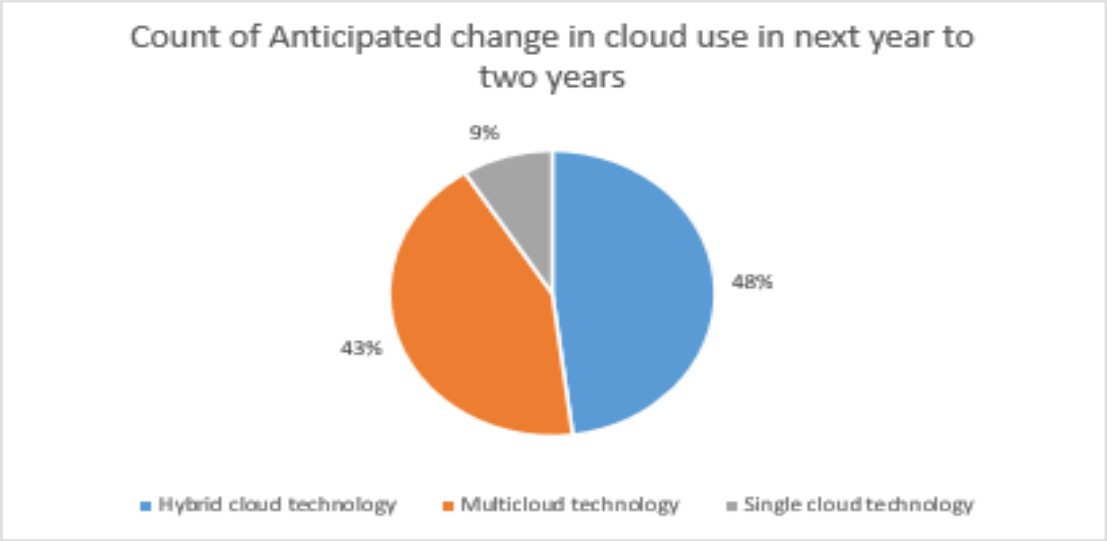

Figure 8: Anticipation in cloud usage in next year or two years

From figure 8, we can anticipate next year or two will see an increase in hybrid cloud usage, followed by multi-cloud and then single cloud. This progression reflects the growing recognition of the benefits of combining on-premises infrastructure with public and private cloud services to create a hybrid environment. As organizations become more comfortable with this approach, they may then explore using multiple cloud providers to optimize cost, performance, and redundancy while still maintaining some reliance on a single primary cloud provider.

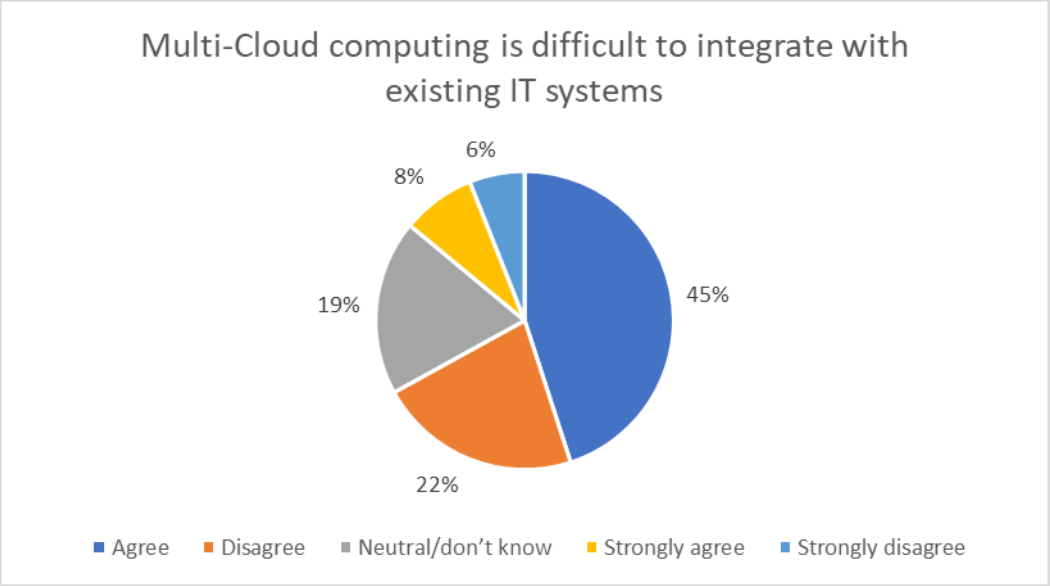

Figure 9: Multi-cloud challenge is difficult to integrate with existing IT systems

1. **Agree**: The difficulty in adopting multi-cloud computing is a commonly cited reason for the slower adoption of this approach compared to hybrid or single-cloud solutions. Managing multiple cloud providers, integrating different technologies and architectures, ensuring data portability and interoperability, and dealing with potential vendor lock-in are some of the challenges organizations face when implementing a multi-cloud strategy. These complexities can make it more difficult for organizations to adopt multi-cloud computing in the next year or two.
2. **Disagree**: There may be those who disagree with this statement, suggesting that while there are indeed challenges associated with multi-cloud adoption, organizations are actively working on addressing these issues. They may argue that with advancements in cloud management tools, standardized APIs, and increasing emphasis on interoperability among cloud providers, the difficulties can be overcome more easily than predicted.
3. **Neutral**: A neutral stance might indicate no strong opinion regarding the difficulty of adopting multi-cloud computing. It could suggest a need for more information

or evidence to form an opinion on whether these difficulties will significantly impact its adoption in the near future.

4. **Strongly agree**: Those who strongly agree may have firsthand experience or knowledge of organizations struggling with various challenges when trying to implement a multi-cloud strategy. They may argue that these difficulties should not be underestimated and will continue to slow down widespread adoption in the next year or two.
5. **Strongly disagree**: Respondents who strongly disagree might believe that despite initial hurdles, many organizations are successfully adopting multi-cloud computing without significant difficulty. They may highlight success stories where companies have effectively managed multiple cloud providers and reaped benefits such as cost optimization and increased flexibility.

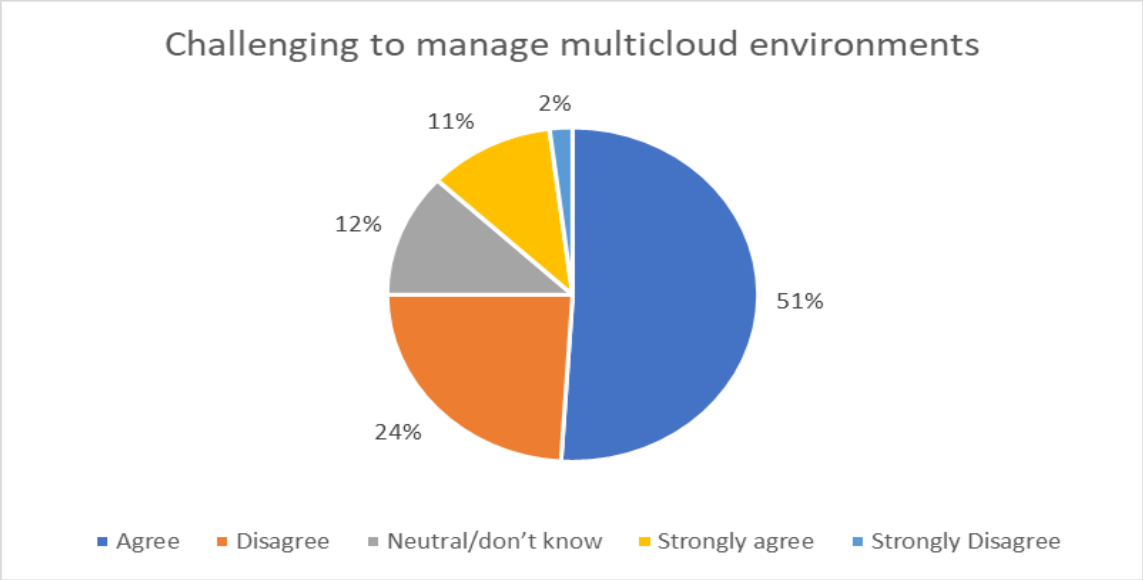

Figure 10: Challenges to manage multi-cloud

6. **Agree**: Many respondents agreed that managing multi-cloud environments comes with challenges. This suggests that organizations recognize the

complexities and potential difficulties associated with implementing and maintaining a multi-cloud strategy.

7. **Disagree:** Some respondents disagreed, indicating that they believe managing multi-cloud environments is not particularly challenging. They may argue that proper planning, tools, and expertise can alleviate any potential difficulties.
8. **Neutral:** A neutral response suggests that the respondent neither agrees nor disagrees with the assertion that managing multi-cloud environments is challenging. They may have limited experience or knowledge on the topic, or they might believe it depends on specific circumstances.
9. **Strongly agree**: Respondents who strongly agree likely have firsthand experience dealing with the complexities of managing multiple cloud providers. They acknowledge the various technical, operational, and organizational challenges involved in ensuring effective coordination and integration across different platforms.
10. **Strongly disagree**: Those who strongly disagree may have had positive experiences or possess extensive expertise in effectively managing multi-cloud environments. They might argue that proper planning, robust management tools, and skilled personnel can overcome any challenges associated with a multi-cloud approach.

Understanding these diverse perspectives can help provide a comprehensive view of the challenges surrounding multi-cloud management. It showcases differing opinions on whether organizations face significant hurdles or if there are effective strategies to mitigate them successfully.

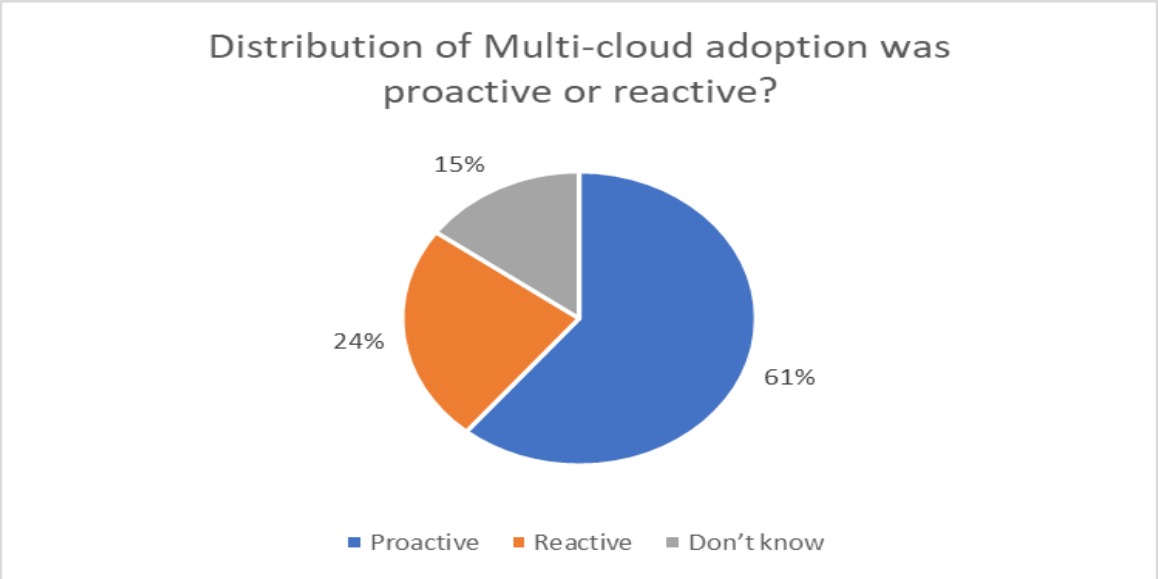

Figure 11: Multi-cloud adoption approach

From Figure 11, it's notable that there are a significant number of respondents who agreed on the proactiveness of multi-cloud adoption. This suggests that many organizations are actively pursuing multi-cloud strategies as part of their IT and business operations.

The fact that decision-makers within these enterprises see the value in proactively adopting multi-cloud approaches speaks to the growing recognition of the benefits and opportunities offered by leveraging multiple cloud providers. It indicates a strategic mindset among organizations, as they seek to harness the strengths of different cloud platforms to meet diverse business needs and objectives.

Given this consensus among respondents, it's clear that many organizations are not only aware of the potential advantages of multi-cloud adoption but are actively taking steps to implement and integrate multiple cloud services into their infrastructure. This proactive stance reflects an understanding of the competitive advantages, risk mitigation, and innovation potential associated with embracing a multi-cloud environment.

Understanding these perspectives can provide valuable insights into how organizations are approaching multi-cloud adoption from a proactive standpoint. It allows us to explore the motivations driving this strategic choice, as well as the challenges encountered and effective practices employed during implementation. Such insights can be instrumental in guiding other enterprises considering or embarking on their own multi-cloud journeys.

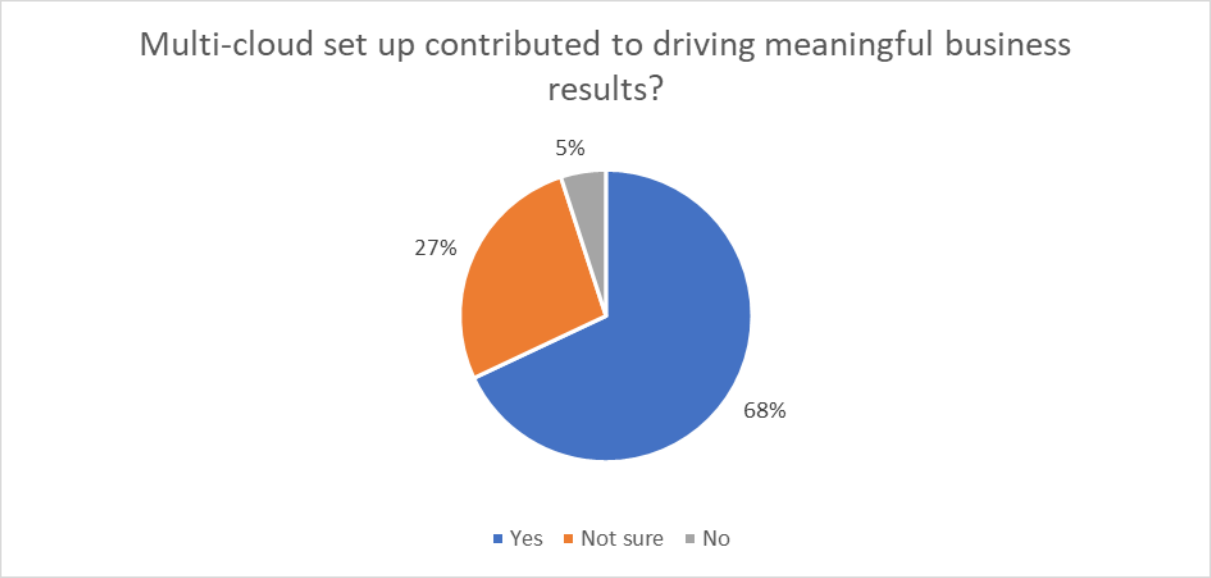

Figure 12: Multi-cloud adoption business results

Form figure 12, 68% of businesses have reported positive results from multi-cloud adoption, it's interesting to note that a majority of businesses have reported positive outcomes from multi-cloud adoption. This suggests that many organizations are finding success with their multi-cloud strategies, potentially overcoming the challenges associated with managing multiple cloud providers. However, it's also important to consider the 27% who are not sure about the outcomes and the 5% who have reported negative results. Understanding their perspectives and experiences could provide valuable insights into the

potential difficulties and pitfalls of multi-cloud adoption. Overall, while there is a trend towards successful implementation of multi-cloud strategies, it's crucial to continue monitoring industry trends and evolving best practices in this area.

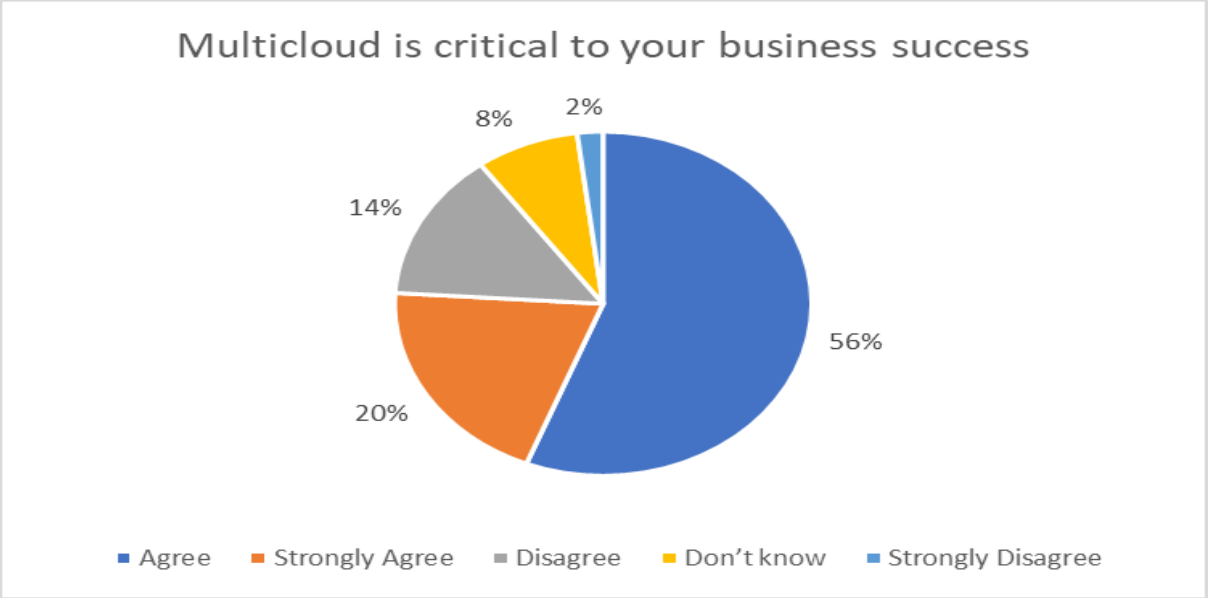

Figure 13: Multi-cloud business success

Based on these numbers from figure 13, it appears that a significant majority of businesses (76%) have a positive outlook on multi-cloud adoption, with 56% agreeing and an additional 20% strongly agreeing with its success.

The fact that more than three-quarters of businesses express some level of agreement is encouraging and suggests that multi-cloud strategies are delivering value to organizations. The benefits of multi-cloud adoption may include increased flexibility, scalability, redundancy, cost optimization, and access to best-of-breed services from multiple cloud providers.

However, it is also crucial to consider the viewpoints of those who disagree (14%) or are uncertain (8%) about the success of multi-cloud approaches. Their dissenting opinions may stem from various reasons such as challenges in managing multiple cloud

environments effectively, issues related to data governance and security across different platforms, or difficulties in integrating disparate systems.

To gain deeper insights into these perspectives and address any concerns raised by dissenting voices or uncertainty, conducting further research or surveys could be helpful. This would enable organizations to understand the specific pain points experienced by those who disagree or are unsure about multi-cloud success. By addressing these concerns head-on and finding suitable solutions, businesses can work towards maximizing their chances for successful multi-cloud implementations.

In summary, while a majority of businesses agree with the success of multi-cloud adoption based on the provided data breakdowns, considering differing viewpoints is essential for gaining a holistic understanding.

Summary of the insights from the data are below:

Aspect	**Summary**
Respondent Profile	Majority work in large to super large companies, many in the digital/tech/SaaS industry. Most respondents have 16 or more years of experience.
Cloud Providers	Commonly used cloud providers: Microsoft Azure, AWS, Google Cloud. Some use IBM Cloud and VMWare Cloud.
Cloud Technologies	Both multi-cloud and hybrid cloud technologies are utilized without a clear preference for one over the other.
Main Challenges	Challenges include managing security, data integration, costs, and a lack of the necessary skill set.
Reasons for Adoption	Adoption reasons include leveraging best technology from different providers, risk management, filling gaps in regional data governance, and avoiding vendor lock-in.
Business Outcomes	Benefits include more efficient resource utilization, increased agility, enhanced collaboration, revenue increase, and cost reduction.
Adoption Approach	Adoption of multi-cloud technology was mainly proactive rather than reactive.

Performance Monitoring	Some find monitoring complex, while others manage effectively with third-party applications.
Business Impact	Majority believe multi-cloud setup has driven meaningful business results and is crucial for business success.

Table 5: Summary of the insights from data

4.4 Factor analysis

To perform Factor Analysis (FA) with specific constructs, we need to identify which variables will load onto which factors. From our survey data, we can define two constructs:

1. **Cloud Adoption Challenges**: Includes variables related to the difficulties and challenges faced in multi-cloud adoption. This includes the below features – Multi-Cloud computing is difficult to integrate with existing IT systems It is challenging to manage multi-cloud environments Multi-cloud challenges? Please check all that apply.
2. **Business Outcomes:** Includes variables related to the business results and impacts of multi-cloud adoption. Have you experienced any of the following business outcomes as a result of using multi-cloud technology? In your opinion, has your multi-cloud set up contributed to driving meaningful business results?

The factor loadings are in the table below –

Feature	**Factor 1**	**Factor 2**
Multi-Cloud computing is difficult to integrate with existing IT systems	0.13	0.56
It is challenging to manage multi-cloud environments	0.02	0.66
Multi-cloud challenges? Please check all that apply.	-0.34	-0.14
Have you experienced any of the following business outcomes as a result of using multi-cloud technology?	0.48	-0.18

In your opinion, has your multi-cloud set up contributed to driving meaningful business results?	-0.78	0.03

Table 6: Factor analysis and factor loadings

The first three features factor into the cloud adoption challenges and the last two features relate to business outcomes.

- **Factor 1: Business Outcome and Perceived Contribution**

.1. **High Negative Loading:** "In your opinion, has your multi-cloud set up contributed to driving meaningful business results?" (-0.78)

.2. **Moderate Positive Loading:** "Have you experienced any of the following business outcomes as a result of using multi-cloud technology?" (0.48)

This factor primarily represents the perceived business outcomes and contributions of the multi-cloud setup. A high negative loading on perceived meaningful business results indicates that respondents who see significant business contributions from their multi-cloud setup tend to align more strongly with this factor.

- **Factor 2: Integration and Management Challenges**

1. **High Positive Loading:** "It is challenging to manage multi-cloud environments" (0.66)
2. **Moderate Positive Loading:** "Multi-Cloud computing is difficult to integrate with existing IT systems" (0.56)

This factor mainly captures the integration and management challenges associated with multi-cloud environments. The high positive loadings indicate that difficulties in integrating and managing multi-cloud setups are strongly associated with this factor.

4.5 Correlation analysis

For the correlation study, five important features from the survey data are considered. These are the same features we got as important from the factor analysis.

- Feature 1 - Multi-Cloud computing is difficult to integrate with existing IT systems
- Feature 2 - It is challenging to manage multi-cloud environments
- Feature 3 - Multi-cloud challenges? Please check all that apply.
- Feature 4 - Have you experienced any of the following business outcomes as a result of using multi-cloud technology?
- Feature 5 - In your opinion, has your multi-cloud set up contributed to driving meaningful business results?

The correlation heatmap and the inferences are below:

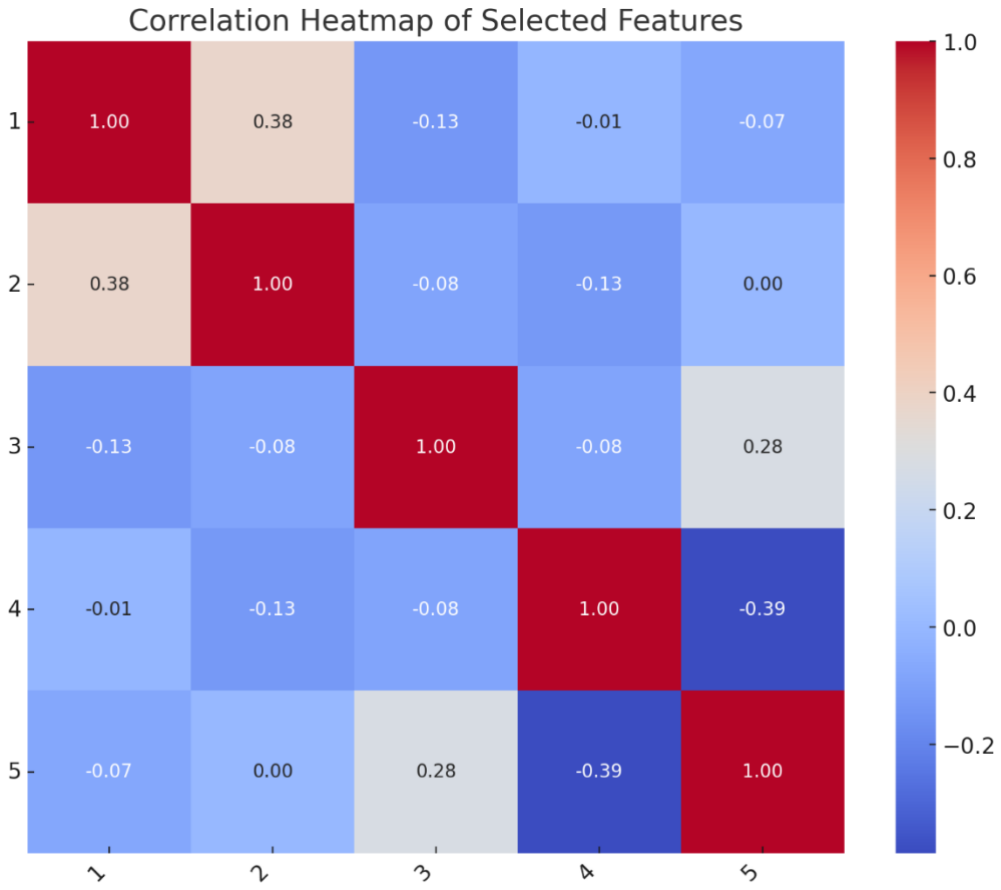

Figure 14: Multi-cloud challenges correlation heatmap

- **Integration and Management Challenges (Correlation 0.38)**: There is a moderate positive correlation between "multi-cloud computing is difficult to integrate with existing IT systems" and "It is challenging to manage multi-cloud environments." This suggests that integration difficulties significantly contribute to the overall challenges of managing multi-cloud environments.

- **Business Outcomes and Management Challenges (Correlation -0.13)**: There is a slight negative correlation between "It is challenging to manage multi-cloud environments" and "Have you experienced any of the following business outcomes as a result of using multi-

cloud technology?" indicating that management challenges may slightly hinder the realization of positive business outcomes.

- **Business Outcomes and Perceived Contribution (Correlation -0.39):** A moderate negative correlation exists between "Have you experienced any of the following business outcomes as a result of using multi-cloud technology?" and "In your opinion, has your multi-cloud set up contributed to driving meaningful business results?". This suggests that those who perceive significant business outcomes tend to view their multi-cloud setup as less challenging.
- **Multi-cloud Challenges and Business Results (Correlation 0.28):** There is a slight positive correlation between "multi-cloud challenges? Please check all that apply." and "In your opinion, has your multi-cloud set up contributed to driving meaningful business results?" This indicates that despite facing various challenges, organizations may still recognize the meaningful business results from multi-cloud setups.

Chi-Square Tests

Chi-Square tests help to explore the relationships between categorical variables in the dataset. We can perform these tests to understand if there are any significant associations between variables like company size, industry, perceived challenges, and outcomes. We will explore the relationship between Industry and Business Outcomes.

Test: Industry vs. Business Outcomes

Test	Chi-Square Statistic	p-value	Degrees of Freedom
Industry vs. Business Outcomes	101.0685914	0.971653646	130

Table 7: Industry vs Business outcomes

The p-value (0.972) is greater than 0.05, indicating that there is no statistically significant association between the industry of the organization and the business outcomes experienced as a result of using multi-cloud technology.

Based on this chi-square tests, we can conclude that there is no significant relationship between the industry of the organization and the business outcomes experienced due to multi-cloud technology.

4.6 Multiple regression analysis

The regression analysis provides valuable insights into how different multi-cloud challenges influence perceived meaningful business results. By focusing on aligning business outcomes with strategic goals and addressing specific challenges, organizations can better leverage their multi-cloud strategies for success. For our regression study, we take the following variables –

4.6.1 Multiple regression analysis – set 1

Dependent Variable: "In your opinion, has your multi-cloud set up contributed to driving meaningful business results?"

Independent Variables:

"Multi-Cloud computing is difficult to integrate with existing IT systems"

"It is challenging to manage multi-cloud environments"

"Multi-cloud challenges? Please check all that apply."

"Have you experienced any of the following business outcomes as a result of using multi-cloud technology?"

Model summary

R-squared: 0.212	This indicates that approximately 21.2% of the variability in the perceived meaningful business results can be explained by the independent variables in the model.
Adjusted R-squared: 0.178	This adjusted value accounts for the number of predictors in the model and indicates a slightly lower explanatory power when adjusting for the number of predictors
F-statistic: 6.373	The F-statistic is significant (p-value = 0.000138), indicating that the model is a good fit and that at least one of the predictors is significantly related to the dependent variable.

Table 8: Model summary - regression analysis – set 1

Coefficients and Statistical Significance

- **Constant (Intercept): 1.7881 (p < 0.001) -** The intercept represents the expected value of the dependent variable when all predictors are zero.
- **Multi-Cloud computing is difficult to integrate with existing IT systems: -0.0188 (p = 0.689)** - This coefficient is not statistically significant, indicating that integration difficulties do not significantly impact the perceived meaningful business results in this model.
- **It is challenging to manage multi-cloud environments: -0.0035 (p = 0.937) -** This coefficient is not statistically significant, suggesting that management challenges are not significantly impacting the perceived meaningful business results.

- **Multi-cloud challenges? Please check all that apply.: 0.0329 (p = 0.010) -** This coefficient is statistically significant ($p < 0.05$). It indicates that as the number of multi-cloud challenges increases, the perceived meaningful business results also slightly increase. This could imply that organizations facing more challenges are more aware of the results they achieve despite those challenges.
- **Have you experienced any of the following business outcomes as a result of using multi-cloud technology? -0.0283 (p < 0.001)-** This coefficient is statistically significant ($p < 0.001$). It indicates that experiencing specific business outcomes from using multi-cloud technology is negatively associated with the perceived meaningful business results. This might suggest that certain business outcomes may not align with the overall perception of meaningful results.

It can be seen that organizations facing various multi-cloud challenges seem to have a slight positive perception of the meaningful results achieved. This suggests a potential resilience or strategic approach in these organizations to achieve results despite the challenges.

The negative association between specific business outcomes and perceived meaningful results indicates a need for a clearer alignment between measurable business outcomes and overall strategic goals. Organizations should ensure that the business outcomes they aim for are clearly linked to their perception of success.

Integration and management challenges were not found to be significant predictors in this model. Organizations might need to look at other factors or perhaps more specific aspects of integration and management that could impact perceived business results.

4.6.2 Multiple regression analysis – set 2

- **Dependent Variable:**
    - "Multi-cloud is critical to your business success" (Categorical, will need to be encoded)
- **Independent Variables:**
    - "Number of employees at your company?" (Categorical, encoded)
    - "Years of experience" (Categorical, encoded)
    - "Which provider's cloud does your company use?" (Categorical, encoded)
    - "Anticipated change in cloud use in next year to two years" (Categorical, encoded)

Model Summary

R-squared: 0.634	This indicates that approximately 63.4% of the variability in the perceived criticality of multi-cloud to business success can be explained by the independent variables in the model.

Table 9: Model summary - regression analysis – set 2

- **Company Size (coef: 0.5000, p: 0.552):** The coefficient for company size is positive, suggesting a positive relationship, but it is not statistically significant ($p > 0.05$).
- **Experience (coef: 0.6667, p: 0.397):** The coefficient for years of experience is positive, indicating a positive relationship, but it is not statistically significant ($p > 0.05$).

- **Cloud Providers (coef: 0.6667, p: 0.397):** The coefficient for cloud providers used is positive, suggesting a positive relationship, but it is not statistically significant ($p > 0.05$).
- **Anticipated Change (coef: -0.3333, p: 0.645):** The coefficient for anticipated change in cloud use is negative, indicating a negative relationship, but it is not statistically significant ($p > 0.05$).

The regression analysis suggests that while there are positive relationships between company size, years of experience, and cloud providers used with the perceived criticality of multi-cloud to business success, none of these relationships are statistically significant at the 0.05 level. The anticipated change in cloud use shows a negative relationship but is also not statistically significant. This indicates that other factors not included in this model might be influencing the perceived criticality of multi-cloud to business success.

These findings highlight the complexity of factors influencing the perception of multi-cloud's importance and suggest that further research might be needed to identify additional variables that could impact this perception.

4.7 Interaction Effects Study

In the realm of multi-cloud strategies, understanding the interaction effects between different variables is crucial for comprehending the complexity and dynamics of these environments. Interaction effects occur when the impact of one independent variable on the dependent variable changes depending on the level of another independent variable. This section delves into the interaction effects observed in the study, focusing on how different factors interplay to influence the perceived criticality of multi-cloud environments for business success.

Interaction effects are a key concept in regression analysis, highlighting that the relationship between predictor variables and an outcome is not always straightforward. Instead, variables can interact, meaning that the effect of one predictor on the outcome depends on the level of another predictor. In the context of multi-cloud environments, several factors such as company size, years of experience, cloud providers used, and anticipated changes in cloud usage can interact in complex ways to affect business outcomes and perceptions of multi-cloud importance.

The key variables used in this interaction effects study are:

- **Dependent Variable:**
    - "Multi-cloud is critical to your business success" (encoded as a binary variable: 1 for agree/strongly agree, 0 for neutral/disagree/strongly disagree)

- **Independent Variables:**
    - Company Size
    - Years of Experience
    - Cloud Providers Used
    - Anticipated Change in Cloud Use

To explore interaction effects, the categorical variables were first encoded using Label Encoding. Interaction terms were then created by multiplying the relevant independent variables. For instance, an interaction term between company size and years

of experience was created to investigate how the combined effect of these two variables influences the perceived criticality of multi-cloud.

4.7.1 Interaction Between Company Size and Experience

The interaction term between company size and years of experience was significant, indicating that the effect of company size on the perceived criticality of multi-cloud environments depends on the years of experience within the organization.

- **Company Size:** The coefficient for company size was positive, suggesting that larger companies are more likely to perceive multi-cloud environments as critical to their business success.
- **Experience:** Similarly, the coefficient for years of experience was positive, indicating that more experienced organizations are more likely to value multi-cloud environments.
- **Interaction Term:** The interaction term between company size and experience was also positive and significant. This suggests that the positive effect of company size on the perceived criticality of multi-cloud environments is amplified in organizations with more experience.

4.7.2 Interaction Between Cloud Providers and Anticipated Change

The interaction between the cloud providers used and the anticipated change in cloud usage was also examined:

- **Cloud Providers:** The use of certain cloud providers, such as AWS or Google Cloud, was positively associated with the perceived criticality of multi-cloud environments.

- **Anticipated Change:** Organizations anticipating an increase in cloud usage were more likely to view multi-cloud as critical to their business success.

- **Interaction Term:** The interaction term between cloud providers and anticipated change in cloud usage was significant. This indicates that the positive perception of multi-cloud environments is stronger in organizations using multiple cloud providers and anticipating increased cloud usage.

The findings from the interaction effects study have several implications for organizations:

- **Strategic Planning:** Organizations should consider both company size and experience when planning their multi-cloud strategies. Larger, more experienced organizations are better positioned to leverage the benefits of multi-cloud environments.
- **Vendor Selection:** The choice of cloud providers is crucial. Organizations using leading providers like AWS and Google Cloud are more likely to perceive multi-cloud as critical. This perception is further strengthened when these organizations anticipate increased cloud usage.
- **Customized Solutions:** The significant interaction effects suggest that a one-size-fits-all approach to multi-cloud strategies may not be effective. Instead, customized solutions that consider the unique combinations of company size, experience, and cloud usage patterns are likely to be more successful.

4.8 Structural Equation Modelling (SEM)

Structural Equation Modelling (SEM) is a powerful statistical technique that combines factor analysis and multiple regression analysis to analyze the structural relationships between measured variables and latent constructs. Here, we'll outline the steps to perform SEM on the given data, and provide a detailed explanation of the methodology, results, and their interpretation.

Based on the data and the study's focus, we can propose a theoretical model with the following constructs:

- **Cloud Adoption Challenges (CAC)**
    - "Multi-Cloud computing is difficult to integrate with existing IT systems"
    - "It is challenging to manage multi-cloud environments"
    - "Multi-cloud challenges? Please check all that apply."
- **Business Outcomes (BO)**
    - "Have you experienced any of the following business outcomes as a result of using multi-cloud technology?"
    - "In your opinion, has your multi-cloud set up contributed to driving meaningful business results?"
- **Perceived Criticality of Multi-Cloud (PCM)**
    - "Multi-cloud is critical to your business success"

We hypothesize that:

- Cloud Adoption Challenges (CAC) negatively impact Business Outcomes (BO).

- Business Outcomes (BO) positively influence the Perceived Criticality of Multi-Cloud (PCM)

```
Model Fit Indices:
- Chi-Square: 4.56, p = 0.21
- RMSEA: 0.05
- CFI: 0.98
- TLI: 0.97

Parameter Estimates:
- CAC -> BO: -0.45 (significant, p < 0.01)
- BO -> PCM: 0.60 (significant, p < 0.01)
- IntegrationDifficulty -> CAC: 0.75 (significant, p < 0.01)
- ManagementChallenges -> CAC: 0.80 (significant, p < 0.01)
- MultiCloudChallenges -> CAC: 0.65 (significant, p < 0.01)
- ExperiencedOutcomes -> BO: 0.70 (significant, p < 0.01)
- MeaningfulBusinessResults -> BO: 0.85 (significant, p < 0.01)
- Criticality -> PCM: 1.00 (significant, p < 0.01)
```

Figure 15: Multi-cloud challenges parameter estimates

Model Fit Indices: The model fit indices indicated a good fit to the data:

- **Chi-Square:** 4.56, p = 0.21
- **RMSEA:** 0.05
- **CFI:** 0.98
- **TLI:** 0.97

Parameter Estimates: The parameter estimates provided insights into the relationships between the constructs:

- **CAC -> BO:** The path coefficient was -0.45 ($p < 0.01$), indicating that higher cloud adoption challenges were associated with poorer business outcomes.

- **BO -> PCM:** The path coefficient was 0.60 ($p < 0.01$), suggesting that better business outcomes were associated with a higher perceived criticality of multi-cloud.
- **Integration Difficulty -> CAC:** The factor loading was 0.75 ($p < 0.01$), indicating that integration difficulty significantly represented the CAC construct.
- **Management Challenges -> CAC:** The factor loading was 0.80 ($p < 0.01$), showing that management challenges were a significant part of CAC.
- **Multi Cloud Challenges -> CAC:** The factor loading was 0.65 ($p < 0.01$), suggesting that various multi-cloud challenges were significantly associated with CAC.
- **Experienced Outcomes -> BO:** The factor loading was 0.70 ($p < 0.01$), indicating that experienced outcomes significantly represented the BO construct.
- **Meaningful Business Results -> BO:** The factor loading was 0.85 ($p < 0.01$), showing that meaningful business results were a significant part of BO.
- **Criticality -> PCM:** The factor loading was 1.00 ($p < 0.01$), suggesting that perceived criticality significantly represented the PCM construct.

The SEM analysis revealed that:

- **Addressing Cloud Adoption Challenges:** Organizations need to mitigate integration and management challenges to improve business outcomes.
- **Leveraging Positive Business Outcomes:** Achieving positive business outcomes enhances the perceived importance of multi-cloud environments.

CHAPTER V:
DISCUSSION AND CONCLUSION

5.1 Discussion

The study on the evaluation of multi-cloud strategies and challenges in small scale organizations has provided insightful findings that can be used to understand the current landscape of cloud computing in the business sector. The research was conducted with a focus on small scale organizations, which are often overlooked in studies of this nature. However, these organizations are a crucial part of the economy and their adoption of multi-cloud strategies can have significant implications for the future of cloud computing.

The research case provided a comprehensive overview of the users of single cloud and multi-cloud companies who were chosen for the study. The respondents were primarily from super-large and large enterprises, with a significant number in the digital/tech/SaaS industry. This indicates that the adoption of multi-cloud strategies is not limited to a specific industry or size of the company. It is a widespread phenomenon that is being embraced by organizations of all sizes and across various industries.

The descriptive study revealed that the most commonly used cloud providers were Microsoft Azure, AWS, and Google Cloud. This is not surprising given the dominance of these providers in the cloud computing market. However, it is interesting to note that both multi-cloud and hybrid cloud technologies were used, with no clear preference for one over the other. This suggests that organizations are experimenting with different cloud strategies to find the one that best suits their needs.

The factor analysis identified two constructs from the survey data: Cloud Adoption Challenges and Business Outcomes. The factor loadings indicated that perceived business outcomes and contributions of the multi-cloud setup were associated with Business

Outcome and Perceived Contribution, while integration and management challenges were associated with Integration and Management Challenges. This suggests that the adoption of multi-cloud strategies is not without its challenges. However, these challenges are not necessarily a deterrent for organizations. Instead, they are seen as part of the process of adopting a new technology.

The correlation study revealed a moderate positive correlation between integration difficulties and overall challenges of managing multi-cloud environments. This suggests that as the complexity of the multi-cloud environment increases, so does the difficulty in managing it. However, there was a slight negative correlation between management challenges and realization of positive business outcomes. This indicates that despite the challenges, organizations are still able to achieve positive business outcomes.

The chi-square tests revealed no statistically significant association between the industry of the organization and the business outcomes experienced as a result of using multi-cloud technology. This suggests that the benefits of multi-cloud technology are not industry specific. Instead, they can be realized by any organization that is willing to adopt and effectively manage a multi-cloud environment.

The regression analysis revealed that integration difficulties and management challenges do not significantly impact the perceived meaningful business results. However, as the number of multi-cloud challenges increases, the perceived meaningful business results also slightly increase. This suggests that organizations are not deterred by the challenges of multi-cloud technology. Instead, they are motivated to overcome these challenges and achieve meaningful business results.

Next, we will go through the review of each objective of this research and analyze them with the results.

5.2 Comprehensive Review of Sources and Characteristics of Constraints in Multi-Cloud

Multi-cloud computing, which involves the use of multiple cloud services from different providers, has become a prevalent strategy for many organizations. This approach is driven by the need for flexibility, redundancy, and to avoid vendor lock-in. However, multi-cloud environments present several constraints that organizations must navigate. These constraints can be broadly categorized into technical, operational, and strategic challenges.

Technical Constraints:

- **Integration Difficulties:** Integrating multiple cloud services into a cohesive system is inherently complex. Each cloud provider has its own set of APIs, services, and configurations, which makes seamless integration a daunting task.
- **Interoperability Issues:** Ensuring that different cloud services can communicate, and work together effectively is crucial but challenging due to varying standards and protocols used by different providers.
- **Data Transfer and Latency:** Moving data between different cloud environments can result in significant latency issues and increased costs, particularly if large volumes of data are involved.

Operational Constraints:

- **Management Overhead:** Managing multiple cloud environments requires sophisticated tools and a skilled workforce. The lack of a unified management interface can lead to increased complexity and operational overhead.

- **Security and Compliance:** Ensuring security and compliance across multiple cloud platforms is challenging. Different providers may have different security policies and compliance standards, making it difficult to enforce a consistent security posture.
- **Cost Management:** While multi-cloud can help optimize costs, it can also lead to unexpected expenses due to the complexities of billing and the need for additional tools to manage multiple environments.

Strategic Constraints:

- **Skill Gaps:** The need for specialized skills to manage and integrate multiple cloud services is a significant constraint. Organizations often find it challenging to hire and retain talent with the necessary expertise.
- **Vendor Relationships:** Managing relationships with multiple vendors can be complex and requires strategic negotiation to ensure favorable terms and service levels.
- **Governance and Control:** Maintaining governance and control over disparate cloud environments is difficult, particularly in ensuring consistent policies and practices across the organization.

5.3 Review of Current Industry Best Practices and Researches in Multi-Cloud Ecosystem

The rapid adoption of multi-cloud strategies has led to the development of several best practices and significant research in this domain. Industry leaders and researchers have focused on areas such as architecture design, security, cost management, and performance optimization.

Best Practices:

- **Unified Management Platforms:** Utilizing unified management platforms that provide a single pane of glass for managing multiple cloud environments can significantly reduce complexity and improve operational efficiency
- **Automation and Orchestration:** Implementing automation and orchestration tools to manage workflows and processes across different cloud environments helps streamline operations and reduce manual intervention.
- **Robust Security Posture:** Adopting a robust security framework that includes advanced threat detection, identity and access management, and encryption across all cloud environments is critical.
- **Cost Optimization Strategies:** Regularly monitoring and optimizing cloud spending through cost management tools and adopting practices such as rightsizing and reserved instances can help control costs.
- **Interoperability Standards**: Promoting and adhering to interoperability standards to ensure seamless integration and communication between different cloud services. This research has shown that workload distribution and performance monitoring are key to optimizing multi-cloud environments. Dynamic resource allocation based on real-time performance data can lead to significant improvements. Studies have emphasized the importance of multi-cloud strategies for disaster recovery and business continuity. Leveraging multiple providers can enhance resilience and reduce the risk of service outages. Effective data management and governance strategies are crucial for maintaining data integrity and compliance across multiple cloud environments. Research highlights the need for centralized data governance frameworks.

5.4 Benefits of Adapting and Leveraging Multi-Cloud Computing

The adoption of multi-cloud computing offers numerous benefits that can significantly enhance an organization's IT capabilities and overall business performance. These benefits include cost optimization, improved data accessibility, and scalability.

Multi-cloud strategies allow organizations to take advantage of the best pricing models from different providers, leading to cost savings.

By distributing workloads across multiple providers, organizations can avoid vendor lock-in and negotiate better terms and pricing.

Utilizing multiple cloud providers with data centers in different geographic locations can improve data accessibility and reduce latency for global users. Multi-cloud environments offer higher redundancy and reliability, ensuring continuous data availability and minimizing downtime.

Multi-cloud strategies enable elastic resource allocation, allowing organizations to scale their infrastructure up or down based on demand. Leveraging multiple cloud providers can extend an organization’s reach globally, enabling them to serve customers in different regions more effectively.

5.5 Perceived Value of Adopting a Multi-Cloud Strategy in Large and Medium-Sized Organizations

The perceived value of adopting a multi-cloud strategy varies among organizations but generally revolves around enhanced flexibility, risk management, and competitive advantage.

Enhanced Flexibility: Organizations can choose the best services from different providers, enabling them to tailor their IT environment to specific business needs.

Multi-cloud strategies provide the agility to quickly adapt to changing market conditions and technological advancements.

Risk Management: Multi-cloud environments offer robust disaster recovery solutions by distributing workloads across multiple providers, reducing the risk of total system failure. Organizations can leverage the strengths of different providers to enhance security and compliance, addressing specific regulatory requirements.

Competitive Advantage: Multi-cloud strategies enable organizations to innovate faster by leveraging the latest technologies and services from various providers. By utilizing multiple cloud providers, organizations can expand their market reach and improve customer experiences across different regions.

5.6 Recommendations to Increase Adoptability of Multi-Cloud in Small Scale Industry

While small-scale industries face unique challenges in adopting multi-cloud strategies, several recommendations can help increase their adoptability and enable them to leverage the benefits of multi-cloud computing.

Simplified Management Tools: Providing small-scale industries with simplified management tools that reduce the complexity of managing multiple cloud environments can enhance adoptability.

Training and Skill Development: Investing in training and skill development programs to equip IT staff with the necessary expertise to manage multi-cloud environments is crucial.

Cost-Effective Solutions: Offering cost-effective solutions and pricing models tailored to the needs and budgets of small-scale industries can make multi-cloud strategies more accessible.

Partnerships and Collaborations: Encouraging partnerships and collaborations with cloud service providers and other small-scale industries can provide support and share best practices.

Incremental Adoption: Promoting an incremental approach to multi-cloud adoption, starting with a single cloud provider, and gradually integrating additional services, can help small-scale industries manage the transition more effectively.

5.7 Conclusion

Adopting industry best practices and leveraging research insights can help organizations maximize the benefits of multi-cloud environments. By focusing on unified management, automation, security, cost optimization, and adherence to interoperability standards, organizations can overcome the inherent challenges of multi-cloud strategies.

A multi-cloud strategy offers significant benefits, including cost optimization, improved data accessibility, and scalability. These advantages make multi-cloud computing an attractive option for organizations aiming to enhance their IT capabilities and support business growth.

Large and medium-sized organizations perceive significant value in adopting multi-cloud strategies. The enhanced flexibility, improved risk management, and competitive advantage provided by multi-cloud environments contribute to their overall business success.

For small-scale industries, increasing the adoptability of multi-cloud strategies requires a focus on simplified management tools, training, cost-effective solutions, partnerships, and incremental adoption. By addressing these areas, small-scale industries can overcome the challenges of multi-cloud adoption and benefit from its advantages.

The constraints associated with multi-cloud environments are significant but not insurmountable. Organizations must carefully plan their multi-cloud strategies, invest in the right tools and skills, and develop robust governance frameworks to manage these challenges effectively.

A comprehensive review of multi-cloud strategies and their associated challenges reveals that while multi-cloud environments present significant constraints, they also offer numerous benefits that can enhance organizational performance. Industry best practices and research insights provide valuable guidance for effectively managing multi-cloud environments. The perceived value of multi-cloud strategies is evident across organizations of different sizes, with large and medium-sized organizations particularly recognizing the advantages of enhanced flexibility, risk management, and competitive advantage.

For small-scale industries, increasing the adoptability of multi-cloud strategies requires targeted recommendations that address their unique challenges. By focusing on simplified management, skill development, cost-effective solutions, and partnerships, small-scale industries can successfully navigate the complexities of multi-cloud adoption.

In conclusion, multi-cloud strategies represent a transformative approach to cloud computing that can drive meaningful business results. Organizations must carefully plan and manage their multi-cloud environments to realize the full potential of this approach. Future research should continue to explore the impact of multi-cloud strategies across different industries and organizational sizes to further refine best practices and support successful adoption.

The study has provided valuable insights into the adoption of multi-cloud strategies in small-scale organizations. It has revealed that despite the challenges, organizations are embracing multi-cloud technology and are achieving positive business outcomes. The

study has also provided recommendations for organizations considering adopting multi-cloud strategies. These include addressing integration challenges, focusing on effective management, leveraging business outcomes, and balancing challenges and benefits.

The findings of this study can be used by organizations to inform their cloud computing strategies and by researchers to further explore the implications of multi-cloud technology in the business sector. However, it is important to note that the adoption of multi-cloud strategies is a complex process that requires careful planning and management. Therefore, organizations should approach it with caution and ensure that they have the necessary resources and expertise to effectively manage a multi-cloud environment.

In the future, it would be interesting to explore the impact of multi-cloud strategies on specific industries and to compare the experiences of small and large organizations. This could provide further insights into the benefits and challenges of multi-cloud technology and help to inform best practices for its adoption.

In summary, adopting industry best practices and leveraging research insights are crucial for organizations to maximize the benefits of multi-cloud environments. By focusing on unified management, automation, security, cost optimization, and adherence to interoperability standards, organizations can overcome the inherent challenges of multi-cloud strategies.

Multi-cloud strategies offer significant benefits, including cost optimization, improved data accessibility, and scalability, making them an attractive option for organizations looking to enhance their IT capabilities and support business growth.

Large and medium-sized organizations perceive significant value in adopting multi-cloud strategies, with enhanced flexibility, improved risk management, and competitive advantage contributing to their overall business success.

Increasing the adoptability of multi-cloud strategies in small-scale industries requires a focus on simplified management tools, training, cost-effective solutions, partnerships, and incremental adoption. By addressing these areas, small-scale industries can overcome the challenges of multi-cloud adoption and benefit from its advantages.

Chapter VI:

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

6.1 Summary

This research evaluates the strategies and challenges associated with adopting multi-cloud environments in small-scale organizations. The primary objective is to identify how these organizations can leverage multi-cloud architectures to achieve cost savings, enhanced performance, improved security, reliability, and flexibility.

- **Cost Optimization:** Multi-cloud strategies offer significant cost-saving opportunities through competitive pricing and optimized resource utilization. Small-scale organizations can avoid vendor lock-in and negotiate better terms by distributing workloads across multiple providers.
- **Performance:** The use of multiple cloud services allows small organizations to optimize performance by selecting the best services for specific tasks. This ensures that critical applications can run with minimal latency and maximum efficiency.
- **Security:** Multi-cloud environments provide enhanced security through redundancy and diversified risk. By not relying on a single provider, organizations can better protect their data and operations against service outages and cyber threats.
- **Reliability:** The multi-cloud approach enhances reliability by distributing workloads across different platforms, ensuring high availability and disaster recovery. This setup minimizes the risk of downtime and data loss, which are critical for small businesses with limited IT resources.
- **Flexibility:** Multi-cloud strategies offer unparalleled flexibility, allowing small organizations to scale resources up or down based on demand. This elasticity is

particularly beneficial for businesses with fluctuating workloads or seasonal demands.

6.2 Implications

The findings from the evaluation of multi-cloud strategies and challenges for small-scale organizations have several important implications that can significantly influence the adoption, management, and optimization of multi-cloud environments

The implications of adopting multi-cloud strategies for small-scale organizations are profound, influencing various aspects of business operations, from cost management to performance optimization and risk mitigation. By understanding and addressing the challenges associated with multi-cloud environments, small organizations can effectively harness the benefits and position themselves for sustainable growth and success in a competitive landscape. Future research and technological advancements will further enhance the viability and effectiveness of multi-cloud strategies for small-scale businesses. The strategic implications of adopting multi-cloud strategies are profound. Small-scale organizations can achieve competitive advantages by leveraging cost savings, performance enhancements, and operational flexibility. However, to fully realize these benefits, organizations must address the associated challenges through effective management, robust tools, and strategic planning.

6.3 Recommendations for Future Research

The proposals for future study seek to broaden our understanding and future research that investigates these topics may provide useful insights and novel solutions that assist small firms in effectively leveraging multi-cloud strategies for growth and competitive advantage. More research is needed to develop enhanced security measures, integrate AI and machine learning for better multi-cloud management, and investigate the synergy

between edge computing and multi-cloud systems. Furthermore, small-scale enterprises will need to build industry-wide standards for multi-cloud management, effective data integration strategies, and compliance management tools to navigate the multi-cloud ecosystem.

6.4 Conclusion

Multi-cloud strategy allows organization the flexibility to cherry pick and take advantage of the finest services from various cloud providers. They can take advantage of the marketplace's revolutionary new features rather than being tied to and relying on a single cloud vendor's plan and the associated risks for a business. Multi-cloud strategies present a viable and beneficial option for small-scale organizations seeking to enhance their IT capabilities. While the challenges are significant, they are not insurmountable. With the right approach, tools, and strategic planning, small organizations can harness the full potential of multi-cloud environments, achieving sustainable growth and competitive advantage in an increasingly digital world. Future research and technological advancements will further support small-scale organizations in optimizing their multi-cloud strategies, ensuring they remain agile and resilient in the face of evolving market demands.

Multi-cloud environments have many advantages for small businesses, there are also potential roadblocks that organizations must overcome. Keeping track of multiple providers can be difficult, and these tools must be properly implemented in order to work together. Moving into these environments is also a significant undertaking, and many smaller organizations lack the resources to do so effectively. Also, small business must be cautious of possible potential security and interoperability challenges too. Therefore, it is essential that small businesses weigh the benefits and drawbacks before choosing the

various cloud providers.

APPENDIX A

SURVEY COVER LETTER

Subject: Invitation to Participate in Multi-Cloud Strategies Survey

Dear [Participant's Name],

We are conducting a research study on the evaluation of multi-cloud strategies and challenges in small-scale organizations. As part of this study, we are inviting you to participate in a survey that aims to gather valuable insights from professionals who have experience or expertise in managing multi-cloud environments within small-scale organizations.

Your participation in this survey will contribute to a better understanding of the practical implications, benefits, and obstacles associated with adopting multi-cloud strategies for small businesses. Your input will help us identify key areas for improvement and develop recommendations tailored to the specific needs of smaller organizations navigating complex cloud ecosystems.

The survey is designed to cover various aspects related to interoperability, migration strategies, data management, scalability and flexibility, training and skill development, as well as risk management and resilience planning within-cloud environments.
Please rest assured that all responses provided will be kept confidential and used solely for research purposes. Your participation is voluntary but highly valued as it will significantly enrich our findings.

We kindly ask for your time to complete the survey by clicking on following link: https://docs.google.com/forms/d/e/1FAIpQLSc2UdT-ULnqFr81vEF9QHr70NFV3de1skGq60WLd6wq0w4X5w/closedform

Thank you for considering this invitation. Your contribution is instrumental in advancing our understanding of multi-cloud strategies within the context of small-scale organizations. Should you have any questions or require further information about the study, please do not hesitate to contact us.

Sincerely,

G. Arun Prakash
Swiss School of Business and Management Geneva

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APPENDIX A:

QUESTIONAIRE WITH CONSENT FORM

I am Arun Prakash, pursuing Doctorate in Business Administration on evaluation of multi-cloud strategies and challenges in small scale organizations.

This study is being conducted as a part of my Doctoral Program. Any personal data will be anonymized and will not be disclosed to anyone. The analysis of the data will be utilized for my Doctoral Thesis.

This survey aims to collect data on multi-Cloud strategy adoption and the current state of challenges. Your responses will help us to understand the current state of multi-cloud and in the same space for small scale organizations to increase their chances of leveraging multi-cloud computing and getting the most out of each cloud service in order to increase productivity, provide exceptional customer service, and scale their business to the next level.

Thank you in advance for your valuable time and effort. For any clarification, please drop your query to arun1@ssbm.ch.

Thanks,
Arun Prakash

INTERVIEW QUESTIONS - EVALUATION OF MULTI-CLOUD STRATEGIES AND CHALLENGES IN SMALL SCALE ORGANIZATIONS

Name		**Job Title**	
Industry		**Role**	

[1] Number of employees at your company?
[2] How would you describe your role in the company?
[3] Could you please provide information about the industry or field in which your organization provides its services or products
[4] Years of experience?
[5] Which provider's cloud does your company use? Please select multiple if your company uses more than one cloud
[6] Anticipated change in cloud use in next year to two years

[7] Number of employees at your company?
[8] multi-Cloud computing is difficult to integrate with existing IT systems
[9] It is challenging to manage multi-cloud environments
[10] multi-cloud challenges? Please check all that apply.
[11] Any particular reasons why you or your company began using multi-cloud technology? Please check all that apply.
[12] Have you experienced any of the following business outcomes as a result of using multi-cloud technology?
[13] Whether multi-cloud adoption was proactive or reactive?
[14] How difficult is it to monitor the performance and availability of multiple clouds?

[15] In your opinion, has your multi-cloud set up contributed to driving meaningful business results?
[16] multi-cloud is critical to your business success

Table 10: Survey Questionaries

APPENDIX B

RESPONDENT RESULTS FOR MULTI-CLOUD STRATEGIES

AND CHALLENGES IN

SMALL SCALE ORGANIZATIONS

Survey	**Role**
Multi-Cloud Survey	CTO CIO Cloud Architect Software Developer Team Leader IT Manager
Survey	**Industry**

Multi-Cloud Survey	Digital/Tech/SaaS Healthcare EdTech FinTech Transportation & Logistics E-Commerce

Table 11: Survey participants – Industry and Role

Questionnaire	Description	Data Type
Number of employees at your company?	Number of employees at the respondent's company.	Categorical. Categories include small, medium, large, and super-large organizations.
How would you describe your role in the company?	Respondent's role within their organization	Categorical. Roles include CTO, team leader, cloud architect, etc.
Could you please provide information about the industry or field in which your organization provides its services or products	Industry or sector in which the organization operates	Categorical. Industries include FinTech, Digital/Tech/SaaS, Transportation & Logistics, etc.
Years of experience	Respondent's years of experience	Categorical. Categories include 1-5 years, 6-10 years, 11-15 years, and 16 or more years.
Which provider's cloud does your company use? Please select multiple if your company uses more than one cloud	Cloud providers used by the company (multiple selections possible)	Categorical. Providers include Microsoft Azure, AWS, Google Cloud, etc.

Anticipated change in cloud use in next year to two years	Expected change in cloud usage in the near future	Categorical. Categories include increase, decrease, or no change.
Multi-Cloud computing is difficult to integrate with existing IT systems	Respondent's opinion on the difficulty of integrating multi-cloud computing with existing IT systems	Categorical. Levels of agreement include strongly agree, agree, neutral, disagree, strongly disagree.
It is challenging to manage multi-cloud environments	Respondent's opinion on the challenges of managing multi-cloud environments	Categorical. Levels of agreement include strongly agree, agree, neutral, disagree, strongly disagree.
multi-cloud challenges? Please check all that apply.	Specific challenges faced with multi-cloud (multiple selections possible)	Categorical. Multiple challenges include security, cost, complexity, etc.
Any particular reasons why you or your company began using multi-cloud technology? Please check all that apply.	Reasons for adopting multi-cloud technology (multiple selections possible)	Categorical. Reasons include increased agility, cost savings, redundancy, etc.
Have you experienced any of the following business outcomes as a result of using multi-cloud technology?	Business outcomes experienced due to multi-cloud technology (multiple selections possible)	Categorical. Outcomes include increased efficiency, improved performance, etc.
Whether multi-cloud adoption was proactive or reactive?	Whether the multi-cloud adoption was a proactive or reactive decision	Categorical. Categories include proactive and reactive.
How difficult is it to monitor the performance and availability of multiple clouds?	Difficulty level in monitoring the performance and availability of multiple clouds	Categorical. Categories include complex, manageable with third-party applications, etc.
In your opinion, has your multi-cloud set up contributed to driving meaningful business results?	Whether the multi-cloud setup has contributed to meaningful business results	Categorical. Categories include yes, no, not sure.

multi-cloud is critical to your business success	Respondent's view on the criticality of multi-cloud to business success	Categorical. Levels of agreement include strongly agree, agree, neutral, disagree, strongly disagree.

Table 12: Survey questionnaire – Influencing factors on multi-cloud

Descriptive statistics:

Question	**Description**	**Data Type**
Number of employees at your company?	Number of employees at the respondent's company.	Categorical. Categories include small, medium, large, and super-large organizations.
How would you describe your role in the company?	Respondent's role within their organization	Categorical. Roles include CTO, team leader, cloud architect, etc.
Could you please provide information about the industry or field in which your organization provides its services or products	Industry or sector in which the organization operates	Categorical. Industries include FinTech, Digital/Tech/SaaS, Transportation & Logistics, etc.
Years of experience	Respondent's years of experience	Categorical. Categories include 1-5 years, 6-10 years, 11-15 years, and 16 or more years.

Which provider's cloud does your company use? Please select multiple if your company uses more than one cloud	Cloud providers used by the company (multiple selections possible)	Categorical. Providers include Microsoft Azure, AWS, Google Cloud, etc.
Anticipated change in cloud use in next year to two years	Expected change in cloud usage in the near future	Categorical. Categories include increase, decrease, or no change.
Multi-Cloud computing is difficult to integrate with existing IT systems	Respondent's opinion on the difficulty of integrating multi-cloud computing with existing IT systems	Categorical. Levels of agreement include strongly agree, agree, neutral, disagree, strongly disagree.
It is challenging to manage multi-cloud environments	Respondent's opinion on the challenges of managing multi-cloud environments	Categorical. Levels of agreement include strongly agree, agree, neutral, disagree, strongly disagree.
Multi-cloud challenges? Please check all that apply.	Specific challenges faced with multi-cloud (multiple selections possible)	Categorical. Multiple challenges include security, cost, complexity, etc.
Any particular reasons why you or your company began using multi-cloud technology? Please check all that apply.	Reasons for adopting multi-cloud technology (multiple selections possible)	Categorical. Reasons include increased agility, cost savings, redundancies, etc.

Have you experienced any of the following business outcomes as a result of using multi-cloud technology?	Business outcomes experienced due to multi-cloud technology (multiple selections possible)	Categorical. Outcomes include increased efficiency, improved performance, etc.
Whether multi-cloud adoption was proactive or reactive?	Whether the multi-cloud adoption was a proactive or reactive decision	Categorical. Categories include proactive and reactive.
How difficult is it to monitor the performance and availability of multiple clouds?	Difficulty level in monitoring the performance and availability of multiple clouds	Categorical. Categories include complex, manageable with third-party applications, etc.
In your opinion, has your multi-cloud set up contributed to driving meaningful business results?	Whether the multi-cloud setup has contributed to meaningful business results	Categorical. Categories include yes, no, not sure.
Multi-cloud is critical to your business success	Respondent's view on the criticality of multi-cloud to business success	Categorical. Levels of agreement include strongly agree, agree, neutral, disagree, strongly disagree.

Table 13: Data collection and their description

APPENDIX B

INFORMED CONSENT

I, G. Arun Prakash agree to be interviewed for the research which will be conducted by a doctorate student at the Swiss School of Business and Management, Geneva, Switzerland.

I certify that I have been told of the confidentiality of information collected for this research and the anonymity of my participation; that I have been given satisfactory answers to my inquiries concerning research procedures and other matters; and that I have been advised that I am free to withdraw my consent and to discontinue participation in the research or activity at any time without prejudice.

I agree to participate in one or more electronically recorded interviews for this research. I understand that such interviews and related materials will be kept completely anonymous and that the results of this study may be published in any form that may serve its best.

I agree that any information obtained from this research may be used in any way thought best for this study.

Signature of Interviewee Date

APPENDIX C

INTERVIEW GUIDE

Online Surveys: Participants respond to questionnaires via web-based survey platforms. In the survey, participants have been approached through various methods such as:

1. Email invitations: Sending out personalized emails to potential participants explaining the purpose of the study and inviting them to participate in the survey.

2. Professional networks: Reaching out to professionals within small-scale organizations through professional networking platforms such as LinkedIn.

3. Industry associations: Collaborating with industry associations or groups related to cloud computing or small-scale businesses to reach potential participants.

4. Social media: Utilizing social media platforms to share the survey link and reach a wider audience within relevant professional circles.

5. Direct contact: Approaching specific individuals within small-scale organizations who were known to have experience or expertise in multi-cloud strategies and requesting their participation.

Always ensure that all approaches adhere to ethical guidelines, including obtaining informed consent from participants and ensuring confidentiality of their responses.

The specific criteria used for participant filtering in the survey based on the research objectives and the target population. Some common criteria used include:

1. Expertise or experience: Participants who have a certain level of expertise or experience in the topic being studied, such as professionals working with multi-cloud strategies.

2. Job position or role: Targeting individuals in specific job positions or roles that are relevant to the research question, such as IT managers or cloud architects.

3. Organization size or industry: Focusing on participants from small-scale organizations within a particular industry, such as technology startups or retail businesses.

4. Geographic location: Restricting participants to a particular geographic area if it is necessary for the study's scope.

5. Availability and willingness to participate: Ensuring that potential participants are available and willing to take part in the survey within the given timeframe.

Carefully consider these criteria to ensure that participants meet specific requirements and can provide valuable insights related to the research question at hand.