International Journal of Emerging Trends in Computer Science and Information Technology
ISSN: 3050-9246 | https://doi.org/10.56472/ICCSAIML25-116
Eureka Vision Publication | ICCSAIML'25-Conference Proceeding

Original Article

Multi-Cloud FinOps: AI-Driven Cost Allocation and Optimization Strategies

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Abstract - *While organizations are still chugging along the fast lane of technology evolution, they are also choosing a multi-cloud strategy to address their evolving and complex business needs. Multi-cloud is the use of services from various cloud providers (e.g., Amazon Web Services (AWS), Microsoft Azure, and Google Cloud), which offers flexibility, resilience, and performance optimization. However, managing and optimizing costs across multiple cloud environments is one of the biggest challenges organizations are facing. As cloud adoption increases, organizations are looking for ways to manage cloud costs efficiently while using resources optimally. Financial Operations (FinOps) is emerging as a key practice that is increasingly helping organizations manage cloud costs effectively. Cloud FinOps is a financial discipline and a cultural practice that seeks to bring together finance, engineering, and operations. It is focused on cross-functional collaboration in cloud spending to help optimize cloud resources, understand cloud costs, and drive financial accountability for the cloud. Cost allocation and Optimization-driven approach leveraging AI for FinOps in multi-cloud. Machine Learning, Predictive Analytics and Anomaly Detection-based AI technologies can be used for Cloud financial management. It discusses the tools/platforms available for multi-cloud FinOps and how AI can be integrated with them to automate activities like cost allocation, usage forecasting, optimization etc. It also discusses why the paper emphasizes the difficulties organizations encounter in implementing AI-based FinOps strategies, including data integration issues, model complexity, and organizational inertia. Justifying the need for such AI-based FinOps for enterprises operating in a multi-cloud, this article presents relevant literature, case studies and real-world examples. It also covers what lies ahead in cloud financial operations and how the convergence of technology evolutions, like AI and the cloud, will drive the future state of cloud cost management for the enterprise.*

Keywords - *Cloud Resource Optimisation, Multi Cloud Environnement, Financial Accountability, Finops Strategies, Data Integration.*

1. Introduction

1.1 Definition of FinOps

FinOps, or Financial Operations, is a set of cultural and operational practices that, when combined, enable the effective financial management of cloud resources; perhaps with the rise of cloud computing, companies leveraging cloud providers such as the likes of Amazon Web Services (AWS), Microsoft Azure and Google Cloud for their computing, storage and networking needs. Although these cloud services offer efficiency and scalability, the complexity of pricing models, usage-based costs, and billing mechanisms that cloud computing introduces can generate a model that is difficult to manage without an equally systems-based financial oversight infrastructure.

FinOps enables most of the finance, operations, and engineering teams in any organization to come together for this common goal. It is a practice that promotes collaboration between departments that would otherwise be siloed and single-minded in a way that helps ensure cloud resources are being used effectively and cost-efficiently. FinOps is about helping bring this same level of transparency, accountability, and control to how we manage cloud costs, but without losing all the speed and agility that is made possible by the cloud.

FinOps is really more of an optimization process and is less about tracking costs; rather, it is about using data to make decisions and drive collaboration to maximize your return on investment in the cloud. It does this by aligning financial governance, resource allocation strategies and operational best practices. But lately, the process has also kind of extended with various kinds of automation tools, and even AI that actually help to visualize the cloud financial management and help cloud cost optimization to make it better.

Table 1. Overview of FinOps Elements

Element	Description
Cost Allocation	Determining how cloud resources are billed to various business units or projects.
Resource Optimization	Ensuring that cloud resources are being used efficiently to reduce waste.
Collaboration	Involving finance, operations, and engineering teams to manage cloud expenses.
Automation	Leveraging AI and automation to streamline cloud financial management processes.

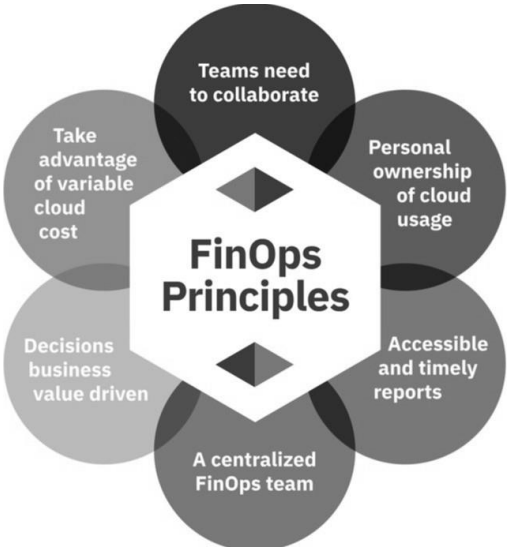

Figure 1. Finops Principle

1.2 The Rise of Multi-Cloud Environments

As organizations migrate more and more of their applications to the cloud, many are taking the step of leveraging a multi-cloud model, using services from more than one cloud provider. A multi-cloud strategy allows businesses to discover vendor locks, boost performance, and spread the workload across various platforms. Cloud computing towards multi-cloud also allows businesses to engage in a multi-faceted scheme with cloud service providers for specific purposes (Google Cloud for big data processing, AWS for computing, Azure for hybrid cloud solutions), aligning cloud usage with business needs (price, flexibility, reliability, etc.).

At the same time, though, a multi-cloud strategy creates unique challenges — especially when it comes to managing costs. Pricing is different for each cloud provider in terms of pay-as-you-go and reserved pricing. The models vary among the different service types, like compute instances, storage, and network services. Organizations utilizing many providers have to track, allocate, and optimize costs across various platforms.

Contrary to what happens in a single cloud ecosystem, in a multi-cloud environment, cost allocation is not easy. For this, the organization needs to keep track of what is being consumed where through their providers and add them on the fly to their corresponding tags, business units or projects. This usually requires advanced tools with the ability to collate data from multiple sources and give real-time visibility into spending. These tools prevent organizations from over-provisioning or missing out on potential savings when an organization's resources are efficiently utilized on the appropriate cloud provider.

Table 2. Advantages of Multi-Cloud Strategy

Advantage	Description
Flexibility	Using multiple providers for different services and geographies.
Cost Optimization	Ability to choose the most cost-effective provider for different workloads.
Risk Mitigation	Avoiding over-reliance on a single provider by distributing risk across multiple cloud platforms.
Performance Enhancement	Leveraging the strengths of each cloud provider for specific use cases (e.g., GPU-powered instances on AWS, big data services on Google Cloud).

Figure 2. Security Considerations in a Multi-Cloud World

1.3 Challenges in Cost Management in Multi-Cloud Environments

Multi-cloud has introduced many complexities in relation to cloud cost management and has created some challenges. The pain points range from lack of transparency on billing, also trouble aligning to the correct business units or project costing.

Here are some of the common pain points from a multi-cloud cost management perspective:

Diverse pricing models: The service levels for each cloud provider has a difference in pricing model. So for example, AWS and Azure and Google Cloud all have different prices for compute, different prices for storage and network bandwidth. The absence of standardized pricing models and this ambiguity not only complicates comparison between providers, but also for organizations to ascertain on which provider the separate workloads will run.

Data Visibility and Transparency: As organizations have to manage numerous cloud providers, it has become nearly impossible for organizations to have visibility and transparency on their overall cloud expenditure. Billing information from other providers is often in siloes, contained in separate reports, and not updated in real time. Lack of visibility into cloud cost data results in missed savings opportunities along with increased costs.

This could be due to several reasons in general: Manual Cost Tracking: Many organizations track their cloud costs with manual processes, flagging in spreadsheets or simple cloud cost management tools. In the cloud landscape, such approaches are slow, error-prone and do not scale in the case of larger, more complex environments. This often leads to organizations struggling to accurately track and manage cloud costs.

Fuzzy Logic in Resource Allocation and Optimization: Many times external organisations do not track the proper allocation of available resources across the business units or departments after it crosses a particular threshold. This is usually material inefficient, where departments may be underutilizing cloud and some departments might be over-utilizing cloud, increasing their costs. Moreover, dormant or suboptimal resources unused compute instances or storage volumes, for instance result in continual charges without contributing value to the organization.

Multi-Cloud Environments: If there are complexities with cloud costs, the situation worsens when organizations are in a multi-cloud environment. They need to ensure correct tagging and tracking so that resources used across multiple providers are appropriately allocated to the relevant departments or projects. This is particularly problematic in cases where resources are pooled or when billing details are decentralized between suppliers.

Table 3. Challenges in Multi-Cloud Cost Management

Challenge	Description
Inconsistent Pricing Models	Different providers use different cost structures and pricing models, making cost comparison difficult.
Resource Visibility	Difficulty in tracking cloud resources spread across multiple providers.
Data Integration	Managing and integrating data from various cloud platforms into a unified financial dashboard.

1.4 The Role of AI in Multi-Cloud FinOps

Artificial Intelligence (AI) has proven to be one of the best tools to reap the solutions for most of the challenges posed by multi-cloud cost management. Using machine learning, predictive analytics, and automation, AI allows organizations to make better, more informed, data-based decisions regarding their cloud resources. They help automate the cost allocation process for an organization, enhance resource optimization, forecast future cloud spending, and identify saving opportunities.

Cloud financial operations increasingly parallels automated practices from AI/rulesbased solutions to do a lot of the manual labor of the operation. Machine learning algorithms, for example, can review past usage data to find patterns in cloud consumption, anticipate future use trends, and recommend more cost-effective resource distributions. This reduces the need for manual intervention and allows finance and engineering teams to focus on higher value activities like strategic planning and decision-making.

AI can help in getting better cost allocations. Dynamic Pricing: AI tools can calculate real-time resource usage in a multi-cloud approach and automatically bill the costs to relevant departments or projects. This eliminates the inaccuracies associated with manual cost allocation, ensuring that no one department is charged more for what it uses. AI Tools can also enable live reporting of Cloud costs, thus giving visibility to an organization on their spend and the ability to adjust accordingly.

AI can also improve the optimization of cloud resources. AI can help to highlight areas where resources may be underutilized for instance, it can identify idle compute instances or unused storage volumes by analysing usage patterns. It is then able to suggest that you scale down or even stop using those resources to manage costs or move the workloads to other cloud providers that provide their service at a lower price point. AI algorithms can also assist with lower cloud costs by

recommending not only the best pricing models based on expected usage predictions, from pay-as-you-go to reserved instances or spot pricing for specific workloads.

Moreover, by analysing historical data, AI can also help to improve cloud cost forecasting which essentially allows you to predict future spending trends. These predictions can help companies budget their clouds accurately, making it simpler to catch potential excess spending before it strikes. These companies are trained on data that reach back until October in 2023.

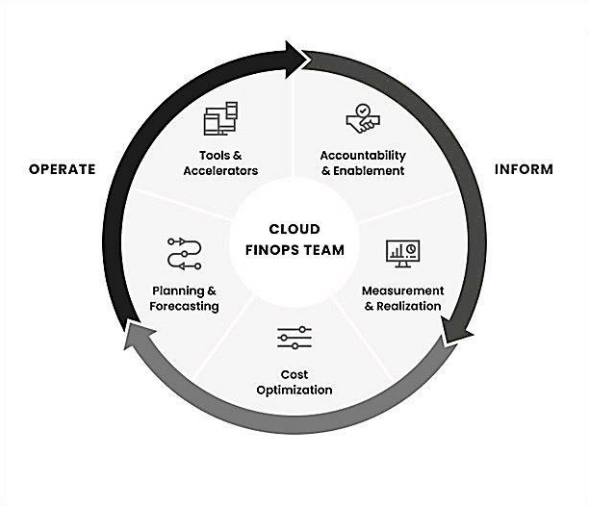

Figure 3. Cloud Finops

1.5 The Future of AI-Driven FinOps in Multi-Cloud Environments

The role of AI in multi-cloud FinOps is still evolving, but its potential is immense. As AI technologies continue to advance, organizations will gain even more sophisticated tools for managing cloud costs. Future developments in AI-driven FinOps may include:

- Advanced Predictive Analytics: As machine learning models become more sophisticated, they will be able to predict future cloud costs with greater accuracy, factoring in variables such as market trends, seasonal usage spikes, and external economic factors.
- AI-Powered Resource Allocation: AI may evolve to automatically allocate cloud resources in real-time based on workload requirements and cost considerations, optimizing resource usage without human intervention.
- Enhanced Integration Across Providers: Future AI tools may provide deeper integration across multi-cloud platforms, allowing organizations to gain a unified view of their cloud expenses and more easily compare pricing and resource usage across providers.
- Real-Time Optimization: AI may become capable of making real-time decisions about resource allocation, dynamically adjusting cloud resources based on demand to minimize costs and maximize performance.

With a rapidly growing market presence, it is someone [Golkow] thinks will become more important as organizations continue to adopt more multi-cloud strategies as AI and FinOps ensure cost optimization, financial accountability, and operational efficiency in the cloud. Thus, these AI-driven solutions will empower organizations to automate the management of their cloud expenses, provide transparency and facilitate collaboration between finance and technical teams, and drive smart, cost-effective decisions in the multi-cloud era.

2. Literature Review

FinOps as a practice has grown with the same complexity and scale that cloud computing environments have." With enterprises shifting more workloads to the cloud, one of the biggest challenges they face is managing costs. This article explores the evolution of FinOps, the incorporation of AI into the cloud cost management field, and the impact AI will have on optimizing financial operations across multi-cloud environments. Existing tools are explored along with recent research with an emphasis on the potential of AI to address issues faced in cloud financial management.

2.1 Evolution of FinOps Practices

FinOps principles were first introduced when organizations started to see the need for financial management to catch up with a cloud-first approach. Cloud computing was initially adopted because of its flexibility, scalability and performance advantages. But these advantages also had a cost variable, and frequently high, costs. Cloud pricing is dynamic, varying according to resource usage patterns, provisioning and de-provisioning of components, as well as cloud vendor pricing models, all of which made traditional financial models inadequate. Kander et al. found that the level of clinical diversification

was subject to scrutiny. Janssen et al. (2020) found that in 2020, the early state of cloud financial management was characterized by a disconnect between finance and technical teams, which impaired cost optimization.

It means that as cloud adoption progressed, so did the complexity of managing resources across multiple providers. As organizations adopted Cloud Computing, they were facing operational and financial challenges, which led to a need for FinOps framework, which brought together finance, operations, and engineering teams to develop a way to centralize usage around the way the organization could view its cloud spending. According to industry experts from (2021) Gartner, FinOps practices help enterprises build greater cost transparency, fostering trust-based decision-making and ultimately better forecasting with less risk of unexpected spend in the cloud.

In the subsequent years, FinOps evolved further with a focus on automation and process optimization. Cloud Management Platforms (CMP) such as Apptio and Cloud Health specialized on enhancing and broadening the FinOps scope by providing the insights for cost and usage visibility alongside comprehensive visibility of costs and recommended actions for optimization of resources. They offered the finance team detailed reports, identification of spending trends, visibility, and segmentation of cloud costs against specific departments or business units. Tarif Abuba: At that time those tools were performing really well but, there was still some limitations with the scalability, and manage the efficiency of Data Processing.

Table 4. Phases in the Evolution of FinOps

Phase	Description
Ad-Hoc Management	Initial stage with no formalized process. Departments handle costs independently without central oversight.
Integration	Introduction of shared responsibility and cooperation between finance and technical teams.
FinOps Framework	Formalization of processes, tools, and best practices for collaborative cloud financial management.

2.2 Current AI-driven Approaches in Cloud Cost Management

Is AI the Future of Cloud Cost Management? AI algorithms can sift through enormous data sets in seconds, find correlations, and predict outcomes in ways that it would be virtually impossible for humans to figure out by hand. AI is merely a technology that cloud cost automation can leverage to manage the cloud. AI-powered tools can also be used to detect inefficiencies and can also suggest corrective actions such as resizing underutilised resources or moving workloads to lower-cost providers.

A key study by Lee et al. (2020), focused on machine learning applied to predicting costs for cloud environments. AI can analyse past usage data to predict future cloud costs and shine a light on potential overspend. Similarly, such models can anticipate changes in workload patterns enabling the organization to adjust resource allocation proactively. As organizations seek to better align cloud spending with business imperatives, predictive cost optimization models are proving their worth in cloud financial operations. AI also contributes significantly to anomaly detection in a cloud cost management system. Cloud usage data is inherently fuzzy, and pinpointing anomalies in spending can prove challenging.

AI tools excel in unsupervised learning, hence can immediately identify and highlight abnormal spikes in cloud resource usage, making potential cost overruns apparent before becoming a snowballing problem. This early warning system also allows teams to detect and solve problems early on thus avoiding expensive surprises. Research by Patel et al. According to the work of (2021), one of the more explicit functionalities of AI in cloud management tools, such as Cloud Health and Apptio, is employing machine learning model to assist in anomaly detection by automatically identifying anomalous billing behaviour and suggesting optimizations.

Table 5. AI Techniques in Cloud Cost Optimization

AI Technique	Description
Predictive Analytics	Using historical data to predict future cloud resource usage and costs.
Optimization Algorithms	Machine learning models that optimize resource allocation based on usage patterns.
Natural Language Processing (NLP)	Analysing unstructured data (such as invoices) using NLP to extract relevant financial data for cost allocation.

2.3 The Role of AI Technologies

Which could be ML, NLP, optimization algos etc., all playing a warmer role in this making. The defining benefit of these applications would be on more effective cost allocation, resource optimization, and predictive analysis. For instance, data even goes through a machine learning system used to examine previous data, identify patterns, and estimate future costs. In addition to that, it helps to resort to managing the resource based on usage patterns. This helps in avoiding over-provisioning, and the cloud resources get utilized optimally which reduces wastage.

Multi-cloud environments are also another hurdle to SMEs due to the multitude of billing systems to manage, AI technologies help overcome this hurdle too. The billing systems of popular cloud providers are not as easy to integrate with. This is where AI-powered tools can step in to fill these gaps by aggregating data from multiple providers and offering a holistic

view of cloud expenditure. Furthermore, this mode of billing data aggregation for different cloud providers has also contributed to organizations with better cost transparency, giving them the ability to track accurate cost attribution between multiple business units or projects (Brown & Zhang, 2021).

AI based predictive analytics models are also critical in understanding trends related to cloud spending. These models help businesses to project the cloud spend as well as decision-making using external factors such as industry trends and expected usage growth. Research by Smith et al. According to (2020), predictive analytics in AI-powered tools can lead to up to 40% more accurate predictions, helping the organizations allocate their budgets accordingly.

2.4 Challenges and Opportunities

AI-driven cloud cost management has come a long way since then, but these technologies still face integration challenges. Until organizations can pull data from those sources, the biggest pain point may be integrating it across multiple cloud providers (particularly when it comes to reconciling billing information across multiple platforms). Moreover, AI algorithms can be complex and require a level of expertise to implement effectively, which can hinder wide-spread adoption in some organizations. The evolution of AI technologies also brings with it the potential for even further optimization in cost allocation and resource utilization, but solutions need to become more palatable in terms of integration into existing FinOps frameworks.

The good news is, by practicing AI in the real world, we also see several in-depth case studies proving its effectiveness in a multi-cloud environment. With many organizations leveraging AI-driven cost management tools, studies analysing the long-term effects of adopting these systems on cloud financial management are still few and far between. The case studies which will be formulated will be identifying how can we leverage AI for cost optimization of Cloud Infrastructure and showing some apparent metrics for the improvement in the overall financial landscape.

3. Multi-Cloud Ecosystem

3.1 Overview of Major Cloud Providers (AWS, Azure, Google Cloud)

This section will explore the key players in the cloud space, highlighting their cost models, pricing structures, and unique offerings.

Table 6. Key features of major cloud provides

Provider	Key Features	Cost Allocation Model
AWS	Compute, Storage, AI, and Analytics	Pay-as-you-go, Reserved
Microsoft Azure	Hybrid Cloud, Enterprise Integrations	Pay-as-you-go, Reserved
Google Cloud	AI, Big Data, Multi-Cloud Management	Pay-as-you-go, Committed

3.2 Cost Allocation Models in Multi-Cloud Environments

The principles of cost allocation in a multi-cloud environment include the ability to track costs across multiple platforms and allocate those costs appropriately to departments or projects. For this, sophisticated tools which can bring together billing from multiple cloud providers and deploy AI-driven models to more accurately allocate costs are required.

3.3 Building Multi-Cloud Infrastructure for AI

Cloud Health and similar AI-enabled tools allow firms to understand their cloud spending across multiple platforms in real time. It enables teams to assign costs in real-time and realign resources for expense reduction.

4. AI-Driven Cost Allocation

One such critical function that AI-powered roots is cost allocation that comes as a streamlined yet efficient financier through multi-cloud platforms. Cost Allocation Today Prescriptive Approach with no Human Era and Limited ScalabilityThe traditional approaches to cost allocation process is either manual or non-scientific or cloud native In contrast, AI technologies like machine learning algorithms and predictive analytics can automate and optimize this process, allowing organizations to map their cloud costs to specific business units, projects, or departments with far greater accuracy.

Supervised learning ML models can look for patterns in historical data on cloud usage and nuanced trends to make better classification on costs. They can implement run-time cost allocation, which continuously monitor and adjust allocations based on real-time resource consumption, charging departments based on actual costs rather than assumed allocation. Another example could be AI monitoring underutilized resources or the demand shift to dynamically allocate and display the charges assigned for cost transparency.

AI-based cost allocation systems are also built to aggregate data from multiple cloud providers, enabling businesses to manage spending effortlessly in the increasingly multi-cloud age. AI tools can also pull data from multiple platforms like AWS, Azure or Google Cloud into a single pane, aggregating cloud spend and streamlining tracking and cost management for finance teams across all services. Training data Byte by Byte Your financial statements, cash flow, and management accounting

reflect not only the impact of directly recognizable costs but also indirect costs that cannot be attributed in the early stages, such as inventory, suggest this visual representation of costs.

4.1 How AI Can Enhance Cost Allocation in Multi-Cloud

By analysing data in real-time, AI can provide a fair distribution of resources in multi-cloud environments and predict how they will be used. Machine learning algorithms may be trained to locate underutilized resources, and suggest optimal methods for resourcing.

4.2 AI Techniques Utilized in Cost Allocation

Some of the AI techniques that can be thrown in for cost allocation are machine learning, predictive analytics, natural language processing (NLP), etc. They allow organizations to automate cost allocation processes and enhance resource utilization.

5. AI-Driven Cost Optimization

When combined with advanced algorithms, these optimization techniques allow businesses to take maximum advantage of optimized use of resources in a multi-cloud environment with the least wastage through AI-based cost optimization. One of the fundamental advantages of AI for Cloud cost optimization is, identifying underutilized resources. With the help of machine learning models, AI can monitor the usage patterns of cloud resources over time and detect all the instances or services that might be under-utilized. For instance, an AI may flag idle or sitting storage volumes or virtual machines as storages that are so it may even suggest the same to be downsized, paused or terminated altogether, to shed off unnecessary costs.

Predictive cost optimization AI can be used to forecast future cloud consumption and anticipate spending with approximate accuracy based on historical data and trend analysis. Not only do these models better predict future costs, they suggest what changes can be made proactively, such as moving workloads across cloud providers to achieve lower costs, or optimize pricing models (e.g., choosing reserved instances over pay-as-you-go). And it allows businesses to budget for the cloud more manageably, so they can dodge shocks like uncalled-for, inflated costs.

Furthermore, AI-based dynamic resource allocation allows better cloud performance with reduced costs. AI tools can automate putting the right scaling in place for cloud resources based on real-time demand, ensuring that the organization does not spend excessive amounts of money on high-usage periods and over-commit resources during low-usage periods. Through the application of AI to "infuse" the balance between performance and cost in the environment, organizations have the opportunity to make significant savings while also maintaining the ideal state for cloud performance. In summary, AI-enabled cost optimization allows companies to make better data-based choices and lower their total cloud costs.

6. Challenges in AI-Driven Cost Optimization

Though AI-driven cost optimization in multi-cloud environments has tremendous potential, there are several challenges that impede its complete realization and effectiveness. The main challenge in this regard is data integration. Multi-cloud deployments are made up of a variety of cloud providers each with their unique billing, usage report, and data formats. But aggregating and integrating this data into one single, coherent system for processing by AI can be cumbersome and time-consuming. If data is either inaccurate or fragmented, it results in sub-optimal cost optimization & poor decision-making due to which AI tools (applications) do not deliver the desired result. Algorithm complexity poses another significant challenge. Machine learning algorithms and AI models need a good number of sets of data for their training.

They also require ongoing oversight and adjustments to their accuracy over time. Deployed AI systems can be difficult to manage and have no knowledge of the proprietary manual assumptions used when training these systems many organizations do not have the data or resources to adequately manage integrated models, leading to misconfigured models, inaccurate predictions, and ultimately poor business decisions. Furthermore, organizations will have to weigh the trade-off between model accuracy and interpretability. Although complex structures can provide excellent precision, one of the main challenges with advanced models is the inability of stakeholders who do not have a technical background to comprehend such models, so solutions that run based on artificial intelligence may not be adopted.

In addition, organizational resistance to change is a challenge. Cloud financial management usually adheres to legacy methods, and AI integration calls for a cultural transformation to promote automation and data-driven choices. That’s always going to be a struggle and requires strong leadership and benefits communication when it comes to AI-powered optimization.

6.1 Characterisation of data availability and integration

Integrating data from various cloud providers is one of the most tough issues involved with AI-driven cost optimization. Each provider maintains its billing and usage data, which makes it hard to maintain a single view.

6.2 AI Algorithm Complexity

AI models can be very intricate and may need a lot of resources when being developed and managed. They are trained on comprehensive, scalable data and incorporate top-notch technology that organizations must have.

7. Conclusion

In short, AI Cost Optimization In Multi-Cloud FinOps Is Here Purpose-built AI tools offer a more accurate, dynamic and real-time method for allocating costs, reducing the over-provisioning and waste risk and matching cloud resource usage with business needs. AI automatically addresses the more mundane elements of cloud management like resource tracking, cost forecasting and anomaly detection in order to reduce the risks posed by human error and manual inefficiency, enabling organizations to optimize their cloud costs across multiple providers.

However AI in Cloud financial management also comes with some challenges. The power of AI-based optimization could be limited by data silos across different cloud stacks, complex AI models and organizational inertia. Given the challenges they face, organizations should invest in robust AI solutions, develop the requisite technical capabilities and foster collaboration among finance, operations, and engineering teams.

AI technologies will evolve further with more powerful and deeper insights and more complex optimization strategies as we move forward. With the evolution of AI-powered FinOps, organizations will be able to manage their cloud spend effectively, retain control over cloud cost and with it, become financially accountable by establishing effective management of multi-cloud complexity. More deeply, cloud financial operations will get more integrated with AI across the enterprise, and that means more enhanced data driven decision making capacity for cloud financial operations.

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