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| RESEARCH ARTICLE

Modernizing Legacy Banking Systems: Migration Strategies and Cost Optimization in Financial Enterprises

Ashmitha Nagraj
Senior Full Stack Engineer
Corresponding Author: Ashmitha Nagraj, **E-mail**: nagrajashmitha@gmail.com

| ABSTRACT

The banking industry is currently at an inflection point. Legacy platforms, many of which are decades old utilizing COBOL have been driving core banking processes globally. However, many of these legacy platforms are struggling to support the growing demand for innovation and improved customer experience. This paper examines the imperative for modernization within financial organizations, by analyzing why banks cannot wait much longer before they begin to transform the underlying technology that supports their business mode. Using current case studies from the financial services industry and new methodologies, this paper provides an overview of possible migration methods to support the transition, and how to best achieve both the reduction of risk and the maximum potential for innovation. This study suggests that a hybrid approach of strategic re-platforming and incremental modernization provides the most effective way to measure the success of a project using a wide range of metrics. Additionally, cost optimization was identified as one of the key elements in achieving a successful modernization project, and cloud-native architecture was identified as having significant potential to improve long term financial and operational performance. These findings should provide a practical roadmap for financial executives who are trying to navigate the challenging journey from legacy constraint to technological freedom.

| KEYWORDS

Legacy Banking Systems, Cloud Migration, Financial Technology, Modernization Strategies, Cost Optimization, Digital Transformation, AI, FinTech

| ARTICLE INFORMATION

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I. Introduction

Despite ongoing digital transformation initiatives, a substantial proportion of the core technology infrastructure within major banks remains based on long-established legacy systems. Most of the technology used today in banking consists of legacy systems which essentially means systems that have outlived their purpose but continue to support the operations of the organization. Legacy systems in banking can be described as mainframe-based applications that consist of monolithic architecture; that were created prior to the advent of the Internet, Cloud Computing, Mobile Banking, etc. Many of these systems were developed during the 1970s and 1980s when the priority was on reliability and transaction processing and not API connectivity or customer experience. A significant share of global banks still uses core systems that are two decades old.

As such, the limitations associated with legacy systems are becoming increasingly difficult to work with. Legacy systems generally include:

- High costs of maintenance are inherent in today's technology.
- The problems of integrating new digital channels and third-party services with old technologies.
- Long cycles of development that make it difficult to respond to market changes.

- Difficulties in applying security patches and updates.
- Reliance on a decreasing number of experts who know how to use outdated technologies.

The stakes have been raised for financial institutions today. Customers' expectations have also been shaped by the experience they have had in other sectors where they have experienced digital solutions from startups not limited by legacy technology. These startups can now rapidly deliver solutions that will threaten traditional banks' share of the market.

The first part of this research will provide an overview of the current literature related to the modernization of banking technology. Next, it will examine the key issues that are forcing banks to modernize their systems. The body of this paper will present a variety of migration strategies as well as numerous banking examples, along with cost optimization methods that are tailored to the specific needs of large financial services organizations. It will end with a review of trends that will impact how technology is used in banking for years to come.

II. Literature Review

The body of literature related to legacy banking has grown rapidly in the last several years as it has become increasingly clear that transformation is needed throughout the industry. There are several areas that have been identified as requiring special consideration.

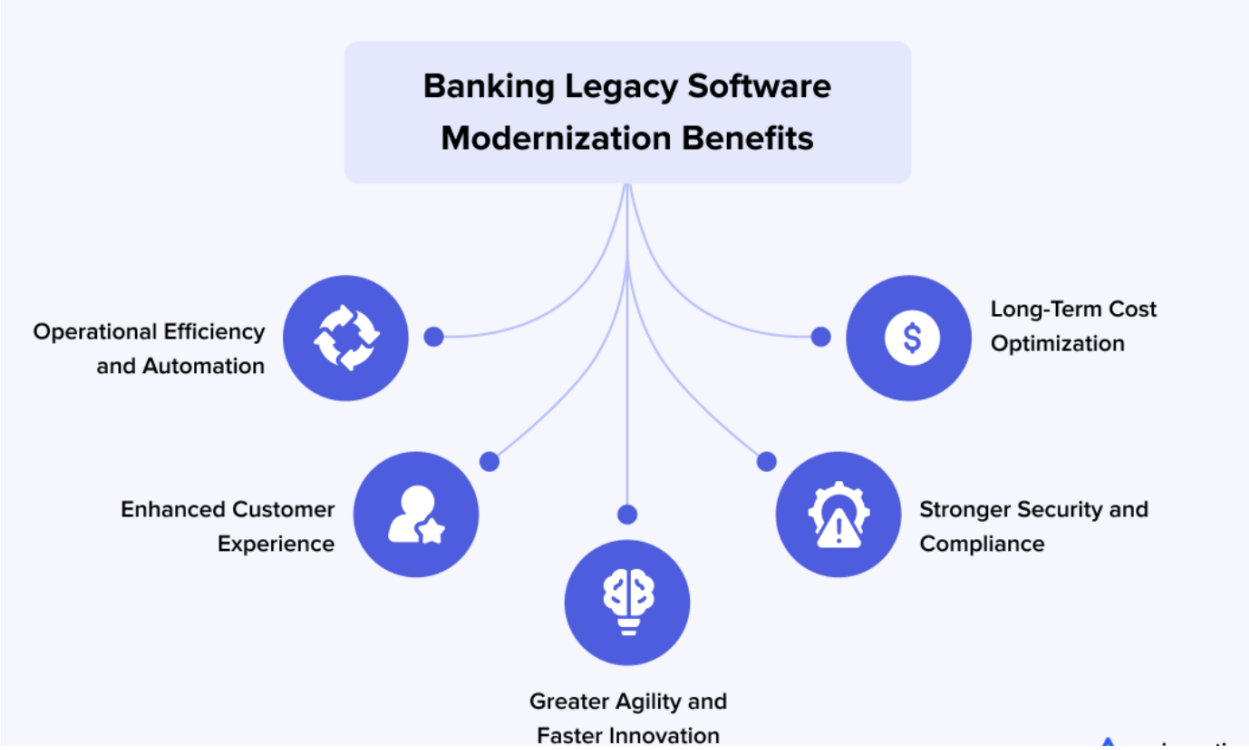

Figure 1: Banking Legacy Software Modernization Benefits

There are increasing disadvantages of legacy banking systems. A review of operational expenses at 120 financial institutions found that banks utilizing legacy core systems were spending 2.8 times as much as banks that had undergone a modernization process within the last five years [1].

Another significant area of concern has been security vulnerabilities. A review of 78 bank security breaches between 2020 and 2021 indicated that 63% utilized unpatched vulnerabilities in legacy systems to breach the bank's security system [2]. The findings clearly demonstrated how delaying the implementation of security patches creates prolonged exposures to emerging threats. Given that the financial services industry is the most targeted sector by hackers, this is a very significant issue.

In addition to researching legacy banking systems, researchers have also begun to examine modernization approaches. There has been considerable interest in cloud adoption in banking. An examination of 35 mid-sized banks over a three-year period found that there was an average reduction of 42 percent in costs after migrating to the cloud [3]. The results of the study further

demonstrated that while "lift and shift" type approaches resulted in cost reductions ranging from 15 to 20 percent, cloud native refactoring type approaches provided the greatest long term economic benefits. [3].

The microservices architecture model has become the most popular. A case study of a global bank using a practical decomposition methodology to decompose its monolithic banking application into domain-specific microservices illustrated how this was able to enable the global bank to deliver features in days rather than months [4]. A case study of three banks revealed a number of challenges each bank faced in implementing microservices based architectures including data consistency, organizational alignment, and the high cost of implementing an initial solution [5].

Open banking and API-based architecture have been additional areas of research activity. This research shows how technological modernization can be linked to positive business outcomes and not just provide operational efficiencies.

AI and ML have also been a subject of interest in research but with mixed conclusions. A review of AI deployments at 45 financial institutions identified that legacy system constraints were the main barriers to effectively deploying AI, with 78% of respondents stating that data access and data quality were the main obstacles to AI deployments [7].

While there is a growing body of research on the topic of technology modernization, there remain some research gaps. There is limited empirical evidence that compares the long-term outcomes of various modernization strategies, specifically total cost of ownership over the entire duration of the modernization project. In addition, there is very little research on the organizational and cultural aspects of technology transformation in traditional banking settings. Finally, there is a lack of practical methods for mitigating risks during large-scale migrations of mission-critical financial systems.

III. Challenges and Drivers for Modernization

The pressures compelling banks toward modernization come from multiple directions simultaneously, creating what many industry leaders describe as a "perfect storm" that makes technological transformation no longer optional.

Key Business Drivers

Customer expectations have fundamentally shifted: Consumers today who are influenced by their use of streaming services like Netflix, as well as online shopping through retailers such as Amazon, have come to expect seamless cross-channel customer experience, a level of customization in how they interact with each company, and rapid delivery of products or services [8]. Legacy banking systems developed during a time when banking was primarily done at a physical location, creating structural barriers to delivering these types of experiences [10].

Competitive pressures have intensified dramatically: In today's banking world, there are variety of new players in addition to the old established players like digital-only Neobanks as well as fintech companies focusing on high margin areas. Additionally, large technology companies like Apple Pay and Google Wallet are entering into the financial services space. The competitive advantage of these new competitors is that they do not have legacy technology to slow down their ability to innovate versus traditional banks.

Regulatory compliance has become exponentially more complex: Legacy systems were built to function under old rules of conduct; they were never designed for such complex or open structures. Non-compliance can result in significant financial costs and loss of reputation due to high-profile regulatory actions over the last few years.

Operational risks have reached critical levels: Most banks are reliant upon legacy system codes written decades ago by programmers who wrote in COBOL as they try to keep their current systems running. The U.S. government had to quickly ramp up their unemployment systems due to the rapid spread of COVID-19. This crisis showed how vulnerable these old systems are when an organization is desperately looking for COBOL programmers to fix their systems [8]. Furthermore, because there may be limited availability of security patches for legacy systems and/or because legacy systems have limited support, legacy systems will continue to expose themselves to new security risks at a faster rate than newer systems.

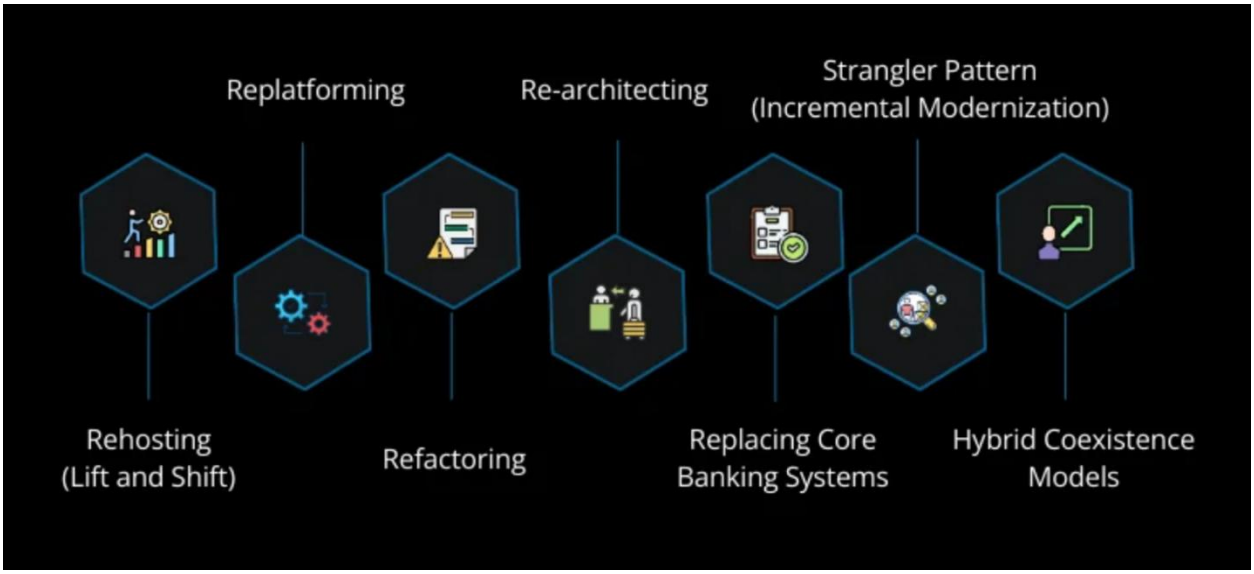

Figure 2: Key Legacy System Modernization Approaches

Common Challenges

Despite these compelling drivers, banks face substantial hurdles in modernization efforts:

The complexity of existing systems cannot be overstated: The large number of interconnected applications at a typical large bank can be in the hundreds or thousands. Additionally, many applications have undocumented relationships as well as data flows. As such, this large number of applications and interfaces leads to a substantial amount of analysis paralysis.

High migration costs and uncertain returns create budgetary challenges: While it is obvious that the economic deterioration of legacy maintenance will continue, the high cost of investing in modernization can be daunting. Communicating Return on Investment (ROI) to board members and investors who expect quarterly returns for their investments can also be a huge challenge, especially when the first phase of the benefit from this investment may be intangible. [9]

Organizational resistance often proves as challenging as technical hurdles: Legacy systems reflect the accumulated business processes and organizational structures developed and evolved over many decades. Change in legacy systems typically will include both a redesign of the business processes and an organizational change. Banking culture is also risk adverse and this creates another barrier to the successful completion of a bold transformation initiative.

Data migration complexities create substantial risk: A significant challenge for banking is migrating decades worth of customer information and all the related transactions to a new system without making mistakes. A breach of data integrity can cause serious problems for banks including loss of compliance or directly impacting the customers who depend on the banking service.

The same reasons for deferring modernization efforts despite clear advantages of doing so exist today. But, as noted below, several alternative strategies have been developed to help overcome some of the above obstacles.

IV. Migration Strategies

Financial Institutions have developed various methods for updating legacy systems with different levels of risk, timeline for implementation, and levels of transformation.

The most effective method for an Institution will depend upon, level of risk tolerance by the Institution, severity of technical debt, pressure from competitors, and number of resources available.

1. Rehosting (Lift-and-Shift)

Rehosting is the process of taking current software applications and placing them on new infrastructure with little to no modification to the original application code or design. Rehosting is also referred to as "Lift & Shift." In general, rehosting is migrating from an on-premises data center to a Cloud computing environment. In banking contexts, rehosting is generally used as a first step to begin a modernization journey.

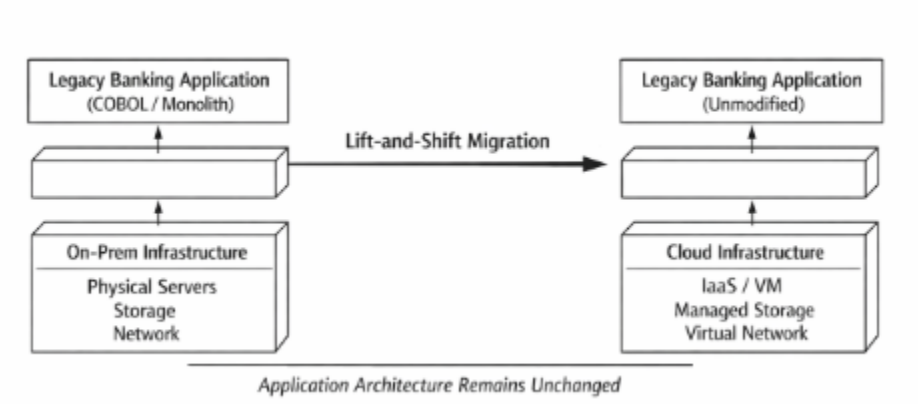

Figure 3: Rehosting (Lift-and-Shift): migration from on-premises infrastructure to cloud infrastructure without application redesign

Benefits of rehosting:

- Short implementation timeframe (generally 3 - 6 months per application)
- Limited disruption to business operations
- Lower initial costs compared to more comprehensive approaches

For banks that need to address either data center contract expirations or rapidly reduce infrastructure costs, rehosting is a pragmatic first step.

However, limitations are significant. Rehosting only captures a fraction of potential cloud benefits. Applications remain fundamentally unchanged and therefore carry over their architectural limitations.

2. Re-platforming (Lift-Tinker-and-Shift)

A new level of re-hosting is achieved through re-platforming in that it makes certain optimizations as part of the migration process without fundamentally changing an application's architecture. The optimizations can be made to databases, to middleware and/or to applications themselves.

In addition to providing significant increases in performance and reductions in maintenance costs when compared to rewriting an application from scratch, re-platforming also provides the opportunity to capture some of the benefits of cloud computing including automated scaling, disaster recovery and cost savings over time. In other words, re-platforming represents a middle ground option for financial institutions with limited transformation budgets and those seeking to generate tangible and demonstrable results from their transformation efforts.

While there are trade-offs associated with re-platforming, the trade-offs are substantial. Re-platformed applications inherit all the fundamental architectural limitations of the original system. In addition, technical debt is significantly reduced through the re-platforming process, and the full benefits of modern architecture are not realized.

3. Refactoring/Rearchitecting

Refactoring is a way of completely redesigning an application using cloud native features and modern architecture, specifically microservice-based or API driven architecture.

Refactoring produces extraordinary results. Companies experience dramatic reductions in technical debt; development velocity is improved dramatically; and companies realize the full potential of cloud benefits such as cost savings, resiliency and scalability.

In addition, refactoring allows businesses to be agile and to integrate in ways that traditional architecture simply cannot allow [7].

However, there are many challenges associated with refactoring. Refactoring is expensive in terms of both dollars and people. The duration of projects varies from 2-5 years based upon the scope of the project. Additionally, while some organizations have successfully completed a comprehensive refactoring effort in less than five years, other organizations have taken much longer [9].

4. Rebuilding (Complete Replacement)

The greatest extent of system replacement occurs when all legacy systems are replaced by contemporary systems that may be commercial off-the-shelf (COTS) or cloud native in nature.

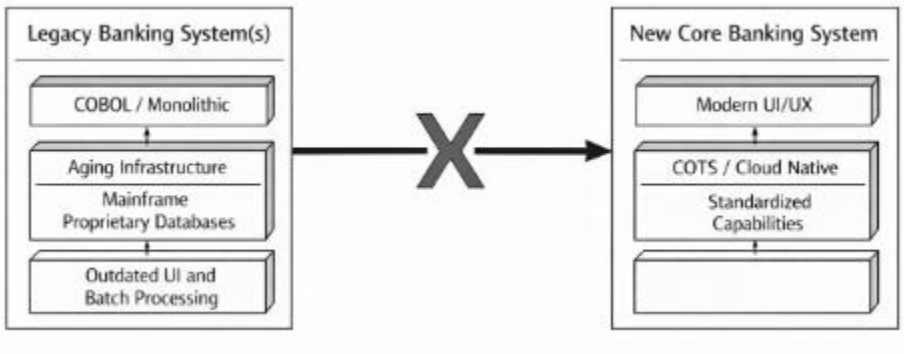

Figure 4: Complete core system replacement of legacy bank systems with modern, commercial solutions.

Adopting a clean-slate model mitigates inherited architectural constraints, enables process redesign aligned with industry best practices, and provides access to vendor-supported roadmaps for sustained modernization. For banks that have numerous systems developed over time through acquisitions and/or development, a clean slate provides the ability to create a common platform for the first time.

The costs and the disruptions associated with creating a clean slate are extreme. Core system replacements are usually the most expensive option available for banks. Additionally, they are usually the longest in duration and require the most organizational disruption. The banking industry has experienced many failed core system replacements including some high-profile failures that occurred when banks abandoned their initiatives after investing hundreds of millions of dollars.

5. Hybrid Approaches

More major financial institutions are choosing a middle ground on their modernization options instead of deciding between a complete digital overhaul or sticking with the status quo.

Advantages of a Hybrid Approach

Hybrid modernization approaches allow organizations to reduce the risks associated with massive system changes by taking things one step at a time. A hybrid approach also allows organizations to realize business benefits faster. Finally, because hybrid approaches allow organizations to focus on the business benefits first and then to adapt the modernization approach as needed as new technologies emerge and as market conditions change, hybrid approaches provide organizations with greater flexibility.

For very large organizations that have hundreds of legacy applications, hybrid approaches allow organizations to prioritize their modernization efforts based on the potential business benefit of each application instead of based solely on the technical challenges involved.

Challenges Associated with Implementing a Hybrid Modernization Approach

One of the biggest challenges organizations will face when implementing a hybrid modernization approach is managing the complexity of implementation. An organization needs to be able to govern multiple modernization work streams simultaneously while ensuring that there is coherence in terms of the overall organizational architecture. Many banks do not yet have the capability to manage both the multiple modernization work streams and ensure that the overall architecture remains coherent.

Successful Hybrid Approaches Are Those That Focus on Business Outcomes

The recent experience of the financial services industry suggests that the most successful hybrid modernization approaches are those that focus on achieving specific business outcomes rather than on being technically pure.

V. Cost Optimization in Migration

Financial institutions are facing unique challenges when it comes to cost optimization during modernization journeys of their technology transformations. These challenges are largely attributed to the highly regulated environment of banking, and the high availability expectations associated with financial data processing. These two aspects result in significant differences in cost structure relative to many other sectors undergoing similar technological transformations.

Cost estimation techniques used for financial institution's banking technology have changed dramatically since Total Cost of Ownership (TCO) models were first introduced. Today, leading banks use advanced approaches to estimate not only the direct costs of the new technology but also the indirect costs of implementing such technologies, i.e., regulatory compliance costs, operational risks, etc.

Return on Investment (ROI) calculations for banking technology have changed as well. While ROI calculations continue to include traditional metrics such as infrastructure cost reductions, progressive institutions today quantify the economic impact of improved time-to-market, customer experience improvement, and risk reduction. For example, DBS Bank has developed a "digital value capture" framework that demonstrated return 2.6 times over five years based on the inclusion of these comprehensive metrics. [11]

Optimization Strategies

The incremental migration process is particularly cost-effective in bank environments. Many successful banks are moving away from the "big bang" replacement model and instead adopting domain driven modernization where they transform a single bounded business capability at a time.

Automating aspects of the migration process have been transformative for reducing costs for leading institutions. Many of these organizations now use automated testing frameworks, code analysis tools, and even AI assisted migration techniques to automate the labor-intensive manual tasks involved in large scale transformations. According to Spanish banking group BBVA, their automated code analysis and migration tools resulted in 60% cost savings during their modernization program as opposed to the manual methods used prior to the application of the automated tools.[12]

Cost management practices related to cloud computing have developed substantially for the financial services industry. While many institutions are realizing significant savings on infrastructure costs with cloud computing, advanced organizations are developing sophisticated FinOps (Financial Operations) practices to further optimize cloud spending through right sizing, terminating unnecessary resources, and selecting the most suitable instances based on workload requirements.

Implementing DevOps and Continuous Integration / Continuous Deployment (CI/CD) practices consistently results in substantial cost reductions by automating manual tasks, improving quality, and decreasing cycle times. These improvements also drastically lowered the direct and opportunity costs associated with previous traditional release methodologies.

Best Practices and Pitfalls

When banks successfully modernize their systems and processes, several common patterns appear. Phased (incremental) approaches to modernizing systems are more effective in terms of cost and risk than a "big bang" migration to all new systems.

Investments in the cultural transformation of the organization will generate significant value, although it is often very difficult to measure the return on investment (ROI). Banks that have made cultural transformation investments through employee education/training and recruitment of new digitally skilled employees, as well as changing how they work, have had significantly lower costs and greater success with modernizing their systems compared to banks that only focused on the technological side of modernizing.

Common pitfalls that dramatically increase modernization costs include:

- Underestimating data migration complexity and quality issues
- Insufficient business involvement leading to misaligned technical solutions
- Inadequate testing strategies for high-complexity financial systems
- Attempting to modernize technology without addressing underlying business processes
- Failing to establish appropriate governance mechanisms for hybrid transitional states

VI. Latest Trends and Future Outlook

The rate of technological progress within the banking space continues to accelerate with an increasing number of emerging trends positioned to shape future modernization approaches.

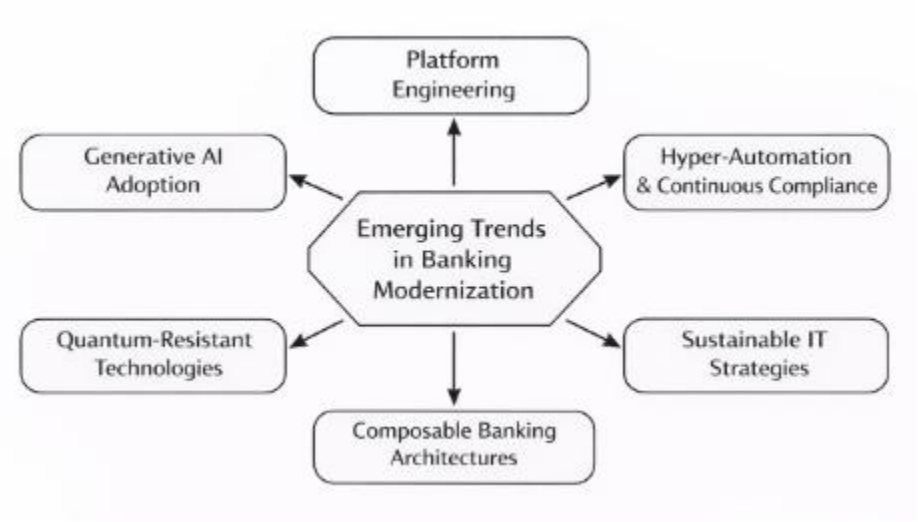

Figure 5: Emerging Trends in Banking Modernization

Generative AI is quickly evolving into a potential driver of legacy modernization. Several early banking uses of Generative AI include generating automated code reviews and refactoring, creating migration scripts and generating synthetic test data. Industry case evidence states that using AI-assisted code review tools they were able to increase their understanding of legacy code by 40% which significantly reduced their timeline for modernizing [13].

While Generative AI is still relatively immature, it has the potential to transform the cost structure associated with large scale, complex transformation initiatives.

Platform engineering is becoming increasingly popular as banks realize the importance of establishing internal developer platforms that will provide abstraction of underlying infrastructure complexities. Top-tier institutions are now building banking specific platform solutions that contain pre-built regulatory compliance elements, security controls and financial services patterns that can be reused as part of the solution. The use of a "golden path" provides a more rapid path to modernization by utilizing pre-approved patterns that have already been validated to meet banking specific requirements. Banks are increasingly implementing layers of automation prior to or concurrently with the replacement of legacy systems to improve operational efficiencies while the modernization of those legacy systems occurs.

Frameworks for Continuous Compliance are beginning to emerge in response to the evolving regulatory environment. The practice of embedding compliance as code, where automated controls, testing and documentation occur throughout the development lifecycle, is beginning to gain traction. The evolution of compliance from a point-in-time exercise to one of continuous assurance can reduce the regulatory burden associated with modernization and improve overall risk management.

Sustainability within financial IT infrastructure has evolved from being an aspirational goal to a required component of financial institution's IT strategies. Financial institutions are under increasing pressure from both regulatory bodies and stakeholders to minimize their environmental footprint. As such, cloud migrations are increasingly being evaluated based on the carbon footprint reductions that can be achieved through migration.

Looking forward, this study anticipates several developments that will shape banking modernization in coming years:

- Accelerated adoption of platform business models that extend banking capabilities beyond traditional boundaries
- Increased regulatory focus on technological resilience and operational continuity
- Growing convergence of traditional financial services with embedded finance capabilities
- Maturation of quantum-resistant cryptography as quantum computing threats emerge
- Evolution toward truly composable banking architectures that enable rapid reconfiguration of financial capabilities

VII. Conclusion

The modernization of legacy banking systems presents a unique combination of both challenges and opportunities for financial institutions. The study presents three key findings that provide strategic guidance for bank leaders navigating this complex transformation process.

First, the economic realities of supporting legacy systems are becoming increasingly unsustainable. As financial institutions delay or decline to modernize, they experience increased costs, declining competitive advantage, and increasing operational risks.

Second, the best migration approaches for financial institutions are contextual and should be based upon the needs of individual organizations, rather than general industry-based models. Successful approaches are typically combinations of multiple migration strategies such as rehosting when applicable, refactoring when beneficial, and replacement when necessary. When a company views modernization to achieve business objectives, it tends to yield greater ROI compared to viewing modernization strictly from a technology purity standpoint.

Third, cost savings in banking modernization go well beyond what has traditionally been included in IT budgets. Top performing companies today use broad value frameworks to measure the impact of modernization such as innovation, reduced risk, improved customer experience, and other qualitative measures of success in addition to quantifiable reductions in operating costs. In many cases, the business justification for modernizing is transformed from a pure cost savings argument to one of strategic investment.

Analysis of the study results suggests these strategic recommendations for financial executives pursuing modernization efforts:

- Begin with business outcomes and avoid the trap of mandating technology solutions
- Invest in building organizational capabilities and transforming the culture of the organization at the same time
- Use incremental approaches to continuously provide value to stakeholders while mitigating risk
- Develop metrics that capture both financial and non-financial benefits of modernization
- Establish governance structures and policies for managing a hybrid, multi-speed IT environment

The banks that will ultimately succeed in their digital transformations will see technology as the foundation of their business strategy, not simply as a cost center. While transitioning from legacy limitations to technological freedom is a long-term process, the study demonstrates that the process is not only possible, but also essential.

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