



TECHNICAL

NOTES & MANUALS

Harnessing Emerging Digital Technologies toward a New Frontier of Public Financial Management

Sailendra Pattanayak, Lorena Rivero del Paso, Herve Tourpe, and Chloe Cho

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Abbreviations

AI	artificial intelligence
API	application programming interface
BIS	Bank for International Settlements
BTr	Bureau of the Treasury
CI/CD	continuous integration and continuous delivery
FMIS	financial management information system
G2P	government to person
GEA	government enterprise architecture
GIF	Government Interoperability Framework
GTMI	GovTech Maturity Index
IoT	Internet of Things
ISO	International Organization for Standardization
IT	information technology
MoF	ministry of finance
NLP	natural language processing
OECD	Organisation for Economic Co-operation and Development
OSS	open-source software
PFM	public financial management
ROI	return on investment
RPA	robotic process automation
SDMX	Statistical Data and Metadata eXchange
SMART	specific, measurable, achievable, relevant, and time-bound

Introduction

Effective digital transformation of public financial management (PFM)¹ hinges on a clear, forward-looking vision that is fit for the future. Legacy PFM systems are often characterized by on-premises setups requiring manual updates, disconnected and siloed operations, and inconsistent vendor support, which lead to high overhead costs and operational inefficiency. Digital modernization of PFM can allow further automation and smarter rules and processes; offer greater security, scalability, and flexibility at potentially lower costs; and ensure that systems can adapt and improve over time to meet growing and changing demands. A vision that considers how people, data, processes, and technologies will evolve together to support an interconnected and responsive ecosystem should guide PFM modernization efforts, ensuring that they enhance efficiency, effectiveness, transparency, and citizen engagement.

Emerging digital technologies will play a critical role, as they have the potential to significantly transform traditional processes and functions of PFM. If properly harnessed, these technologies can

- increase the efficiency and effectiveness by automating routine tasks;
- facilitate data-driven decision making across the budget cycle;
- ensure fiscal sustainability by supporting better data analytics and decisions in fiscal policymaking;
- strengthen transparency and accountability by allowing stakeholders to monitor the use of public funds;
- improve public service delivery by enabling seamless, real-time interactions between citizens and government agencies; and
- promote compliance with global norms through the adoption of international standards and practices in the PFM area.

The adoption of emerging technologies in PFM should be underpinned by a clear strategy that reflects not only the benefits but also the associated costs, risks, and limitations. On the basis of a review of use cases in the public sector, technology trends and research in the private sector, and ongoing discussions and available literature on innovation in PFM, this note highlights strategic considerations for ministries of finance (MoFs) to adopt emerging technologies to transform PFM. These include (1) specific processes and tasks in PFM, (2) the maturity and speculative enthusiasm surrounding the respective technology, and (3) the unique context and culture of each government entity. The note proposes a value-maximization (VM) approach, which calls for an objective-driven technology adoption based on potential gain and feasibility, without recommending any specific technology or examining their application in detail.²

This note is organized as follows: Section I presents a vision for digital transformation of PFM and discusses the paradigmatic shift that will guide the adoption of emerging technologies. Section II delves into the role

¹ The term “PFM” or “public financial management” commonly covers all aspects of managing public resources, including all stages of the budget cycle, resource mobilization and debt management, with a progressive extension to the medium- to long-term implications and risks to public finances from today’s policy decisions (Cangiano, Curristine, and Lazare 2013). Overall, PFM has four objectives (see Section I).

² For a detailed discussion on the digital transformation of specific PFM functions and subfunctions, please refer to “Digital Solutions Guidelines for Public Financial Management” (Rivero del Paso and others 2023) and the associated Handbook (forthcoming).

of emerging technologies in shaping this vision, highlighting the growing interest in government adoption and illustrating how different technologies can be leveraged for different purposes. Section III proposes a VM approach to harnessing the potential of emerging technologies. Section IV concludes, emphasizing sustainable adoption and offering good practices. The note also includes a set of technology cards, which highlight selected technologies that can be adopted in PFM.

I. Envisioning Digital Transformation of PFM

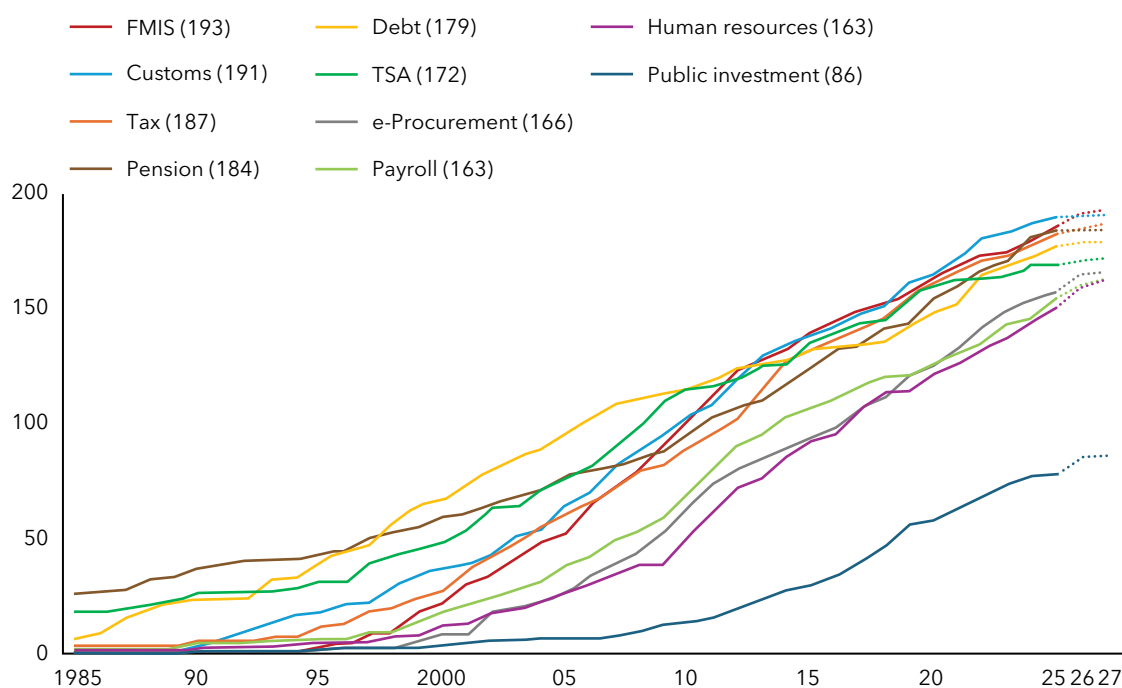
Governments should strive for a digital PFM ecosystem built upon cutting-edge digital solutions that allow real-time, data-driven decision making to achieve core PFM objectives. These objectives include (1) fiscal discipline—ensuring the overall control and sustainability of public finances; (2) allocative efficiency—allocating resources according to government priorities; (3) operational efficiency—executing government programs in an efficient manner to deliver public goods and services; and (4) transparency and accountability—disclosing timely, comprehensive, and accurate fiscal information and institutionalizing accountability in the management of public funds. By leveraging emerging technologies, governments could redesign their PFM processes and functions to be “digital by design,” to name a few:

- Budget preparation could potentially be redesigned with artificial intelligence (AI) agents automating data validation, reporting, and workflow approvals; drastically reducing manual effort; and eliminating redundant layers of review while enabling faster, evidence-based budget formulation.
- Public investment management could leverage building information modeling tools; light detection and ranging technologies; and AI-driven analytics to ensure accurate planning, data-driven project monitoring, and timely, cost-effective completion of infrastructure investments.
- Government payments, including payroll and subsidies, could be processed swiftly and accurately, reaching even the financially excluded and hard-to-reach populations through new payment systems and digital money innovations.
- Government contracts could leverage smart contracts and Internet of Things (IoT)-enabled asset management registries to streamline initiation, automate execution, and ensure transparent oversight of public procurement processes.
- Public debt management could leverage tokenization, distributed ledger technologies, and central bank digital currencies to enable the issuance and automated settlement of digitalized debt instruments, fostering innovation and access for retail investors.
- Performance budgeting could apply machine learning to analyze targets and evaluate effects or generative AI to produce tailored reports for different audiences, reducing the reporting burden.
- Internal control and audit could leverage AI and analytics tools to detect anomalies, noncompliant and fraudulent transactions; facilitate proactive, adaptive, and real-time risk management instead of manual sampling; and provide controllers and auditors with strategic insights into risks.

A. Current Digital PFM Landscape

Almost all countries now use some kind of automated systems to support their PFM functions. These systems range from those with very low-end automation³ to fully automated and interactive systems that are accessible to personnel at all levels of government. Typically, they take the form of a financial management information system (FMIS), which can support a range of functionalities, such as budget planning and preparation, budget execution, treasury operations, cash and debt management, public investment management, and accounting and reporting. Additional functions such as collection of taxes, debt management, payroll management, and procurement are generally automated in separate, stand-alone systems (Dener, Watkins, and Dorotinsky 2011). Although most countries report having an FMIS, its coverage of PFM functions varies greatly (Figure 1; World Bank 2025).

³ For example, digitized spreadsheets supporting paper systems.

Figure 1. Coverage of Digital PFM


Source: Authors, based on the World Bank GTMI data set (December 2025).

Note: The World Bank GTMI survey is self-reported by country authorities and does not indicate the quality of the systems. The figure represents responses from 2025. Dashed lines reflect updates or launches that countries reported as planned for 2026 and 2027. FMIS = financial management information system; GTMI = GovTech Maturity Index; PFM = public financial management; TSA = treasury single account.

Despite large investments from governments and development partners over the past decades,⁴ many existing PFM digital solutions are inadequate to meet governments' evolving needs. Major shortcomings, which span across diverse PFM tasks and processes, typically include (1) poor quality or incomplete, inconsistent data; (2) silos or lack of interoperability across databases, systems, and institutions; (3) outdated information technology (IT) architecture with limited flexibility, scalability, and security; (4) little use of modern data analytics methods for decision making; and (5) slow and cumbersome reporting features, as well as the lack of real-time monitoring (Uña, Allen, and Botton 2019; Rivero del Paso and others 2023).

Cross-country surveys reveal that data quality in these systems remains a concern (Rivero del Paso and others 2023; OECD 2024a). PFM data are often incomplete because of silos or lack of standardized storage and exchange. As such, analysis and forecasting rely mostly on linear models, simple indicators,⁵ and only traditional data sources,⁶ failing to leverage the full potential of advanced analytics or AI. In some cases,

⁴ The total cost of 156 financial management information system projects financed by the World Bank since 1984, including government and borrower co-financing, has reached over \$6 billion as of July 2024 (World Bank 2024).

⁵ As opposed to simple indicators, leveraging machine learning can allow for complex pattern recognition, adaptability, automation, sensitivity, and predictive power.

⁶ Alternative sources of data refer to nontraditional, unconventional, or supplementary data sets that government agencies can leverage to enhance their analysis, decision making, and policy implementation. These sources often complement traditional data sources such as official surveys and administrative records. These include social media data, satellite imagery, web scraping, mobile phone data, geospatial data, crowdsourced data, and open data platforms, among others. This is often referred to as "big data."

significant data are available but go unused, as government agencies lack the required tools, licenses, capacity, or expertise to manage and interpret large databases.

Less-developed economies face additional challenges because of lack of financial resources, digital infrastructure, and required skill set. These structural constraints make it more difficult to transform legacy PFM systems and adopt emerging technologies, widening the digital divide between developed and developing countries. Addressing these challenges will require strategic investments, capacity building, and international cooperation.

B. Potential Future Scenarios of Digital PFM

As large PFM modernization projects take several years and considerable resources, governments need to consider not only the current but also the future technological trends. The different pathways can be conceptualized using the “futures cone” framework (Voros 2017), used in technology planning to help stakeholders anticipate and strategize for different technological developments and their effects (Boldrini 2023). This framework maps scenarios according to their likelihood: probable, plausible, and possible.⁷ Within this framework, this note envisions the following three scenarios:

1. The **probable future** scenario maintains business as usual and represents the default option. Legacy systems remain in place, with slow adaptation, incremental improvements, and responsive measures to maintain operations.
2. The **plausible future** involves progressive modernization that recognizes current trends. Governments may upgrade available technologies to benefit from new features and options, or address specific pain points, such as enhancing cybersecurity measures, automating certain financial processes, expanding interoperability, and incorporating advanced data analytics and AI assistance to improve decision making.
3. The **possible future**, a transformative overhaul, envisions a bold reconstruction through the comprehensive implementation of emerging technologies, such as
 - AI for budget planning and reporting;
 - tokenization for asset management;
 - smart contracts for payroll, debt, and procurement management;
 - IoT for inventory and public investment management;
 - Web3 for digital identity; and
 - digital money for payments and receipts.

This scenario requires significant and fundamental changes that can transform PFM systems and processes into a highly interconnected, transparent, and efficient ecosystem. This, however, requires digital maturity and effective change management (Box 1).

Although predicting the future is impossible, MoFs can proactively map their journey toward a desirable future. Historically, the probable scenario has dominated digital PFM, offering stability but limiting the benefits from modern technologies. Legacy systems can be costly to maintain and vulnerable to security breaches, as they require patching outdated software and lack advanced protective measures in newer

⁷ The futures cone also includes a “preposterous future” scenario. These futures are highly unlikely, implausible, and often dismissed as impossible. However, they can be useful provocations in futures planning sessions to challenge current assumptions and encourage creative thinking. Although preposterous futures occasionally come to pass, they are not included in this note in order to focus on its objective of providing practical advice to practitioners.

technologies (Gainford 2024). To keep pace with the rapidly evolving global financial landscape, governments should look beyond this approach and strategize for proactive technological integration.

Although the radical overhaul may have the greatest potential and thus the most effect, the plausible future can offer a balanced path with substantial advantages. Strategic adoption of select innovations and emerging technologies can deliver meaningful enhancements in PFM performance and resilience, while managing risks and costs. For some countries with digital maturity, the possible scenario is not only ideal but also achievable; but for many, the plausible scenario is the next best and pragmatic option for modernizing and improving PFM. A hybrid approach, where countries adopt a radical vision for specific PFM functions or processes according to their priorities and biggest pain points, can also drive meaningful progress in the digital transformation of PFM.

Box 1. Key Determinants of the Timeline for a Radical Overhaul of Public Financial Management

The timeline for a radical overhaul of public financial management (PFM) systems, partial or full, depends on several factors but will realistically span 10 to 20 years. Early adopters or countries with strong digital foundations and leadership may achieve this future in less than a decade. The following are key considerations:

1. **Technological readiness:** Emerging technologies such as AI, IoT, smart contracts, and digital money are rapidly advancing. Widespread adoption, however, requires them to be not only available but also mature and proven in PFM contexts. Significant progress is expected in this area within 5 to 10 years.
2. **Political will and leadership:** The prioritization of digital transformation in policy agendas and a commitment to innovation can drive necessary changes for a radical overhaul. Ambitious governments may advance rapidly, whereas others may take more than 15 years to develop similar levels of political will and leadership. Global recognition of the benefits of digital transformation could accelerate progress and is already growing.
3. **Institutional capacity:** The vision for a radical overhaul requires robust frameworks, skilled personnel, and effective change management. Building these capacities could take 5 to more than 20 years, depending on the institution's starting point, size of the economy, and efforts invested in capacity building.
4. **Resource availability:** Financing digital PFM initiatives can be a significant challenge, especially with competing priorities. Fragile and conflict-affected states may find it difficult to achieve this vision within the next 10 years. Governments should secure funding, whether through national budgets, international aid, or public-private partnerships, with the understanding that technology investments are not a one-off project but an ongoing strategic endeavor.

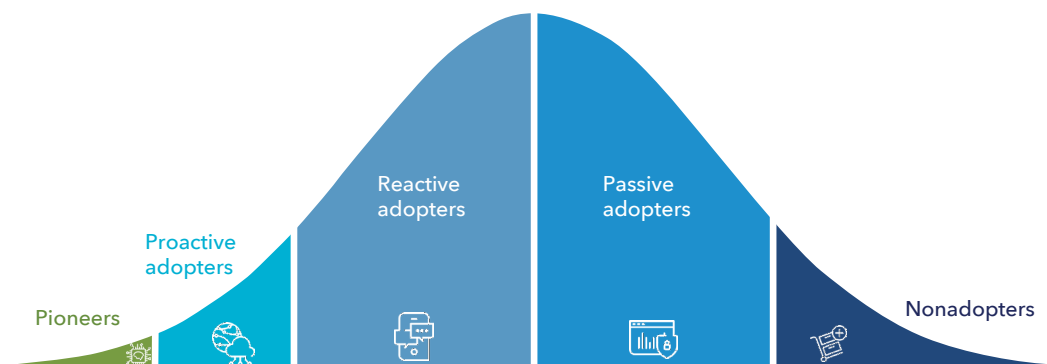
Source: Authors.

C. Organizational Approaches to Adopting Technology

In the strategic decision-making process of adopting new technologies, MoFs face the trade-off between being more innovative and garnering benefit earlier versus lowering the risks of disruption. Some may not have the resources and capacity to adopt technologies readily as they become available. Some may opt for a conservative approach and proceed cautiously, whereas others may take a more aggressive stance and

venture into unexplored territories for potentially large gains. Recognizing this diversity, this note distinguishes four types of adopters: passive adopters, reactive adopters, proactive adopters, and pioneers, which can be depicted across a spectrum parallel to Rogers' diffusion of innovation curve (Figure 2; Rogers 1983).⁸ The fifth category of nonadopters, although not discussed in this note, is shown to capture the organizations that do not frequently adopt emerging technologies and rely heavily on manual or low-tech solutions.

Figure 2. Emerging Technologies in PFM: Types of Adopters



Source: Authors, adapted from Rogers (1983).

Note: PFM = public financial management.

Organizational culture, resource availability, and perceived risks play an important role in determining the approach to innovation. They reflect both the willingness and capacity to embrace emerging technologies in PFM and, all else equal, can determine which future scenario an organization will realize. Each type of adopters may be characterized as follows:

- **Passive adopters (aligned with business-as-usual future):** These organizations typically have a conservative culture, prioritizing stability, continuity, and reliability over innovation and potential benefits. They are more likely to face challenges such as a lack of financial resources and skilled personnel, complex legacy systems, and resistance to change. They will maintain business as usual, adopting digital modernization when faced with external pressures such as changes in laws or regulations.
- **Reactive adopters (aligned with progressive modernization future):** These organizations are risk averse but relatively open to embracing innovations. They recognize the potential of emerging technologies but prefer to carefully tap into the opportunities on a case-by-case basis, learning from others' experiences. They are likely to make incremental investment when risks are low or when benefits have been clearly demonstrated.
- **Proactive adopters and pioneers (aligned with a transformative overhaul future):** These organizations are *open to innovation* and actively explore digital trends and good practices across countries. They frequently and readily adopt technologies that have been tested or explored elsewhere, in either the public or private sector. From those, the organizations with a pioneer mindset, are the most innovative and experimental. Willing to take risks, they actively seek out emerging technologies. They have both a strong appetite for innovation and resources required for experimentation, such as a well-developed digital infrastructure, skilled workforce, and supportive leadership. Organizations in this group are at the forefront of digital transformation in PFM and often serve as trailblazers for others.

⁸ Rogers' theory has been widely used to understand the dynamics of innovation adoption and develop strategies for such adoption.

The adopter types are neither mutually exclusive nor fixed for a government, as the unique context and culture of each agency can vary and evolve over time. Organizations can take advantage of opportunities presented by changes in internal and external factors (Box 2). Culturally, they can become more receptive to innovation and experimentation by fostering an environment that encourages new ideas and views risks as opportunities for growth. The structures, institutions, and processes within the PFM ecosystem should be seen as flexible and adaptable, evolving alongside technologies to achieve continuous automation and digitalization of tasks, outputs, and services. The key will be to embrace change strategically, recognizing that the digital journey in PFM is an ongoing evolution, not a one-time reform.

Box 2. Pioneering Digital Money Use for Fiscal Operations in Brazil and the Philippines

The National Treasury Secretariat of Brazil has taken significant steps to “break paradigms, explore new possibilities, reinvent . . . and innovate.” It has actively modernized its financial systems and payment processes to enhance and simplify service delivery with Pix, an instant payment platform created by the Central Bank of Brazil. The Treasury is also exploring new opportunities presented by Drex, the Brazilian digital currency that the Central Bank is piloting, and organized a hackathon in 2023 to develop innovative solutions using tokenized government securities. It aims to position itself at the forefront of digital PFM and foster an organizational culture of agility, collaboration, and innovation—“making mistakes, learning, and growing” while making use of its greatest asset: data.

In November 2023, the Bureau of the Treasury (BTr) of the Philippines sold its first tokenized bonds to institutional buyers, raising \$270 million and making a significant leap toward innovation in debt management. The initiative builds on earlier efforts, such as the Bonds.ph app, and collaboration with state-owned banks and private sector partners, specifically the Philippine Digital Asset Exchange. BTr was able to navigate compatibility issues through a collaboration with the private sector using a dual registry structure for securities, illustrating how partnerships can help overcome implementation challenges. Although the maiden issuance was limited to institutional buyers, the adoption of blockchain and tokenization reflects an openness to emerging technologies and a favorable environment. BTr aims to tap into the widespread use of the GCash app among Filipinos to offer tokenized bonds to small retail investors who previously lacked access to government securities, expanding the investor base and promoting financial inclusion.

Source: Authors, based on interviews and resources provided by country authorities.

II. Harnessing Emerging Technologies for Digital PFM of the Future

This note focuses specifically on digital technologies that are considered “emerging” in PFM. Although emerging technologies generally refer to rapidly evolving digital tools that have not yet reached full maturity or widespread adoption,⁹ this note also includes those at an early stage of adoption within PFM. Some technologies that are not “new” in other sectors may still be incipient in PFM, where adoption can lag behind. These include not only technologies ranging from AI and robotic process automation (RPA) to blockchain but also related practices, paradigms, architectures, and approaches, ranging from open data and enterprise architecture to microservices.

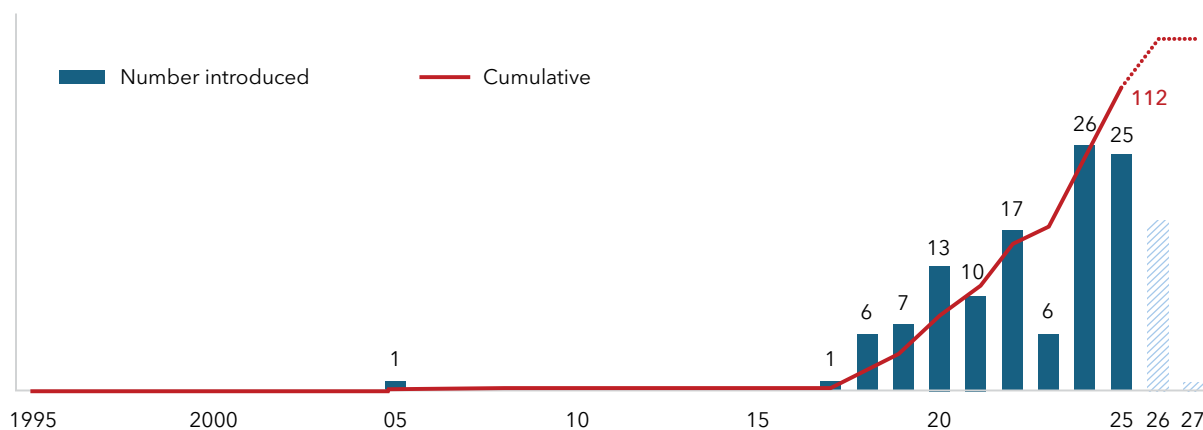
Emerging technologies present unprecedented opportunities for MoFs and other agencies looking to achieve their vision for digital PFM. These technologies can help address the shortcomings of existing systems by automating routine tasks, improving decision making, and enhancing accountability. In the United Arab Emirates, for example, the MoF has automated 63 processes and subprocesses with RPA, significantly reducing errors and processing time (United Arab Emirates Ministry of Finance 2024). In Brazil, generative AI has shown potential for providing valuable insights based on the opinions from the audit office (Tesouro Nacional 2023). Across several countries, digital payments were linked to greater budget transparency (Nose 2023). However, technology by itself is not a panacea; its effects can be difficult to disentangle from other factors (Alonso and others 2023) and can vary across sectors and organizations (Anderton, Botelho, and Reimers 2023; Bijmens and others 2024). For emerging technologies, especially, evidence is still developing—as are the technologies themselves—and significant uncertainties remain around their potential effect on PFM.

A. Trends in Adopting Emerging Technologies

Governments worldwide are exploring how emerging technologies can help create more agile, transparent, and effective public sector systems (Ubaldi and others 2019). By 2025, 112 countries—more than half of the 198 surveyed countries—had introduced a national strategy on emerging technologies (Figure 3). Countries across all regions and levels of development—including Bangladesh, Benin, Rwanda, Uganda, and Vietnam—have drafted or approved a strategy that covers at least one emerging technology. Governments are also increasingly adopting specific technologies and modern technological approaches such as cloud, enterprise architecture, interoperability frameworks, and open-source policies (Figure 4). Although not exclusive to PFM, these developments indicate broader interest and commitment, which can become a catalyst for technology adoption in PFM.

⁹ See Rotolo, Hicks, and Martin 2015 for key attributes of an emerging technology.

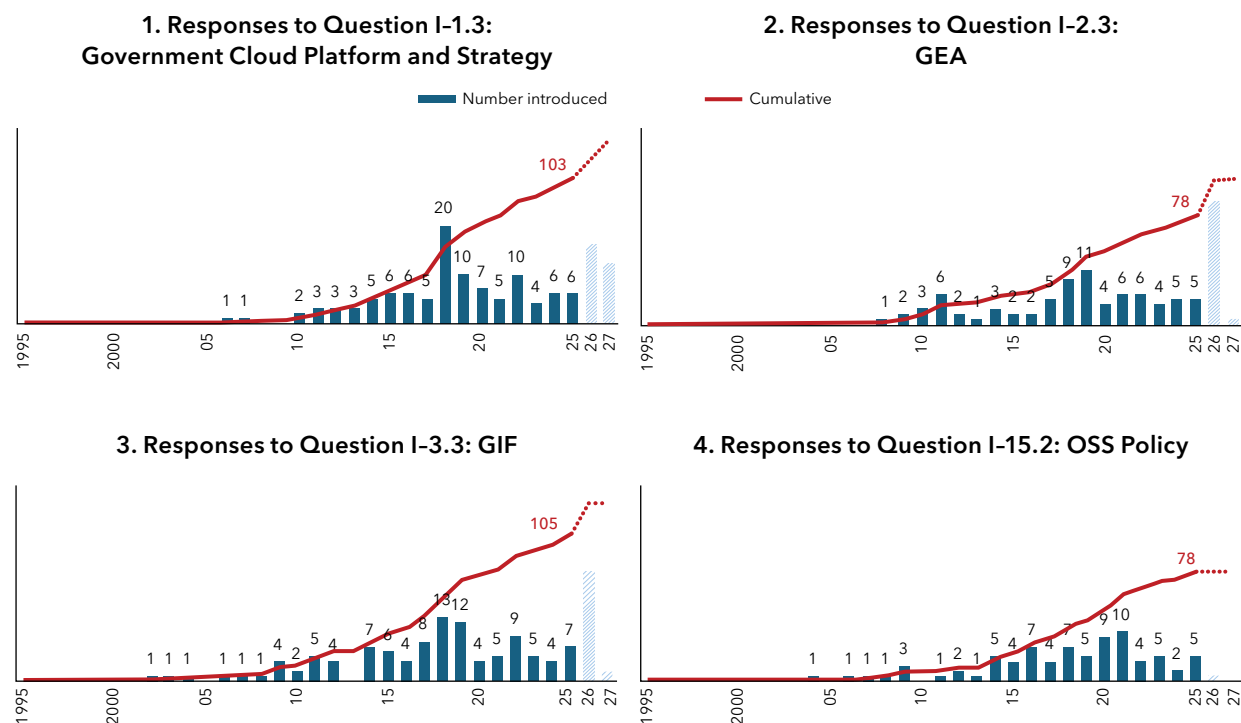
Figure 3. Countries with a National Strategy on Emerging Technologies



Source: Authors, based on the World Bank GTMI data set (December 2025).

Note: The figure represents country responses to question I-17.3, which asks for the year in which a national strategy on disruptive or innovative technologies was approved. The World Bank defines disruptive technologies as “emerging technologies that displace established products, markets, or networks by altering the way agents interact with each other and operate with the broader system. Examples include AI, IoT, blockchain, among others.” The GTMI survey is self-reported by country authorities and does not indicate the quality of the strategies. Dashed lines reflect what countries reported as planned for 2026 and 2027. GTMI = GovTech Maturity Index.

Figure 4. Countries Adopting Select Emerging Technologies and Forms of Technology Adoption

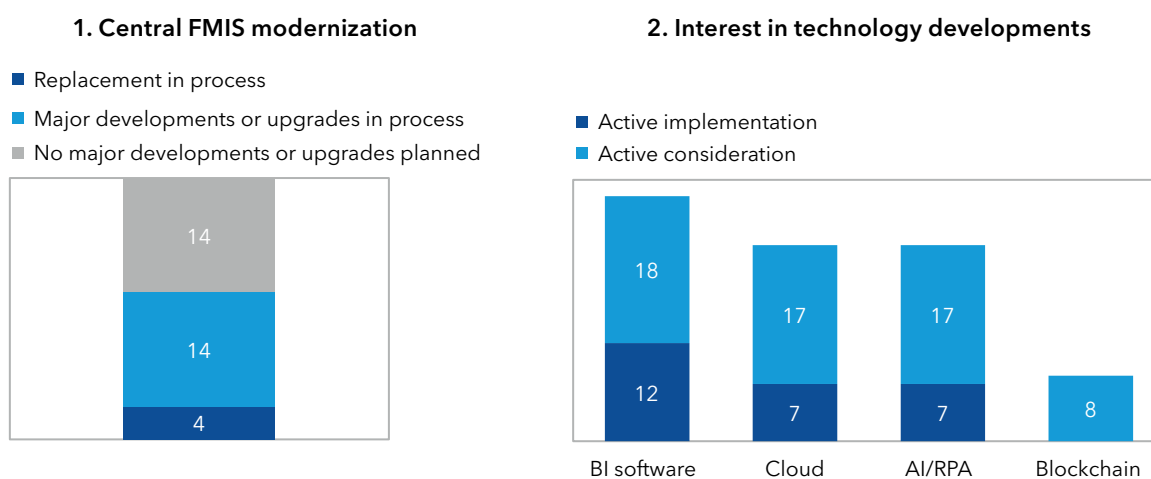


Source: Authors, based on the World Bank GTMI data set (December 2025).

Note: The GTMI survey is self-reported by country authorities and does not indicate the quality of the strategies or solutions. Dashed lines reflect what countries reported as planned for 2026 and 2027. GEA = Government Enterprise Architecture; GIF = Government Interoperability Framework; GTMI = GovTech Maturity Index; OSS = open-source software.

Although adoption remains relatively low in PFM, interest in newer technologies is also growing. As of 2022, less than a quarter of budget and accounting departments in Organisation for Economic Co-operation and Development countries were using AI and RPA and cloud computing;¹⁰ however, a majority reported considering their implementation. This is aligned with some countries' plans to upgrade their FMIS to enhance technical performance, analytical and reporting capabilities, and financial controls (Figure 5; OECD 2024a). Anecdotal evidence indicates that MoFs are exploring AI mainly as an assistive tool or a tool to improve existing processes (OECD 2024b), suggesting that many countries face the "plausible" future of gradual PFM modernization. This survey predates the recent rise of generative and agentic AI, which are now expanding the scope and ambition of digital transformation in the public sector, including PFM. As of 2025, more than 100 countries have approved a national strategy on AI, and another 20 countries plan to approve over the next three years, indicating significant interest that is likely to extend to PFM (World Bank 2025).

Figure 5. Interest in Emerging Technologies among OECD Budget and Accounting Departments, 2022



Source: Figures 3.2 and 3.4 from OECD (2024a).

Note: Data for Chile, Colombia, Israel, Mexico, Slovenia, and the United States are not available. For cloud-based computing services, data for Czechia and Iceland are not available. AI = artificial intelligence; BI = business intelligence; FMIS = financial management information system; OECD = Organisation for Economic Co-operation and Development; RPA = robotic process automation.

B. Emerging Technologies behind Specific Tasks and Outputs in PFM

To fully leverage emerging technologies in PFM, stakeholders need to reorient their understanding of these technologies' role and value. This reorientation requires redesigning and optimizing processes to be made digital by design, making them amenable to innovation, prioritizing the actual needs of users. To facilitate this transition, Tables 1 through 5 present examples of PFM tasks, outputs, and services categorized by their primary purpose, such as

¹⁰ The rate of adoption for artificial intelligence and robotic process automation (AI and RPA) and cloud computing for ministries of finance in Organisation for Economic Co-operation and Development countries was about 23.3 percent, respectively. Although not directly comparable, this was lower than the global adoption rate of government cloud platform at 58 percent in 2022 (World Bank 2025), the share of European enterprises buying cloud computing services at 41 percent in 2021 (Eurostat 2023), and available estimates of AI and RPA adoption in the private sector for similar years, which range from 34 percent to more than 50 percent. See Deloitte (2022), IBM (2022), McKinsey and Company (2022), and Gartner (2024) survey of finance leaders for example.

- capturing, exchanging, and storing data;
- supporting process automation and control;
- building modern architecture, system deployment, and cybersecurity;
- enabling and improving data exploitation or analysis; and
- enhancing fiscal transparency and accountability.

These examples illustrate how technologies and associated development practices—including frameworks, standards, and principles for digital transformation—can be effectively leveraged.

This note is complemented by a set of “technology cards,”¹¹ which provide definitions of selected technologies and their potential use cases in PFM. Tables 1 through 5 include links to these cards. These cards present more examples of real and potential uses of selected technologies in PFM, as well as major preconditions and challenges for their adoption. This note does not recommend any specific technologies, nor does it intend to provide a comprehensive list of technologies; it simply aims to explain how different technologies can be used—and are already being used—to support PFM.

Technologies and practices to capture, exchange, and store data serve as the backbone of PFM systems, as they will determine the level of interoperability and enable—or limit—analyses conducted in subsequent phases of the PFM cycle (Table 1). Adoption of these technologies should respond to the type of data and analysis expected. In addition, to enable data exchange, it is vital to standardize data and establish robust data governance and interoperability frameworks.

Table 1. Technologies and Practices to Capture, Exchange, and Store Data Related to PFM

Generic Task	Example of Specific Tasks	Example of Related Technologies and Practices
Recording data	Accounting and financial reporting: entering financial transaction data into a centralized system	Governments can ensure that financial data are entered in a consistent format using relational database management systems , such as MySQL and PostgreSQL. Emerging technologies, such as Distributed Ledger Technologies , can also be integrated, for example, to enable automated settlement of public debt instruments.
Classifying data by specific attributes	Fiscal forecasting and budget preparation: categorizing expenditures by department or project	Content classification systems can be used to organize, categorize, and label public expenditure and revenue data. AI offers more possibilities for this task of granularization. For example, in Rwanda, the Ministry of Finance and Economic Planning is exploring the use of machine learning to improve the accuracy of budget line classification. In Brazil, natural language processing was used to classify expenditures to their functional categories, reducing the time required from 1,000 hours to only 8 hours.
Storing, accessing, and retrieving data	Fiscal forecasting and budget preparation: storing and retrieving budgetary information	Cloud computing can enable scalable storage and easy access. Many countries, including Brazil, Chile, and India, have adopted cloud-based solutions for select financial management information system modules. Countries have also been experimenting with different ways of storing and managing data, such as through data lakes .

(continued)

¹¹ These technology cards are part of an evolving and growing knowledge product that can be expanded with other new technologies.

Table 1. Technologies and Practices to Capture, Exchange, and Store Data Related to PFM (Continued)

Generic Task	Example of Specific Tasks	Example of Related Technologies and Practices
Exchanging data or information	Cross-functional: sharing financial data between government agencies and external stakeholders	Interoperability between PFM digital solutions and systems can be improved through an API-first approach and data exchange mechanisms such as data standards (national and international ¹). API-first initiatives are generally spearheaded by agencies responsible for national digital transformation, as is the case in the United Arab Emirates and the United Kingdom.

Source: Authors.

Note: AI = artificial intelligence; API = application programming interface; ISO = International Organization for Standardization; PFM = public financial management; SDMX = Statistical Data and Metadata eXchange.

¹ For example, the ISO family of standards includes those governing dates (ISO 8601), times (ISO 8601), and currencies (ISO 4217). ISO 20022 is an international standard for financial messaging that establishes a common language and a harmonized approach for developing financial messages used in electronic data interchange across the financial industry. Likewise, SDMX is an international standard for describing, structuring, and transmitting data across systems and organizations, jointly sponsored by the IMF, the World Bank, the Bank for International Settlements, the Organisation for Economic Co-operation and Development, and the United Nations Statistics Division. National statistics offices are also typically responsible for standardizing the codes used to classify local administrative units.

Several FMISs have evolved to enable data-driven controls, creating opportunities for automation and increased process efficiency in PFM (Table 2). Many emerging technologies can enhance automation and enable smart controls, for instance, by helping to detect irregularities. The introduction of digital money technologies also offers new possibilities to revolutionize PFM, especially in payments.

Table 2. Technologies and Practices to Support Automation and Control Tasks in PFM

Generic Task	Example of Specific Tasks	Example of Related Technologies and Practices
Controlling against a rule	Budget execution and control: enforcing budgetary constraints and preventing overspending	Robotic process automation is used, among other automation tasks, to verify and reconcile expenditure in Finland. In the United States, Treasury has explored smart contracts to automate certain controls including drawdown approvals and limits. AI-enabled systems can also help by detecting potentially noncompliant spending through machine learning or ensuring adherence to specific budgetary rules through expert systems .
Authorizing or validating an action or information	Treasury and cash management: validating invoices for payment	In procurement, robotic process automation can facilitate electronic invoicing, as is the case in Portugal. In service delivery, smart contracts can help enforce eligibility criteria before payment, as being explored in a Dutch municipality. Computer vision technologies, such as the optical character recognition, could also be integrated to gather visual data or extract relevant information from scanned documents.
Making payments and transfers to beneficiaries	Treasury and cash management: processing electronic fund transfers and payments	Kazakhstan is piloting the use of central bank digital currency—a form of digital money that is most commonly issued using tokenization on distributed ledger technology platforms—for a subsidy program. Digital identity technologies ¹ can be used to facilitate the identification and verification of beneficiaries, whereas consent management and open banking can enable secure data sharing and proper authorization in the disbursement of benefits.

Source: Authors.

Note: AI = artificial intelligence; PFM = public financial management.

¹ These could include Open Authorization and OpenID Connect. See also World Bank (2022).

Although the architecture of systems is often overlooked in PFM functional discussions, its design and maintenance are essential for ensuring scalability and business continuity (Table 3). PFM systems must be developed to allow for exponential growth in data and operations. Choosing the appropriate system architecture, such as the loosely coupled components¹² and multicloud optimization,¹³ can allow continuous and iterative modernization of components that may otherwise become obsolete and increase system maintenance costs and vulnerabilities. In addition, digital resilience and cybersecurity are gaining importance because of the growing number of cyber incidents and the emergence of new vulnerabilities. Finally, with enhanced interoperability and access to digital identity and other personal data, MoFs are increasingly exploring privacy-enhancing technologies to facilitate secure exchange of information.

Table 3. Technologies and Practices for Modern System Architecture, Deployment, and Cybersecurity

Generic Task	Example of Specific Tasks	Example of Related Technologies and Practices
Building supportive digital ecosystem and IT architecture	Cross-functional: developing flexible and loosely coupled services to increase adaptability of business process and technology	Paraguay's FMIS is built on a microservices architecture, where services in the business layer are developed using Java and Spring and deployed using Docker. ¹ Although not as widely adopted in PFM, serverless computing can further enhance flexibility by requiring the cloud service provider to handle server management and allowing developers to focus on coding. Edge computing can complement this system, bringing applications closer to data sources.
Deploying digital solutions	Cross-functional: integrating various digital components	In Honduras, the MoF has been considering the use of Kubernetes for deployment. Orchestrators such as Kubernetes enable the management of microservices architectures, often within a cloud environment, ensuring smooth communication between services.
Securing PFM systems	Cross-functional: considering security along all phases of development	Honduras also uses several security tools including Hashicorp Vault and integrates security checks into the CI/CD processes using Jenkins and ArgoCD. ² These practices align with DevSecOps principles, which can incorporate aspects of Zero Trust Security.

(continued)

¹² Loosely coupled components refer to system elements that interact through standardized interfaces while remaining independent in their internal functioning. This design principle ensures that changes in one component—such as upgrades, replacements, or functional enhancements—do not require extensive adjustments in others. Although loose coupling is a core characteristic of microservices architectures, it does not require a full microservices implementation; rather, it reflects an architectural discipline that can be applied in a range of systems. It represents a significant step beyond traditional modular approaches by enabling greater interoperability, resilience, and flexibility in how systems evolve over time.

¹³ Multicloud optimization refers to the strategic use of multiple cloud service providers to improve performance, resilience, cost-effectiveness, and interoperability. It enables institutions to distribute workloads across different providers based on comparative advantages—such as data locality, pricing, security features, or specialized services—while reducing dependency on any single vendor. Although multicloud environments can leverage containerization and other cloud-native architectures, they do not require full adoption of these models; rather, they represent an evolution from traditional single-provider or hybrid configurations toward more flexible, scalable, and risk-mitigating digital infrastructures.

Table 3. Technologies and Practices for Modern System Architecture, Deployment, and Cybersecurity (Continued)

Generic Task	Example of Specific Tasks	Example of Related Technologies and Practices
Ensuring data privacy	Cross-functional: protecting sensitive data and personal information used for decision making	Zero-knowledge proof can help maintain privacy by allowing a set of information to be validated without the underlying data. For example, it can enable G2P payments without exposing either transaction or personal data, such as the recipient's age, income, amount, and use of funds.

Source: Authors.

Note: CI/CD = continuous integration and continuous deployment; FMIS = financial management information system; G2P = government to person; IT = information technology; MoF = ministry of finance; PFM = public financial management.

¹ Paraguay's FMIS adopts a microservices architecture, an approach that organizes the system into small, independent services that communicate through standardized interfaces. This design allows individual services to be updated or scaled without affecting the entire system, thereby strengthening resilience and operational flexibility. Within this architecture, services in the business layer are developed using Java, a widely used programming language for enterprise applications, and Spring, a Java-based framework that supports the development of secure, scalable services. These services are deployed using Docker, a containerization platform that packages applications and their dependencies into portable, self-contained units, enabling consistent deployment across different environments and supporting continuous integration and delivery practices.

² Jenkins is an automation server that coordinates the building, testing, and validation of software changes to ensure they are reliable before deployment. ArgoCD is a deployment tool that automates the delivery of applications to Kubernetes environments, providing consistent, traceable, and controlled deployments. Together, these tools strengthen the reliability and governance of the development and deployment pipeline.

The advances in data analytics can now allow governments to shift their focus toward maximizing the value of data in PFM decision making. The goal of an FMIS is to enhance decision making by government authorities across all fiscal operations; however, legacy systems were traditionally designed primarily for compliance and reporting purposes. Table 4 highlights examples of both general and specific PFM tasks where mature and emerging digital tools can be used to generate smarter insights.

Table 4. Technologies and Practices to Enable Data Exploitation and Improve Decision Making in PFM

Generic task	Example of Specific Tasks	Example of Related Technologies and Practices
Analyzing data for insights and decision support	Performance budgeting: Analyzing expenditure trends and impacts for informed decision making	Business intelligence and data visualization tools are often used by ministries of finance to analyze and visualize financial data. AI can enable augmented analytics, assisting insight generation and explanation in these tools. Agentic AI can go a step further, orchestrating analyses and triggering actions or recommendations. As most PFM data have geographic attributes, Geographic Information System can also serve as a useful tool. In India, for example, the Geographic Information System is used to support the monitoring of different welfare programs as well as the recording of audit evidence.
Projecting or forecasting	Fiscal forecasting and budget preparation: improving accuracy of macrofiscal forecasting	AI has the potential to increase the accuracy and speed of forecasting and predictive analytics. Ministries of finance are exploring the use of machine learning to enhance their macrofiscal forecasting as well as cash flow forecasting, by including unstructured, high-frequency data to "nowcast" key economic indicators.
Assessing risks and scenarios (linked to uncertainties)	Treasury and cash management: mitigating risks in payment processing Fiscal risks management: Identifying financial risks and simulating scenarios	Also in Georgia, the Ministry of Finance developed a prototype AI application to manage risks in Treasury payments. In the green channel, where payment orders are automatically processed, 42 machine learning models analyze historical data to detect anomalies. In the "red channel," where high-risk payment orders are scrutinized, it aims to improve the quality of review. AI tools can also support the identification and management of fiscal risks, with the potential for using generative AI in advanced simulation.

Table 4. Technologies and Practices to Enable Data Exploitation and Improve Decision Making in PFM (*Continued*)

Generic task	Example of Specific Tasks	Example of Related Technologies and Practices
Creating and updating content	Accounting and financial reporting: generating financial reports and statements	Generative AI can be used to produce and format documents, together with other AI technologies such as natural language processing and computer vision that can automate data gathering. Brazil's Treasury is exploring these capabilities to produce written outputs, including contracts and technical notes related to debt under the Salary Variations Compensation.

Source: Authors.

Note: AI = artificial intelligence; PFM = public financial management.

Government portals and open data initiatives have become increasingly important for enabling the disclosure and reuse of fiscal data for transparency and accountability (Table 5). Over the past 20 years, the general understanding of how to effectively design fiscal transparency portals has evolved, along with the open government agenda. Studies suggest that these portals should provide sufficient data granularity to be relevant (de Renzio and Mastruzzi 2016). At the same time, they should incorporate progressive disclosure based on a clear understanding of their audience to avoid data overload (Gracida Sumano and Rivero del Paso 2019).

Table 5. Technologies and Practices to Enhance Fiscal Transparency

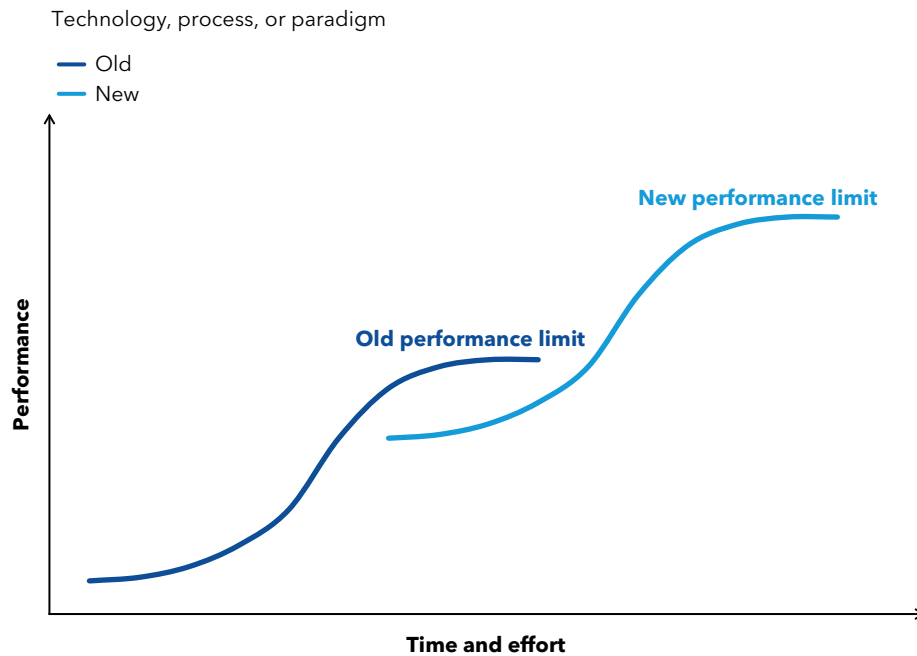
Generic Task	Example of Specific Tasks	Example of Related Technologies and Practices
Making information accessible to the public	Dissemination of fiscal information: providing interactive budget visualizations on a government website	Fiscal transparency portals and other online platforms can incorporate several features—such as mixed or augmented reality, data storytelling, and data visualization tools—to effectively communicate financial data to the public. For example, the Mexican government publishes its public investments portfolio in georeferenced platforms, which allow monitoring of public works using Geographic Information Systems .
Publication of open data	Dissemination of fiscal information: publishing government financial data in a standardized and accessible format	Countries, including South Africa and Uruguay, publish their government budget and spending data using the Open Fiscal Data Package, one of the internationally recognized Data Standards . Governments can have a section dedicated to Open Data in their fiscal transparency portal and use Application Programming Interface to ensure open access, as well.

Source: Authors.

C. Maturity and Speculative Enthusiasm around Emerging Technologies

The maturity of a technology heavily influences its feasibility and practicality, which in turn shapes the decision to adopt a specific technology for a given PFM task. Lack of maturity of some emerging technologies is recurrently a major factor for resistance to their adoption (Batubara, Ubacht, and Janssen 2018; Choi and others 2020; Wang and others 2022).¹⁴ This is because nascent technology comes with initial or inherent flaws, which may be reduced as it matures. The technology S curve (Figure 6) suggests that the performance of a given technology remains low and grows slowly when it is first invented or discovered; with deeper understanding and greater adoption, however, it improves rapidly and surpasses an existing technology (Foster 1986; Gochermann 2022). Navigating this period of discontinuity—during which newer, higher-performing technologies replace mature systems—poses a challenge to governments, which must determine the appropriate time to make the switch to derive the maximum value possible.

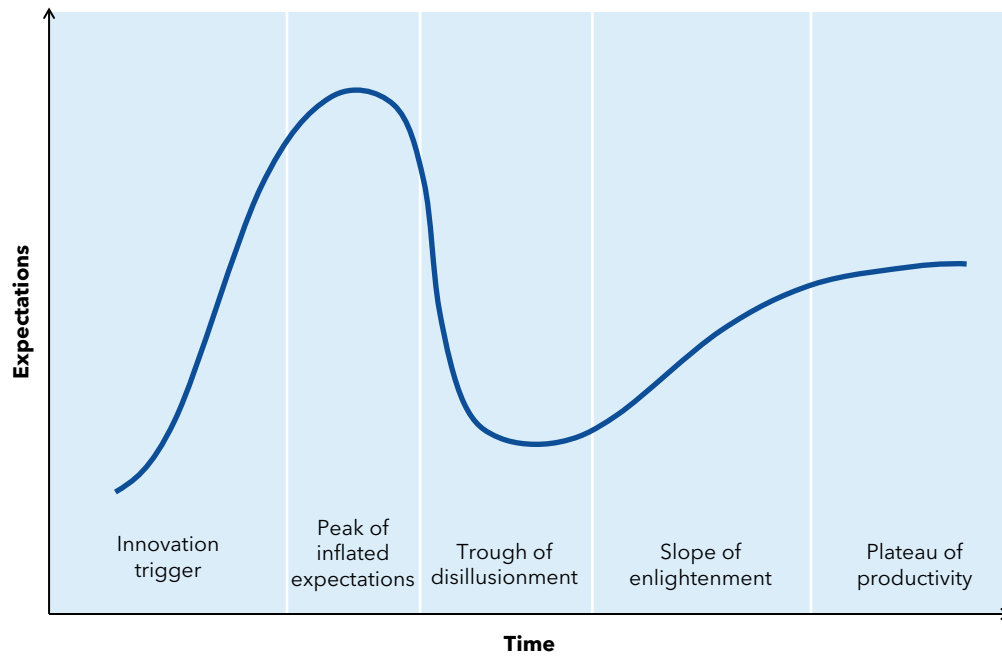
¹⁴ Technological maturity was also found to be correlated with other factors that play crucial roles in determining the pathways organizations can realistically pursue, such as compatibility, scalability, availability of technical expertise and resources, infrastructure readiness, perceived ease of use, and a reduction in perceived risks and security concerns.

Figure 6. Technology S Curve and Benefits of New Technologies

Source: Authors, adapted from Foster (1986) and Goehermann (2022).

Governments should also be cognizant of speculative enthusiasm that can accompany new technologies, which is closely related to their maturity. Often, when a new technology is introduced, it attracts attention because of its novel features or capabilities. As early success stories are highlighted by the media, enthusiasm builds up, and the technology reaches the “peak of inflated expectations” (Gartner 2024). Technology vendors may make exaggerated promises and fuel a sense of urgency to encourage adoption of their solutions, reinforcing speculative enthusiasm. As the technology fails to deliver on these unrealistic expectations, disappointments lead to a sharp decline in interest. With more focused efforts, the technology further matures, and more practical applications emerge—demonstrating real-world benefits. This increases the rate of adoption, and the technology reaches the “plateau of productivity” and becomes a mainstream solution. Some technologies reach this final stage faster than others; some never do, as they disappear or get replaced by other solutions. Figure 7 illustrates this cycle.

Figure 7. Gartner’s Technology Hype Cycle



Source: Authors, adapted from Gartner.

Understanding where an emerging technology is on the S curve and the hype cycle helps to correctly assess the risks and benefits of its adoption in PFM. With these complementary frameworks, organizations can separate hype from real drivers of performance and better understand the current limitations and expected gains of a given technology—helping to set realistic goals and make informed decisions about its adoption. Prioritizing one that has matured enough to move past the peak of inflated expectation, for example, may help avoid hype-based adoption of technologies that are not yet ready to be implemented or deliver tangible benefits in each country. However, although the S curve and hype cycle help to explain the maturity and expectations of emerging technologies, available analyses that focus on industry trends can miss important nuances that affect their adoption, specifically in PFM. For example, although computer vision has reached the plateau of productivity according to Gartner, it has limited use cases and has not reached that state in PFM. Therefore, MoFs may find it beneficial to complement these frameworks with additional analyses of risks and benefits. This is further addressed in the following section on the VM approach.

III. VM Approach to Harnessing Emerging Technologies

As discussed in the previous section, it is important to be cautious of speculative enthusiasm while considering the potential benefit of harnessing emerging technologies for improved PFM performance. Given that there are diverse technological alternatives to address a given problem, this section provides a conceptual framework to help bring together and balance the promise and the hype of adopting emerging technologies to achieve a specific PFM objective.

To support the decision-making process for maximizing value from adopting new technology, this note provides a framework based on two key elements: (1) expected gains from the technology considering the organization's strategic goals and (2) feasibility of realizing those gains. This approach can ensure an examination of the actual needs and constraints of the government prior to technology adoption, preventing one-off or unsustainable digital investments that may arise from the pressure to be seen as technologically advanced or the desire to keep up with global trends. These two key elements are summarized into a VM formula that helps quantify the overall value of a given technology. The VM formula in equation (1) does not need to be applied in every case of technology consideration; instead, it provides a conceptual framework to help structure and guide decision making:







$$VM = G \times F, \quad (1)$$

where G is the score for potential gains of technology adoption, ranging from 1 to 10, measured as the strategic alignment and weighted sum of G_j across different gain areas presented in the Section III.A. F is the score for practical feasibility of technology adoption, ranging from 1 to 10, measured as the weighted sum of F_k across different factors of risk and viability presented in the Section III.B.

A. Identifying and Measuring Potential Gains

Adopting emerging technologies can bring many measurable gains to PFM, ranging from cost savings to stronger cybersecurity. Such benefits can relate to outcomes, outputs, processes, accountability, security, and futureproofing (Table 6). To clearly gauge these gains, it is crucial to define SMART (specific, measurable, achievable, relevant, and time-bound) indicators, with baseline measurements to track progress. Baselines provide a starting point against which progress can be measured, helping not only to understand the effectiveness of efforts to adopt emerging technologies but also to make course corrections and informed decisions to keep moving in the right direction.

Table 6. Potential Gains from Emerging Technologies and Sample Indicators

 Outcome Gains	 Output Gains	 Process Gains
<p>Newer technologies can empower governments to make data-driven decisions, informing policymaking and enabling timely interventions. They can also enhance public service delivery and citizen experiences.</p> <p>Sample indicators:</p> <ul style="list-style-type: none"> • Percentage improvement in the quality of decision making (for example, accuracy of fiscal forecasting, budget credibility) • Reduced time overruns in public investment projects • Satisfaction with public services improved through technology adoption 	<p>Newer technologies can enable governments to collect, store, and analyze data more effectively, enhancing data availability, reliability, and accuracy and helping generate more effective, higher-quality, or new PFM outputs.</p> <p>Sample indicators:</p> <ul style="list-style-type: none"> • Speed of decision making (for example, measured by the time taken to compile data and indicators for key decisions) • Percentage of milestones achieved in time in public investment projects • Percentage of legal requirements fully complied using technology 	<p>Newer technologies can help automate routine tasks, reengineer business processes, and eliminate redundancy, leading to increased efficiency, cost savings, and streamlined operations.</p> <p>Sample indicators:</p> <ul style="list-style-type: none"> • Percentage reduction in time spent on routine tasks • Cost savings from process automation and reengineering • Reduction in time to process payments once goods or services are received • Enhanced employee retention (by freeing them from repetitive tasks)
 Accountability Gains	 Security Gains	 Futureproofing Gains
<p>Newer technologies can help promote transparency and governance, by improving data generation, exploitation, and disclosure or publication, as well as reduced scope for data manipulation.</p> <p>Sample indicators:</p> <ul style="list-style-type: none"> • Increase in fiscal transparency scores • Satisfaction with government provided information on PFM • Improved data access for internal stakeholders (by breaking down functional and agency- or department-level silos) 	<p>Obsolete technologies that are no longer supported can create cybersecurity risks and vulnerabilities. Newer technologies often offer stronger cybersecurity measures, helping safeguard sensitive data and protect critical PFM systems as well as underlying IT infrastructure.</p> <p>Sample indicators:</p> <ul style="list-style-type: none"> • Reduction in cybersecurity incidents or data breaches • Decrease in vulnerabilities associated with obsolete technologies 	<p>Adopting newer technologies helps governments to stay relevant and prepared for future challenges, ensuring that their systems and processes remain effective and efficient over time.</p> <p>Sample indicators:</p> <ul style="list-style-type: none"> • Progress toward achieving the advanced level of maturity for selected functional, IT architectural, and governance and management attributes in the digital solutions guidelines for PFM

Source: Authors.

Note: IT = information technology; PFM = public financial management.

Under the VM approach, where emerging technologies are strategically harnessed to achieve PFM objectives, the overall potential gain is determined by not only the magnitude of their effect but also the relative importance of each area. In this sense, G is closely linked with visualizing the alignment with the organization's strategic objectives. For example, governments aiming to improve their fiscal transparency will find accountability gains more aligned with this goal and more valuable than security gains, whereas those that have experienced a data breach may prioritize security gains over others. Based on the premise of such purposeful technology adoption, and using the six key areas presented in Table 6, G in equation (1) is provided as

$$G = \sum_{j=1}^6 (G_j \times W_j^G) = (G_P \times W_P^G) + (G_{OP} \times W_{OP}^G) + (G_{OC} \times W_{OC}^G) + (G_A \times W_A^G) + (G_S \times W_S^G) + (G_F \times W_F^G), \quad (2)$$

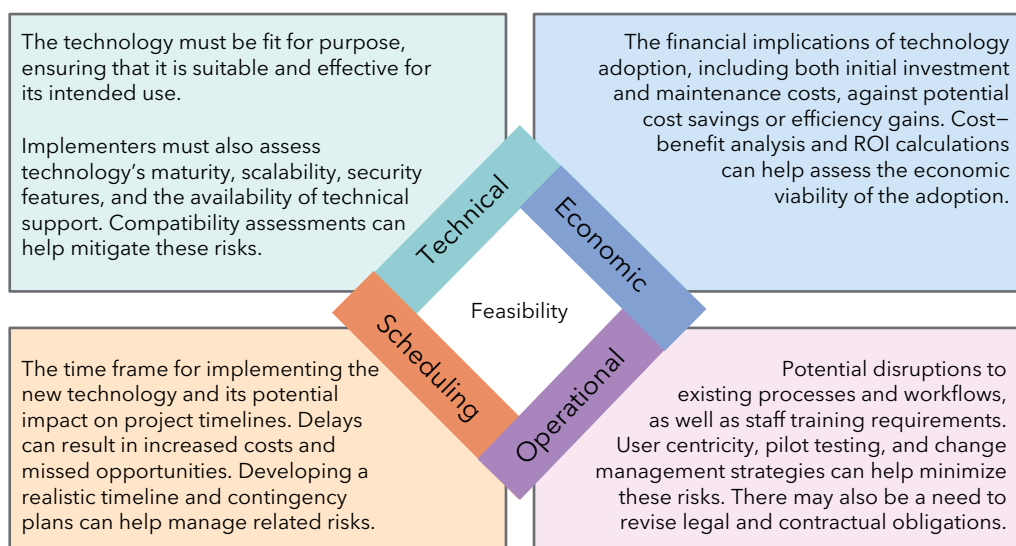
where G_j is the gain score (scale of 1 to 10) for each of the six areas, with G_P referring to gains in process, G_{OP} in output, G_{OC} in outcome, G_A in accountability, G_S in security, and G_F in futureproofing. W_j^G is the weight assigned for each area, reflecting its importance to the MoF and organization's mission and priorities for the digitalization of PFM, with $W_P^G + W_{OP}^G + W_{OC}^G + W_A^G + W_S^G + W_F^G = 1$.

To maximize the value of adopting emerging technologies, a reassessment and reengineering of business processes and legal reforms should accompany it. Advanced digital transformation typically yields benefits that extend beyond cost savings and productivity gains. A common pitfall is automating manual tasks without evaluating existing processes in light of new technological capabilities. Reengineering can optimize or streamline current workflows for easier or more advanced automation. Legislation governing PFM might need to be updated to allow changes in processes based on technological advances, which could otherwise slow down the adoption of newer technologies.¹⁵ Considering these factors in the calculation of can help measure the full potential of emerging technologies and promote a holistic approach to their adoption, overcoming structural and regulatory barriers.

B. Assessing Feasibility of Adopting New Technology

Governments can encounter various challenges that can hinder the successful integration of new technologies in PFM, preventing them from fully realizing their potential benefits. Thus, to maximize and sustain the value, it is essential to assess its viability prior to implementation. Major factors include technical, economic, operational, and scheduling feasibility (Figure 8). Technically, the new technology should be compatible with existing or anticipated infrastructure and fit for its intended purpose.¹⁶ Economically, it should ensure effective allocation of resources through a satisfactory return on investment. Operationally, disruptions to current processes and workflows as well as requirements for staff training, legal changes, and change management should be considered. The time frame for implementation should be realistic to avoid any rush or delay that can undermine its effectiveness.

Figure 8. Feasibility Factors for Adopting New Technologies in PFM



Source: Authors.

Note: PFM = public financial management; ROI = return on investment.

¹⁵ Common current examples of this roadblock to optimization are the acceptance of digital records as legal documents for auditing purposes, which force certain manual processes to be maintained, including physical exchange of information.

¹⁶ A technology described as "fit for purpose" means it is suitable and effective for its intended task. Key factors include efficiency (performing tasks without unnecessary delays), effectiveness (reliably achieving desired outcomes), usability (being user-friendly), and adaptability (flexibility to accommodate changes). In essence, it meets the specific needs and expectations of its users in a practical manner.

As with each area of gains, the weight assigned to each feasibility factor can also vary based on the PFM agency’s specific circumstances or objectives. For example, those with significant budget constraints may prioritize economic feasibility and technologies with the highest return on investment. Pioneers, with a strong culture of innovation, will likely rate operational feasibility higher but consider it less critical in their decision making compared with other types of adopters. In equation (1) is, therefore, provided as

$$F = \sum_{k=1}^4 (F_k \times W_k^F) = (F_T \times W_T^F) + (F_E \times W_E^F) + (F_O \times W_O^F) + (F_S \times W_S^F), \tag{3}$$

where F_k is the feasibility score (scale of 1 to 10) for each of the four factors, with F_T referring to technical feasibility, F_E to economic feasibility, F_O to operational feasibility, and F_S to scheduling feasibility. W_k^F is the weight assigned for each factor, reflecting its importance to the organization’s innovation process based on the specific circumstances and objectives, with $W_T^F + W_E^F + W_O^F + W_S^F = 1$.

Whenever possible, feasibility scores should be assigned with a longer-term perspective, taking into account the practicality and sustainability of adopting new technologies. Considering maintenance implications can help to avoid rushing to adopt new technologies based on speculative enthusiasm or as a result of a “solution in search of a problem” mindset. Promising too much too soon can lead to unrealistic expectations, and when they are not met, the project may need to be scaled down or even canceled, resulting in high sunk costs. In addition, poor project management and oversight can cause problems after implementation, cost overruns, or systems becoming more expensive than the ones they replaced.¹⁷ By conducting comprehensive feasibility analyses that are unbiased and have a longer-term outlook, governments can navigate some of these challenges, balancing innovation with sustainability. Innovation labs and sandbox approaches that allow experimenting with new technologies show potential in further reducing the risks associated with adopting a technology early (Annex 1).

Feasibility analyses help make informed decisions under the VM approach and identify risks emerging technologies pose. Although traditional technologies also come with inherent risks, emerging technologies often introduce new vulnerabilities and challenges. The rapid pace of technological change, the complexity of systems involved, and the lack of established best practices and regulations may exacerbate these risks. Governments must be proactive in assessing and mitigating these risks to ensure a secure and effective modernization of PFM systems. Table 7 highlights several risks that may be identified in feasibility analyses, together with potential mitigation strategies.

Table 7. Key Risks to Mitigate When Adopting Emerging Technologies in PFM

Types of Risks	Examples of Specific Risks	Examples of Mitigation Strategies
Cybersecurity risks (technical)	<ul style="list-style-type: none"> • Data breaches and unauthorized access to sensitive financial information • Vulnerability to cyberattacks, such as malware, phishing, and hacking, especially for newer, untested technologies 	<ul style="list-style-type: none"> • Implementing a comprehensive cybersecurity framework (for example, National Institute of Standards and Technology, ISO 27001) • Conducting regular vulnerability assessments and penetration testing • Enforcing strong access controls and data encryption protocols

(continued)

¹⁷ For example, the Auditor General of Canada determined that the Phoenix pay system—which aimed to deliver cost savings and efficiency improvements in processing payroll for government employees—ended up being “less efficient and more costly than the 40-year-old system it replaced” because of project mismanagement. The audit identified the lack of critical functionality, inadequate testing, limited user consultation, and absence of oversight as critical issues ([Auditor General of Canada. 2018. Report 1 - Building and implementing the Phoenix Pay System](#)).

Table 7. Key Risks to Mitigate When Adopting Emerging Technologies in PFM (*Continued*)

Types of Risks	Examples of Specific Risks	Examples of Mitigation Strategies
Data privacy and sovereignty risks (technical)	<ul style="list-style-type: none"> Misuse or unauthorized disclosure of citizens' personal and financial data Concerns over data sovereignty and the storage of sensitive data in foreign jurisdictions Potential for government surveillance and the erosion of civil liberties 	<ul style="list-style-type: none"> Establishing robust data governance framework and data encryption and security protocols Conducting regular data privacy assessments Reviewing local and international laws and ensuring compliance Using data localization strategies if necessary
Legal and regulatory risks (operational)	<ul style="list-style-type: none"> Lack of clear legal frameworks governing the use of emerging technologies Difficulty in ensuring compliance with existing financial regulations Potential for unintended consequences and legal liabilities of new technologies 	<ul style="list-style-type: none"> Establishing a clear framework and policy for legal and regulatory compliance Engaging legal and regulatory experts upfront in the planning stage Staying updated with relevant laws and regulations (both local and international)
Skill and knowledge gaps (operational)	<ul style="list-style-type: none"> Shortage of qualified personnel with expertise in emerging technologies Difficulty in keeping pace with rapidly evolving technological landscape Need for continuous training and capacity building of public officials 	<ul style="list-style-type: none"> Investing in training and upskilling Collaborating with other stakeholders (such as providing specialized programs at educational institutions or hiring consultants) Developing knowledge management systems to capture and transfer expertise in the future
Ethical risks (operational)	<ul style="list-style-type: none"> Algorithmic bias and the risk of discriminatory outcomes in automated decision making Lack of transparency and accountability in the use of emerging technologies Potential for unintended consequences and negative societal effects 	<ul style="list-style-type: none"> Developing a code of ethics Establishing an ethics committee or an advisory body to help enforce the code Conducting and publishing regular ethics audits Providing ethics training
Change management risks (operational)	<ul style="list-style-type: none"> Resistance to change and the need for organizational cultural shifts Difficulty in aligning new technologies with existing processes and workflows 	<ul style="list-style-type: none"> Developing a comprehensive change management plan Engaging employees early on Providing clear communications and support throughout the transition
Vendor lock-in risks (economic, operational)	<ul style="list-style-type: none"> Dependence on proprietary systems and the difficulty in switching vendors Potential for vendor instability or acquisition, especially when dealing with start-ups 	<ul style="list-style-type: none"> Developing a multivendor strategy and avoiding overreliance on a single provider Ensuring data portability and interoperability through open standards Negotiating flexible licensing terms and establishing exit clauses
Interoperability concerns (technical, operational)	<ul style="list-style-type: none"> Difficulty in ensuring seamless integration and data exchange with legacy systems Lack of standardization and the need for common protocols and formats 	<ul style="list-style-type: none"> Adopting available data standards Conducting interoperability testing Collaborating with vendors to ensure compatibility with legacy systems

Source: Authors.

Note: PFM = public financial management.

C. Making Decisions Based on the VM Approach

The VM formula can be applied to different scenarios to inform the decision-making process of adopting emerging technologies, enabling governments to assess their options systematically. For example, it can be applied to a single technology to estimate the value added from its potential use. It can also be applied to multiple technologies, either separately to compare different options based on their VM scores or together to quantify any synergies from integrating them. Annex 2 illustrates how to apply the formula in various scenarios.

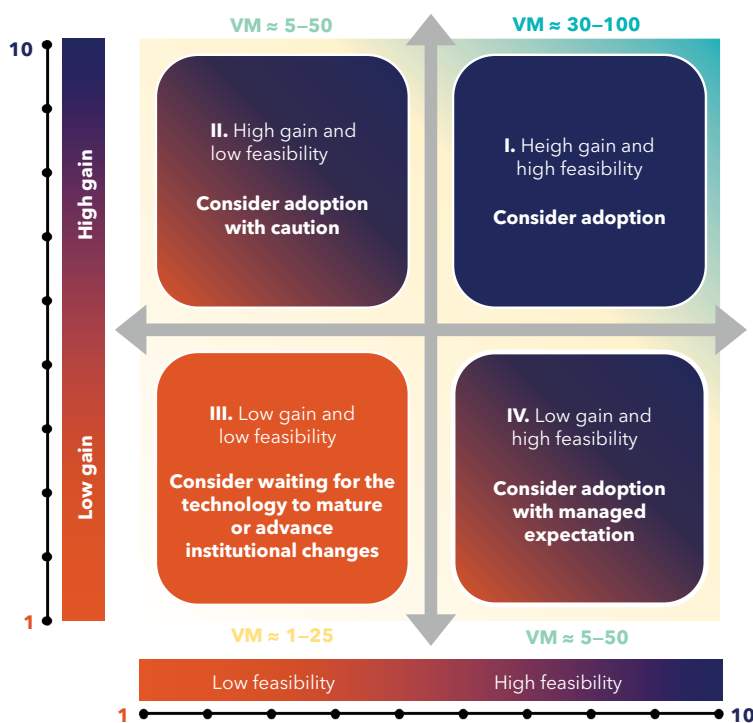
In addition to the VM score, its individual components can help guide the decision as well as the approach to adopting technology. Establishing specific parameters for high and low threshold values of each component can be useful in this regard (Table 8). Two options with the same VM score can have differing levels of gain and feasibility, with potentially different paths to consider (Figure 9). An option with high G and low F scores would require careful planning, accompanied by a thorough risk assessment. It may also benefit from a phased or pilot approach, whereas an option with low G and high F scores may not benefit from a similar incremental approach but instead from setting realistic milestones and ensuring smooth integration with other systems. If countries find that they are scoring lower consistently on a specific feasibility factor, this may affect their longer-term approach to adopting new technologies in PFM and the path toward their objectives.

Table 8. Parameters for Value Maximization

Component	Range	Low		High	
		Threshold	Examples	Threshold	Examples
Gain	1-10	≤4	Cost savings of less than 5 percent; no improvement expected in transparency scores	≥7	Reduction of 50 percent in processing time; protection against data breach and business continuity
Feasibility	1-10	≤4	Downtime of 20 percent expected; more than one year to implement	≥7	Strong compatibility with existing systems; clear and positive return on investment
Value	1-100	<30	Low gain or feasibility	>50	High gain or feasibility

Source: Authors.

Figure 9. Gain-Feasibility Matrix

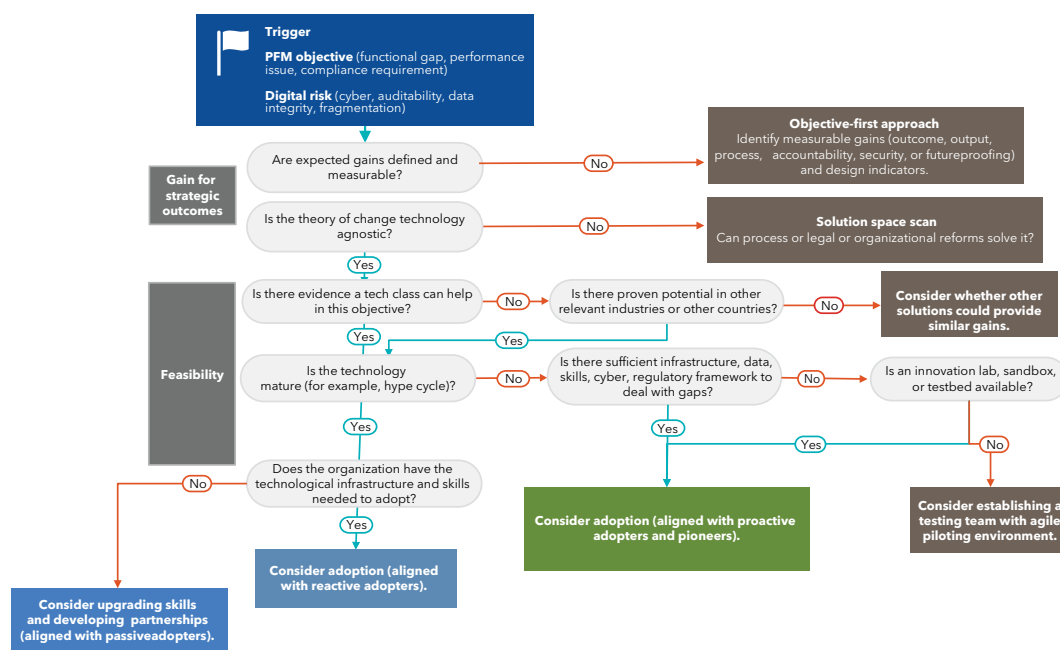


Source: Authors.

Note: VM = value maximization.

Even when comprehensive analyses of gain and feasibility are not possible, the approach and considerations discussed in this note can help policymakers formulate key questions to answer prior to the final decision on adopting emerging technologies. At the very least, they should consider their broader strategic goals in PFM, expected gains from specific technologies, and the feasibility of adoption given the unique circumstances of their country, organization, and PFM framework. These relate to the effect on specific PFM tasks and outcomes, the maturity and speculative enthusiasm of the technology in question, and the distinctive contextual factors that shape the organization's approach to adopting technology, including its culture and risk appetite. Figure 10 presents a sample decision tree that can be adapted by an MoF or a government organization, by adding other key factors such as the level of investment required (that is, economic feasibility).

Figure 10. Decision Tree for Emerging Technology Adoption in PFM



Source: Authors.

Note: PFM = public financial management.

As implied in the decision tree (Figure 10), digital transformation of PFM requires continuous monitoring and improvement of both technologies and processes. Although systems were previously developed to stay in place for several years with only maintenance and operational support, the technology landscape is now evolving at an increasingly faster pace. An organization's digital strategy should thus allow for an agile, iterative, and continuous improvement of business processes, technology selection, and upskilling to enable a constant level of optimization efforts (Amaglobeli and others 2023). Establishing a mechanism for post-implementation validation and calibration—such as a feedback loop to compare realized outcomes against predicted scores, adjusting weights and scores based on lessons learned for future projects—could help to continuously refine the decision process for innovation and adoption of technologies in PFM.

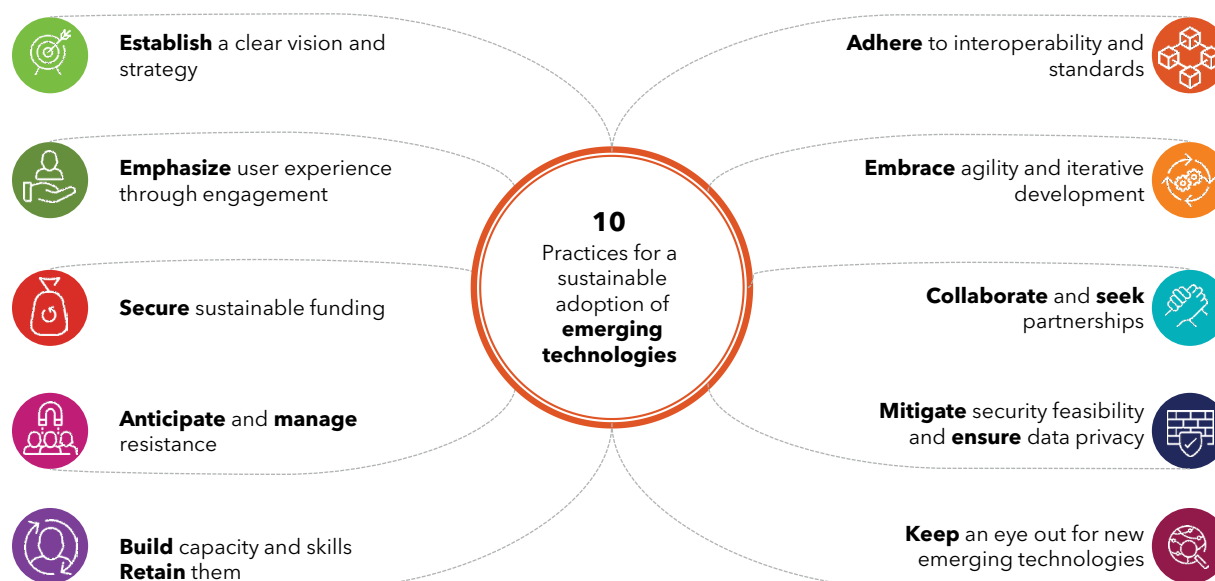
To help policymakers and PFM practitioners understand key technologies and their relevance for PFM more easily, this note is complemented by technology cards in infographics format. These cards aim to bridge the gap between functional and technology experts, making it easier to identify technologies suited to specific PFM tasks, along with their potential benefits and adoption requirements. Given the rapid pace of technological development, the scope of these cards will be expanded to include more emerging technologies in the future.

IV. Ensuring Sustainable Adoption of Emerging Technologies in PFM

This note discusses a vision for digital PFM of the future, exploring the role of emerging technologies, and proposing a VM approach to their adoption. Although some of the technologies considered as emerging are widely adopted in the private sector, they are incipient in the public finance area. Moreover, the integration of these innovations has often faced significant challenges and costly failures, which have hindered technological progress in PFM. Given the current state and historical challenges, it is essential to adopt new technologies in a sustainable manner.

The sustainable adoption of emerging technologies in PFM hinges on a blend of organizational, operational, and financial factors, all connected to a VM approach. Figure 11 highlights 10 practical considerations to help MoFs leverage technology while managing potential risks. First, a clear vision is essential to guide the transition, with measurable gains as discussed in the previous section. It is also important to foster an organizational culture that encourages experimentation and allows for mistakes and unknown risks, especially in the context of adopting emerging technologies. Focusing on user experience ensures that technology solutions meet the needs of end users, driving broader adoption. Once funding is secured—whether through dedicated mechanisms, partnerships with the private sector, or international organizations—managing resistance through champions or advocates and building the necessary skills through training will be crucial. During implementation, embracing core principles such as interoperability, agility, and collaboration, while mitigating security and data privacy risks, will help navigate technical and organizational challenges. Remaining informed about post-implementation technological developments ensures ongoing innovation and future preparedness. These practices are interconnected, underscoring the need for a holistic, longer-term approach to successfully adopting emerging technologies. Annex 3 provides a detailed description of each practice.

Figure 11. Practices for Sustainable Adoption of Emerging Technologies



Source: Authors.

Annex 1. Exploring New Technologies in Safe Environments

Structured frameworks such as innovation labs, regulatory sandboxes, and technology testbeds can provide a controlled, risk-mitigated environment for experimentation and assessment of emerging technologies. These platforms facilitate a symbiotic relationship between and across government agencies and the private sector.

1. Government Innovation Labs: A Multidisciplinary Approach

Innovation labs, or hubs within government settings, serve as incubators for technological exploration and solution development, drawing upon the expertise of technologists, academics, and industry specialists. These labs function as collaborative spaces where innovative ideas can be developed, tested, and refined to address specific public sector challenges.

The US 18F Lab was established by the General Services Administration to help agencies develop user-centric digital services that improve the public's interaction with the government. The lab is composed of designers, software engineers, strategists, and product managers. In 10 years, they have assisted 34 agencies in completing 455 projects that improved government digital services.

2. Regulatory Sandboxes: Facilitating Innovation within Regulated Sectors

Regulatory sandboxes are particularly popular in heavily regulated domains such as financial sectors, as they enable the exploration of innovative products, services, or business models under relaxed regulatory requirements, under specific conditions. Public financial management agencies may consider the use of such an environment when exploring solutions with private sector actors.

Dubai Financial Services Authority opened an Innovation Testing License Program to foster fintech innovations within controlled parameters, supporting the creation of new financial services and products.

The Monetary Authority of Singapore opened a fintech regulatory sandbox to provide a pragmatic framework for testing financial technologies, such as blockchain for cross-border payments, under regulatory oversight, fostering innovation while safeguarding systemic integrity.

3. Technology Testbeds: Testing Specific Technologies

Governments or agencies can establish dedicated testbeds for specific technologies, for instance, to explore the use of blockchain, or artificial intelligence (AI). These testbeds provide a controlled environment for companies and researchers to experiment with new applications and use cases, allowing the ministry to assess their potential benefits and risks.

The government of Japan has established RIKEN Center for Advanced Intelligence Project to conduct research on AI and machine learning, and to collaborate with industry partners to develop AI applications in various domains.

Sources: Bains and Wu 2023; GSA 2024; DFSA 2021; Tönurist, Kattel, and Lember 2017; [MAS Website](#); and [Japan's Riken Website](#).

Annex 2. Sample Application of the Value-Maximization Formula

Formula Recap:

$$VM = G \times F = \sum_{j=1}^n (G_j \times W_j^G) \times \sum_{k=1}^m (F_k \times W_k^F) \quad (1)$$

$$G = \sum_{j=1}^6 (G_j \times W_j^G) = (G_{OC} \times W_{OC}^G) + (G_{OP} \times W_{OP}^G) + (G_P \times W_P^G) + (G_A \times W_A^G) + (G_S \times W_S^G) + (G_F \times W_F^G) \quad (2)$$

$$F = \sum_{k=1}^4 (F_k \times W_k^F) = (F_T \times W_T^F) + (F_E \times W_E^F) + (F_O \times W_O^F) + (F_S \times W_S^F) \quad (3)$$

Scenario 1: Evaluating the Adoption of Technology

Country context: The country's GovTech Maturity Index score was slightly below the average of its income group in 2022. The government has since worked on addressing some gaps, publishing a national digital transformation strategy in early 2024. Based on this strategy, the ministry of finance (MoF) has put forward a Five-Year Plan to gradually modernize public financial management (PFM). However, the country's high and rising public debt levels present significant budget constraints. The MoF is therefore looking for innovative ways to enhance efficiency but is both unwilling and unable to take significant risks.

PFM objective and technology being considered: The MoF is considering the implementation of blockchain-based smart contracts to support automation and control in the management of major construction projects. Currently, a centralized e-procurement platform facilitates implementation, enabling contractors to submit their progress updates and invoices online. Procurement officers monitor the submissions and manually process payments after confirming that milestones are completed. This has been both time-consuming and challenging, causing delays and errors. In this context, smart contracts will be used to automate and enhance progress-based payments. Status for project milestones will be recorded and updated on a blockchain, which will be monitored by the smart contract. Once it verifies their completion, it will integrate with the treasury system to trigger payments based on the associated terms and conditions.

Step 1. Identify and measure potential gains.

- The MoF's medium-term strategy aims to improve efficiency and governance in public expenditure management. Public investment, which accounts for 20 percent of total spending, is a high-priority area in this regard. The adoption of smart contracts will reduce manual interventions and ensure the physical progress of infrastructure projects through timely payments, aligning well with the broader PFM objectives.
- Smart contracts are estimated to reduce processing time by 50 percent and lead to 15 percent cost savings from reductions in administrative overhead. A high score is assigned for process gains, at $G_P = 9$.
- Smart contracts will reduce the time required to review relevant information required for progress monitoring, as well as reduce the risk of noncompliance in payments. Automating payments linked to the physical progress of projects is also expected to increase the number of milestones achieved. $G_{OP} = 8$.
- Smart contracts may improve accuracy and reliability in reporting and decision making by reducing the risk of human error and biased interpretation. Progress payments may provide a stronger incentive for timely execution, leading to fewer time overruns. The potential in this area is not yet clearly proven in the PFM context, however. A slightly lower score is assigned, at $G_{OC} = 7$.

- The blockchain ensures an immutable record of transactions within smart contracts, but it does not guarantee full accountability, especially without a broader decentralized infrastructure. $G_A = 7$.
- All four areas of potential gains are important components of the agency's overall objectives. Equal weights are assigned to each area. $W_P^G = 0.25$; $W_{OP}^G = 0.25$; $W_{OC}^G = 0.25$; $W_A^G = 0.25$.
- A more comprehensive analysis may be conducted to capture potential gains in the remaining areas. For the purpose of this exercise, the overall gain score is calculated using the four areas. $G = (G_P \times W_P^G) + (G_{OP} \times W_{OP}^G) + (G_{OC} \times W_{OC}^G) + (G_A \times W_A^G) = (9 \times 0.25) + (8 \times 0.25) + (7 \times 0.25) + (7 \times 0.25) = 7.75$.

Step 2. Assess feasibility of technology adoption.

- Existing systems for procurement and payment are expected to pose significant compatibility challenges, as none of the existing systems are blockchain based, which could pose an interoperability challenge. The solution itself is not yet mature or widely adopted. Although not impossible, it would be difficult to implement the new solution from a technical perspective. $F_T = 3$.
- Initial costs of implementing smart contracts are estimated to be \$100,000. Annual savings are expected to be \$50,000, with potential large spillover effects from better-managed construction projects. Costs for maintenance and integration (for example, setting up application program interfaces and middleware to facilitate data exchange between the blockchain and the procurement platform) are not yet clear but are expected to be substantial. Although the overall return on investment is expected to be positive, economic feasibility is rated to be medium given this uncertainty. $F_E = 6$.
- Staff will need to be trained on the new system and blockchain technology. The lack of a clear legal and regulatory framework for not only smart contracts but also blockchain presents additional challenges. $F_O = 3$.
- Considering the time required to build the necessary interoperability tools (application program interfaces), implementation is estimated to take more than 18 months, with high probability of further delays. Although scheduling or timeframe feasibility is low, it is assigned a slightly higher score, given the MoF's commitment to preparing a clear action plan. $F_S = 4$.
- Given the high level of public debt and budget constraints, a larger weight is assigned to economic feasibility. $W_T^F = 0.2$; $W_E^F = 0.4$; $W_O^F = 0.2$; $W_S^F = 0.2$.
- Calculate the overall feasibility score: $F = (F_T \times W_T^F) + (F_E \times W_E^F) + (F_O \times W_O^F) + (F_S \times W_S^F) = (3 \times 0.2) + (6 \times 0.4) + (3 \times 0.2) + (4 \times 0.2) = 4.4$.

Step 3. Make decisions based on VM and analysis results.

- Calculate VM: $G \times F = 7.75 \times 4.4 = 33$.
- VM score is in the lower range, with high gain but low feasibility scores. Although the use case is strategically aligned with PFM objectives and can generate important benefits, the lack of underlying decentralized node infrastructure introduces significant feasibility concerns. Cautious with low risk appetite, the MoF decides not to adopt smart contracts until the efforts required to seamlessly integrate the solution with current systems or develop a more appropriate infrastructure are better understood. In the immediate future, it will collaborate with technology providers and academic institutions to harness expertise and address feasibility gaps.

Scenario 2: Comparing Two Available Technology Options

Technology options being considered: The MoF has two options for automation. Option A is the blockchain-based solution considered in the first scenario. Option B is a similar self-executing program, which will be created and stored within the existing centralized platform. When a milestone is reported as complete by a contractor, the program will notify the procurement officer for verification and, upon approval, connect to the treasury system to trigger payments.

Step 1. Identify and measure potential gains for each option.

- Option A: $G_A = 7.75$ as in the first scenario.
- Option B: Process gains are expected to be slightly smaller because of the remaining needs for manual approval, but just like option A, this solution offers vast potential to improve PFM outputs and outcomes while streamlining processes. In addition, it will leverage features such as audit logs, role-based access control, digital signatures, and compliance checks to improve accountability. $G_B = (G_{B,P} \times W_{B,P}^G) + (G_{B,OP} \times W_{B,OP}^G) + (G_{B,OC} \times W_{B,OC}^G) + (G_{B,A} \times W_{B,A}^G) = (8 \times 0.25) + (8 \times 0.25) + (7 \times 0.25) + (7 \times 0.25) = 7.5$.

Step 2. Assess feasibility of technology adoption for each option.

- Option A: $F_A = 4.4$ as in the first scenario.
- Option B: The non-blockchain solution presents fewer technical challenges, as it is easier to integrate with existing platforms and can be implemented using more mature technologies. Savings may be smaller, but so are upfront and integration costs, making the return on investment clear and positive. There are no major regulatory obstacles, staff training needs are more manageable, and change management risks are smaller. The timeline is also shorter as it builds on existing infrastructure and can be deployed more quickly. $F_B = (F_{B,T} \times W_{B,T}^F) + (F_{B,E} \times W_{B,E}^F) + (F_{B,O} \times W_{B,O}^F) + (F_{B,S} \times W_{B,S}^F) = (7 \times 0.2) + (8 \times 0.4) + (7 \times 0.2) + (8 \times 0.2) = 7.6$.

Step 3. Make decisions based on VM and analysis results.

- Calculate $VM_A = 33$; $VM_B = G_B \times F_B = 0.9 \times 7.5 \times 7.6 = 57$.
- The MoF decides to adopt option B given its higher VM value. Option B is a more practical solution that allows for faster and less disruptive implementation, while bringing similar benefits. They will continue to explore option A, given not only the slightly higher gain potential but also their desire to innovate. They are considering using a testbed for this and other applications of blockchain.

Scenario 3. Quantifying Synergies from Integrating Technologies

Additional technology option: Given the lower upfront costs of option B, the MoF has the budget to implement an AI-enabled system that will detect any outliers, discrepancies, or irregularities in the milestone verification process. The algorithm will flag, for example, any deviation from past performance for a given contractor, monitoring their progress in real time and comparing it with the expected progress based on predefined schedules and historical trends. When anomalies are detected, the smart contract will send alerts with a recommended action for the procurement officer and any supporting data evidence. The artificial intelligence (AI) model will also perform a final check before payments are triggered by the smart contract, halting its execution and flagging the treasury system when any irregularities or inconsistencies with the contract terms are identified.

Step 1. Calculate the individual VM score.

- $VM_{SC} = 57$ as in the second scenario.

Step 2. Calculate the total VM score, considering any synergies.

- Integrating the AI model with smart contracts can bring synergies in automation, accuracy, and fraud prevention. Together, the system will serve as an augmented decision-making tool, sending more intelligent alerts to the procurement officer when a milestone is reported as complete (compared with simple notifications). It will reduce processing time significantly, while strengthening oversight and reducing the risks of errors or fraud.
- Feasibility score may be slightly lower. New technical challenges could include aligning the data format from procurement systems to be ingested by the AI and ensuring that the smart contract can be paused based on AI recommendations. Additional requirements for integration and system testing may also increase the time frame. Long-term savings from improved fraud detection, however, could be significant given the synergies.
- Assume process, output, and outcome gains increase by one point each, whereas accountability gains increase by two points given the proactive approach to fraud prevention. Technical and timeframe feasibility scores decrease slightly by one point. $VM_{Combined} = G_{Combined} \times F_{Combined} = 8.75 \times 7.2 = 63$.

Step 3. Make decisions based on VM and analysis results.

- Combining the smart contract with AI will provide a higher value. Added benefits from the synergistic interaction between AI and automation outweigh the additional challenges to implementation. The MoF decides to adopt both to more effectively leverage emerging technologies to improve governance in public investment management. However, mindful of the magnified risks, it will take a phased approach, integrating AI later by prioritizing high-impact features of the smart contract first and gradually expanding to integrate AI.

Annex 3. Practices for Sustainable Adoption of Emerging Technologies



Leadership and vision. Organizations must adopt a forward-looking culture to succeed in implementing new technologies. Many organizations become ossified in their processes, procedures, and systems. They must instead be open to change as newer technologies come along and willing to discard outdated processes as well as systems that are incapable of adapting. Personnel must be incentivized to learn and embrace new ways of doing things.

This can be very difficult to achieve, especially in government. There is a tendency to prefer established ways of doing things, and there are many institutional constraints (many codified into law) to doing things in different ways. Navigating these constraints, identifying which ones can be modified or discarded, and implementing new ways of doing things is no trivial task.



Emphasize user experience through engagement. Effective adoption of emerging technologies in public financial management (PFM) hinges on user acceptance. To ensure sustainable adoption, it is essential to prioritize user experience at every stage of the technology implementation process. This includes actively involving end users in the design, testing, and feedback loops. It is important to note that knowledge of the business process from the perspective of ministry of finance cannot substitute direct engagement with the users (usually persons who use the system to perform transactions or for reporting).

Monitoring and evaluation mechanisms should be integrated to assess the effect of user-engagement strategies and refine them iteratively for continuous improvement. By engaging users early and continuously, organizations can tailor solutions to their needs, increase acceptance, and drive long-term success. This also fosters a culture that values input and feedback, leading to more effective and sustainable adoption of emerging technologies.



Secure sustainable funding. Budget constraints pose a significant hurdle, as the costs associated with acquiring, implementing, and maintaining these technologies can strain government budgets, impeding progress in the modernization. To overcome this challenge, it is crucial to secure sustainable funding sources. This can be achieved through various means, such as establishing dedicated funding mechanisms for technology adoption, seeking partnerships with the private sector or international organizations, and advocating for budget allocations that prioritize technology modernization in PFM processes.



Anticipate and manage resistance. Despite the promise of digital innovations in PFM, government agencies and other key stakeholders that operate in the PFM space may be skeptical and against the cultural change. Successful digital transformation of PFM requires more than emerging technologies or cutting-edge hardware and software. The crucial role of people in digital transformation—how they work with technology and with each other—cannot be overemphasized. Cultural change in government is relatively slow and could potentially impede the realization of the digitalization promise. As such, digitalization champions or change leaders in government will play a key role in driving the required cultural change, advocating for technologies that can enhance efficiency, agility, productivity, and innovative gains in PFM. In addition, they should ensure that the right decisions are taken in the right way at the right time and for the right outcome to keep the PFM digitalization agenda on track.



Build—and retain—capacity and skills. In a rapidly changing technology landscape, it is imperative that managers are aware of what the current landscape looks like and how new capabilities and technologies can be leveraged to the benefit of their organization. Information technology (IT) management can play a role in disseminating such information, but it is also important for people at the functional end of the organization to be able to understand technology and how it can apply to their specific functions and issues.

Staff training is very important in ensuring that new technologies are implemented safely and efficiently. Retention of qualified staff can be difficult in a government setting; therefore, strategies must be set in place, together with human resources.

A common issue in many technology deployments, especially in developing countries, is that a new system might be installed and deployed by a vendor, and at the end of the project it is the IT staff who are left to provide first-level support, although in many cases they are not specifically trained on the new system and have a limited understanding of its functionalities. This can lead to loss of data, introduction of bad or erroneous data into the system, or compromised security and even fraud and theft.

Vendor lock-in, where organizations become overly dependent on a particular technology provider, including for data ownership, can limit flexibility and hinder competition in the long term. Legacy systems, deeply ingrained in many government operations, pose a challenge because of their resistance to integration with modern technologies. Overcoming these multifaceted challenges requires a strategic, multidimensional approach, addressing both technical and organizational aspects of technology adoption in PFM.



Adhere to interoperability and standards. Data governance, quality, and standardization are fundamental considerations, as inconsistencies in data management can compromise the accuracy and reliability of financial information. Interoperability issues pose another challenge, particularly when integrating new systems with existing ones. Seamless communication between diverse PFM platforms is crucial for comprehensive data analysis and decision making. Subject matter expertise is very important in deploying new technologies, as making sense of the data for operating and using big data or artificial intelligence systems requires domain expertise.



Embrace agility and iterative development. Implementing emerging technologies in the public sector requires a flexible and adaptive approach. Embracing agility and iterative development methodologies can help navigate the complexities of public sector operations. Agile methodologies emphasize incremental progress, frequent feedback loops, and collaboration among cross-functional teams.

Implementing agile methodologies in the public sector can be challenging because of bureaucratic processes, rigid procurement policies, and resistance to change. This will require tailoring agile practices to fit the unique needs and constraints of the public sector. This may involve modifying traditional project management approaches to allow for more flexibility and iterative development, and making progress, issues, and decisions transparent by documenting and sharing them openly.



Collaborate and seek partnerships. By working together with other government agencies, private sector partners, academia, and civil society organizations, public sector entities can leverage complementary expertise, resources, and networks to achieve common goals. Governments can share resources, such as data, infrastructure, and expertise, to enhance the effect and efficiency of technology adoption initiatives. This can include joint research and development projects, co-creation of solutions, and shared learning opportunities.

Start-ups, especially those focused on government technology, can play a crucial role in driving innovation and modernization in PFM. Their agility, innovative solutions, and fresh perspectives can help governments overcome traditional barriers to change and implement emerging technologies more effectively, leading to more efficient and transparent financial operations.



Mitigate security risks and ensure data privacy. Cybersecurity risks and data privacy concerns are critical challenges that cannot be ignored. As financial data becomes increasingly digital, the vulnerability to cyber threats grows. Governments must invest in robust cybersecurity measures to protect sensitive financial information from unauthorized access and cyberattacks. The development of a cybersecurity risk mitigation strategy in the PFM area should take into account the following factors:

- Vulnerability of infrastructure to penetration and compromise
- Vulnerability of staff to “social engineering”-type attacks
- Proper stewardship and management of encryption and encrypted resources, especially encryption keys
- Diffused responsibility for infrastructure management so that no one individual has complete control
- Logging, audit trails, and attribution; actions should be attributable to an individual
- Periodic testing of security mechanisms and controls against the latest exploits

Although these risk mitigation actions should be a part of every organization’s IT policies, it must be recognized that true security is a difficult subject and demands expert attention. In many countries, government departments and agencies may not have the budget to hire qualified and trained staff dedicated to ensuring airtight security, performing security audits, or engaging in periodic penetration testing. In those situations, it might make sense to fund a dedicated cybersecurity team at the government or ministry level and empower them to set security policy and enforce it through audits and testing. This team could also have an important role in educating staff in security awareness, to avoid social engineering exploits or malware infestations.

The more capable and complex systems and infrastructures are, the more potential there is for security deficiencies to be exploited. Greater complexity and functionality of systems create a correspondingly larger “attack surface,” which refers to the number of different opportunities for attackers to compromise a system, either by denying use of the system or gaining illegitimate access to it. Every new capability and mechanism, from big data systems to blockchains to cloud resources, increases the potential for an attack because of either the carelessness or ignorance of the implementors, security risks hidden as “bugs” in off-the-shelf software (for example, “zero-day exploits”), misconfiguration, or social engineering exploits.

Big data systems can be misused to present threats to individual privacy. The combination of large and disparate sets of structured and unstructured data can present an opportunity to gather and even infer a lot of information about individuals. In fact, this is the entire business model for many companies. The integration of such information may violate privacy laws in many countries, especially in relation to what government is allowed to do. Not only does this create an opportunity for the government to misuse the data, but also data leaks, either by accident or through malicious actions, can end up releasing data that is not meant to be released to the public, putting personal data at risk of misuse. The intricacies of data privacy, compounded by regulatory frameworks, necessitate careful navigation to ensure compliance while leveraging the advantages of technology. Ethical concerns, public trust, and political and bureaucratic barriers further complicate the landscape, demanding a delicate balance between technological development and the ethical implications associated with data handling.



Keep an eye out for new emerging technologies. Although traditional technical implementations have required robust local technical infrastructure to be in place, newer technologies are characterized by lower barriers to entry. Most of the new technologies described here can be implemented in the cloud, which means that an organization can begin to use them without needing to have or build a physical processing infrastructure. Rather than building a data center and purchasing and installing servers and their ancillary equipment, many services can simply be purchased from a cloud provider on a pay-as-you-go or pay-per-use model. This reduces the amount of support personnel that are needed to keep a traditional data center running.

Newer technologies, however, do require robust internet connectivity if they are to be used effectively. As traditional transaction-processing systems move into the cloud, the users of the system will also require a certain level of internet connectivity. In traditional deployments, the organization running the system required a high-bandwidth connection to the data center, in many cases with dedicated private networks running from the end users to the data center. In cloud deployment, private networks are of no use; instead, a robust connection to the cloud provider (that is, to the internet) becomes necessary. This can eliminate specialized hardware at end user sites and expand the ways in which end users can access the systems. This will have the effect of reducing the technical burden on network administrators at both the end user and the data center level.

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