Technological Opportunities and Recommendations for Modernizing Integrated Financial Management Information Systems in Latin America and the Caribbean

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Abstract[*]

Based on the analysis of some success factors of integrated financial management information systems (IFMIS) in Latin America and the Caribbean (LAC), this paper identifies the technological pillars of a modernization strategy for these systems as a platform for public expenditure management and makes recommendations. It also describes aspects of properly maintaining these systems, extending their life cycles, using international best practices on information technology management, focusing on system users, expanding the use of cloud-based data and services, sharing programming codes, exploring the use of new distributed ledger technologies, expanding horizons for electronic payments, and increasing the use of data analytics, among other emerging technologies.

JEL Codes: H2, H5, H57, H6, H7, H72, O3, O33
Keywords: blockchain, cloud computing, data analytics, fiscal transparency, information systems maintenance, information technology management, integrated financial management information systems (IFMIS), programming code sharing, public expenditure management, public financial management

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List of Abbreviations

LAC	Latin America and the Caribbean
API	Application programming interface
AWS	Amazon Web Services
IDB	Inter-American Development Bank
CBA	Commonwealth Bank of Australia
COBIT	Control Objectives for Information and Related Technology
TSA	Treasury single account
PFM	Public financial management
GSA	United States General Services Administration
IaaS	Infrastructure as a Service
ITIL	Information Technology Infrastructure Library
IPSAS	International Public Sector Accounting Standards
OECD	Organisation for Economic Co-operation and Development
PaaS	Platform as a Service
GDP	Gross domestic product
SaaS	Software as a Service
IFMIS	Integrated financial management information system
IT	Information technology
TIER	Data Center Infrastructure Certification

Introduction

The objective of this paper is to make recommendations for the technological modernization of integrated financial management information systems (IFMIS) in Latin America and the Caribbean (LAC). Based on an analysis of some success factors behind the proper functioning of IFMIS, the paper identifies the technological pillars for a modernization strategy for these systems as a public expenditure management platform. It also sets forth the aspects involved in properly maintaining these systems and extending their life cycles, using international best practices on information technology (IT) management, focusing on system users, increasing the use of cloud-based data and services, sharing programming codes, exploring the use of new distributed ledger technologies, expanding the horizons for electronic payments, and increasing the use of data analytics, among other emerging technologies.

1. Overview of IFMIS in Latin America and the Caribbean

IFMIS are computing systems for public financial management (PFM). IFMIS support the budgetary, financial, and accounting management of the public sector in accordance with the principle of single and timely recording of income and expenditure operations by enabling process integration, making payments, and generating the corresponding financial statements (Pimenta and Pessoa, 2015). Although financial management systems have always existed in the public sector since the implementation of computing systems, the current concept behind the IFMIS is that of a single PFM system for the government as a whole, with a central database and the opportunity to structure and operate a treasury single account (TSA). [1]

IFMIS help improve the efficiency and quality of PFM. IFMIS foster transparency and fiscal discipline and contribute to better management of public resources (Hashim and Piatti, 2018). In addition, the quality of PFM is correlated to the level of development and per capita income of a country. Fritz, Verhoeven, and Avenia (2014) identified a positive correlation between the average consolidated scores of the Public Expenditure and Financial Accountability (PEFA) program, which measures the quality of PFM in a country, and per capita income in more than 90 countries. While there is a weak positive correlation between the quality of PFM and income levels in these countries, it is not possible to establish a causal relationship between the two.

[1] The TSA is a single bank account, or a set of linked bank and virtual accounts, through which the government relies on a single administrator (the treasury) to process its collections and payments, obtain a consolidated financial position at the end of each day, and manage resources in a centralized manner (Fainboim and Pattanayak, 2011). The TSA consists of a set of systems, processes, and rules applicable to a government's PFM.

IFMIS are relatively new in most countries. As a single PFM system for the government as a whole, the IFMIS came into operation in the last three decades. More than two-thirds of the IFMIS versions currently in operation in the world were put in place since 2006, and more than half of the new versions of IFMIS in LAC began operating in the same period.[2]

Table 1.1. IFMIS by Year of Deployment

Year of deployment	Worldwide		LAC		Latin America	
	No. of IFMIS	Percentage	No. of IFMIS	Percentage	No. of IFMIS	Percentage
before 2000	19	9.8	4	12.1	2	10.0
2000–2005	47	24.2	11	33.3	7	35.0
2006–2010	61	31.5	9	27.3	8	40.0
after 2010	67	34.5	9	27.3	3	15.0
Total:	**194**		**33**		**20**	

Source: World Bank Database (CoP FMIS, 2018).

Note: Latin America includes Cuba, the Dominican Republic, and Haiti.

IFMIS can be custom made or procured on the market by purchasing software licenses. There are IFMIS in operation in almost every country in the world; about half are custom made for a specific government and half are procured on the market by purchasing a license (COTS: Commercial off-the-Shelf). Eighty-five percent of Latin American countries (excluding the Caribbean) use custom-made systems. Among the 17 Spanish-speaking countries in Latin America and Brazil, only Nicaragua, Panama, and more recently Ecuador (with its system underway) use IFMIS-COTS acquired on the market through license purchase.

[2] The authors did the calculation based on World Bank database led by Cem Dener.

Table 1.2. IFMIS: Custom Made vs. License Purchase

IFMIS	Worldwide		LAC		Latin America	
	Total	Percentage	Total	Percentage	Total	Percentage
Custom made	106	53.5	19	57.6	17	85.0
License purchase	86	43.4	14	42.4	3	15.0
Unknown	6	3.1	0	0.0	0	0.0
Number of countries	**198**		**33**		**20**	

Source: World Bank database (CoP FMIS, 2018).
Note: Latin America includes Cuba, the Dominican Republic, and Haiti.

PFM and IFMIS receive significant funding from multilateral organizations and donors. The Inter-American Development Bank (IDB) has provided 42 loans to support PFM and IFMIS investment projects in LAC over the past 15 years. The total amount of these loans exceeds US$1 billion, with an average of US$26 million per project including the subnational level (Pimenta and Uña, 2015). Since 1985, the World Bank has committed about US$4 billion in PFM and IFMIS projects through 134 operations in 74 countries, with an average of about US$30 million per project (Hashim and Piatti, 2018: 13).[3]

Many IFMIS in Latin America do not undergo timely updates. The oldest IFMIS in the region is the one in Brazil (since 1986). In the 1990s, IFMIS began to expand throughout the region, predominantly as custom-made, in-house systems, based on a central architecture for TSA operation. In recent years, most of the region's IFMIS are becoming obsolete and in need of upgrading or substitution (Pimenta and Uña, 2015).

The main reasons for IFMIS obsolescence in LAC are institutional and technological in nature. In order for an IFMIS to remain up to date and sustainable over time, a set of conditions must exist, such as an adequate flow of financial resources for an effective maintenance of the IFMIS, with updates and upgrades, and to support a technical team paid at market rates. However, IFMIS maintenance in Latin America did not always meet these conditions. Since most IFMIS in the region were custom developed in the past two decades with a life cycle that would require ongoing preventive maintenance, many of the systems are becoming obsolete as they are not properly maintained.

Lack of resources affects IFMIS. In Latin America, information technology workers in the public sector usually earn less than their peers in the private sector. As a result, some countries often turn to multilateral organizations for recurring loans to contract individual

[3] In addition to expenditures related to the IFMIS itself (coding, licensing, hardware, training, etc.), in some projects these amounts include other expenditures to strengthen some aspects of the public financial administration or fiscal management.

consultants to maintain their IFMIS, as the executing units of these loans have greater administrative and budgetary autonomy. While this practice helps temporarily mitigate the problem, it does not provide a definitive solution, as the problem reemerges once the project is complete and the resources finished. In some cases, governments hire over a hundred individual consultants at market rates to develop an IFMIS, and at the end of the loan term the project runs out of funding. The public sector then requests a new loan to be able to properly maintain the IFMIS and keep it in operation.[4]

In this context of IFMIS in LAC, this paper discusses the following strategies and success factors for the proper functioning of these systems, and identifies technological pillars, analyzed in further detail in Section 3, to make recommendations for improving IFMIS in the region.

2. Strategies and Success Factors for the Proper Functioning of an IFMIS[5]

Based on a literature review of IFMIS, this paper identified nine key strategies as success factors, which are presented below.

Gradual and modular approach to system implementation or updates. Every computing system has a life cycle, and IFMIS are no exception. For custom-developed systems used in most Latin American countries, having preventive, gradual, and ongoing maintenance is key to avoid having to replace the entire system from time to time. Additionally, due to the complexity of IFMIS, implementation is time-consuming. Having a modular development and implementation strategy allows for better process management over time.

Adequate technical and budget resources for system maintenance and updates. The IFMIS administrator must have adequate financial, technical, and technological resources to conduct ongoing preventive maintenance of the system, in addition to developing new functionalities, perfecting existing ones, or adopting new management approaches (such as implementing international accounting standards). The IFMIS administrator must have enough technical resources or purchase adequate functional and technological know-how.

The IFMIS must be user-centered. One of the fundamental principles of an IFMIS is that it is one single system, with a central administrator and operated in a decentralized manner; in other words, users of the IFMIS are scattered across all sectors, agencies, and other government units. It is the thousands of users that determine the quality and timeliness of the data recorded. Therefore, it is important to fulfill their needs and provide ongoing training and technical

[4] Countries such as Argentina, Guatemala, Paraguay, and the Dominican Republic have approved new loans that include resources for IFMIS following the completion of a previous loan that had provided funding for an IFMIS.

[5] This section draws on Fritz, Verhoeven, and Avenia (2014), Gupta et al. (2017), Hashim and Piatti (2016, 2018), and Pimenta and Pessoa (2015).

assistance. The trend is to strengthen the user focus of IFMIS, both by encouraging greater participation in system design and implementation (through user committees) and by improving usability and providing adequate services and training.

Enforcing protocols to prevent transactions outside the system. Some countries use IFMIS as an advanced computing tool but fail to tap into its full potential; that is, users do not input all the information required for each phase of the expenditure cycle (pre-committed, committed, accrued, and paid) into the system in a timely manner.[6] Used in this way, the system cannot generate timely and complete information to facilitate effective cash management.

TSA with broad coverage. The broader the TSA coverage in an IFMIS, the better the conditions for more efficient cash management without idle resources in accounts not controlled by the treasury. Most LAC countries have adopted the concept of TSA as a principle. However, many TSAs still lack complete coverage, and there are resource transfers from the treasury to other entities, agencies, or units (i.e., other branches of the government, universities, or even for pension agencies), as the transfers are not done directly through the IFMIS.

Integration of budget information with payment and accounting record (single record). In this way, system users do not have to enter the same information more than once. It can also ensure the consistency and quality of the information. It is important to have a single record, whenever possible, by integrating both the processes and the budgetary and accounting classification, which promotes greater automation of accounting.

An IFMIS is more than an accounting project; it is a public expenditure management project. An IFMIS is the basis of public accounting and should support both accounting records and automation of financial statement generation. It offers much more than accounting functions, as it supports most PFM functions such as budget preparation and execution, treasury cash management, electronic payments, and public debt management. Some IFMIS are even integrated with other ancillary administrative systems, such as procurement and contracting, payroll payment, and asset management systems.

Adopting International Public Sector Accounting Standards (IPSAS) in the IFMIS. IPSAS are accounting standards for the public sector that use accrual accounting and look at more than just cash flow (as the majority of IFMIS were designed to do). Therefore, it is still necessary to align the IFMIS with these new standards, including the timely recording of public sector assets and liabilities in the system-generated financial statements.

[6] This is the case in the Dominican Republic and other countries of the region.

Technical and political leadership and commitment (political economy of systems). IFMIS are highly complex and far-reaching systems in the public sector and are therefore subject to the political economy of the competing interests of different institutional stakeholders and system users. To align these interests, it is essential to have adequate technical and political leadership, as well as a regulatory framework that strengthens this leadership and proper operation and maintenance of the IFMIS.

Considering these strategies and success factors for the proper functioning of the IFMIS, an opinion survey was conducted in 2018 with 18 IDB specialists who are or were team leaders of projects financed by the Bank[7] that included an IFMIS component in the last 15 years. The survey gauged the perceptions of the main problems with these projects, the most important strategies, the challenges in system maintenance and documentation, the use of cloud services, the sharing of codes and systems, the use of data analytics, among other topics. Based on this survey with IDB specialists, the paper identified the most relevant technological aspects of the success factors from the literature review to determine the technological pillars of IFMIS modernization. These will be analyzed in the third section, along with recommendations.

The survey identified as the most important strategies in these projects: technical and political leadership and commitment of government authorities, process integration, the focus on system users, and the control to prevent expenditures that take place outside the IFMIS. The strategies identified as secondary in importance included system maintenance, the gradual approach to IFMIS implementation, and TSA coverage

The survey also revealed that the biggest problem occurs in project implementation during the stage of contracting consultancies or procuring goods and services. It affects the performance of the implementation unit[8] and consulting service management. Issues of lesser relative importance identified are sustainability, project design, and resistance to change.

For respondents, the biggest obstacle to maintenance is the lack of system documentation procedures and scarce technical resources. Respondents also identified lesser issues, such as the lack of capacity to select and contract technology services. These issues call for institutional capacity building in the entities responsible for IFMIS maintenance to extend its life cycle. Respondents did not list lack of hardware as a major problem.

According to this survey, there is documentation of the functional processes, and in a few cases, there is a unit in charge of keeping the documentation up to date. However, in many cases,

[7] The survey with IDB specialists covers the past 15 years, as these projects have long execution periods, some up to 10 years. The specialists' opinion is up to date.

[8] The performance is affected by delays in previously established execution deadlines and by the difficulty in making the required hiring and achieving the results initially proposed in the project.

there is no complete or up-to-date documentation of the coding (computer programming) of the processes beyond the processes themselves. Two thirds of the respondents replied that the projects did not report using international best practice frameworks such as the Information Technology Infrastructure Library (ITIL)[9] or the Control Objectives for Information and Related Technologies (COBIT)[10] in their IFMIS life cycle management.

For survey respondents, the biggest obstacle to using cloud services is uncertainty over the security of information outside the IFMIS administrator's data centers. The second biggest obstacle regarding cloud use would be the lack of regulation and knowledge. Respondents did not identify potential budget restrictions in the recurrent payments of cloud services as a major problem.

The biggest obstacles to code and system sharing are mistrust in the robustness of open systems and lack of knowledge, followed by uncertainty over information security. In this case respondents did not report mistrust in the quality and coverage of the data or the lack of regulation as a problem.

According to the survey, data analytics is underused in IFMIS databases (only one third of IFMIS databases use data analytics). There is almost always a help desk for users, but without virtual assistants such as chatbots, and there is no measurement of user satisfaction or incident response time.

Based on the conclusions of this survey and in accordance with the strategies and success factors discussed above, the paper selected some technological pillars, opportunities, and trends in information technology to enable a modernization strategy for an IFMIS as a public expenditure management platform. The next section addresses these topics in more detail.

[9] ITIL (Information Technology Infrastructure Library) is a framework of best practices that guides organizations in the use of IT as a tool to facilitate business growth, change, and transformation. More information is available at https://es.wikipedia.org/wiki/Information_Technology_Infrastructure_Library.

[10] COBIT (Control Objectives for Information and Related Technologies) is a framework of best practices created by the Information Systems Audit and Control Association (ISACA) for IT governance. To learn more, visit http://www.isaca.org/COBIT/Pages/COBIT-5-spanish.aspx.

3. Technological Aspects, New Opportunities, and Trends. The New Digital Economy

Coupled with the advent of a new digital economy, the exponential growth of technological innovation and institutional transformation has had an impact on fiscal policy and management not only in developed countries but also in all LAC countries. The effectiveness of fiscal policy in collecting and allocating resources relies heavily on the information and technologies at governments' disposal. The digital revolution provides new and enormous opportunities for public finances (Gupta et al., 2017), and the IFMIS are an essential part of this process.

The two subsections below analyze solutions for IFMIS. The first subsection takes a more conceptual approach and considers mostly current technologies. It proposes a new vision and architecture for system development and updating toward an IFMIS as a platform for public expenditure management with proper and timely system maintenance, system security, and user focus. The second subsection discusses the impacts of five key emerging information technologies[11] on IFMIS in LAC over the short and medium term, in terms of the opportunities they create and trends they enable that must be considered when designing a modernization strategy for these IFMIS.

3.1. IFMIS as a Platform, Adequately Resourced, Well-Maintained, and User-Centered System

While there is no single definition of "digital platform," the term generally refers to digital services on the internet such as search engines, social media, e-commerce platforms, online application stores, and price comparison sites, among others. Generically speaking, these platforms can be characterized by their capabilities to facilitate user transactions; to collect, use, and process large amounts of data; to build networks in which each additional user enhances the experience of all other users; to create and shape new markets through more efficient and disruptive arrangements; and to organize new forms of social participation, among others (European Union, 2016).

The first IFMIS in the late 1980s and early 1990s were developed on proprietary computing platforms accessed through terminals without processing capacity, mostly in a client-server architecture. The server was usually a mainframe computer that stored data and managed

[11] Increasing the use of cloud-based data and services, code sharing, exploring the use of new distributed ledger technologies (such as blockchain), broadening the horizons for electronic payments, and increasing the use of data analytics.

business processes, and the clients were terminals or microcomputers with data collection and presentation functions. Beginning in the late 1990s, with the evolution of the internet, most IFMIS began to be developed and operated on web-type platforms, on which client computers have standardized interfaces (mainly Hypertext Markup Language [HTML]) and access the central system through the internet. This computing modality makes it possible for old but well-maintained centralized systems with business rules and data on mainframes or large servers to survive by wrapping them in layers of web-based standardized protocols and interfaces.

Currently, there is exponential and ongoing growth in server processing, storage, and connectivity capacity, with high reliability and falling prices per processing and storage unit, and high scalability. Operating systems, database software, and programming languages also continue to evolve, taking advantage of new algorithms and technologies while maintaining compatibility with previous versions. This ecosystem is characterized by evolution with backward compatibility, as well as robust and flexible methodologies for system development. Such an ecosystem allows current information systems to incorporate new and sophisticated technologies such as data analytics and artificial intelligence with machine learning as layers, without creating disruptions or requiring radical transformation of the system that processes the business rules.

3.1.1. Strategies of IFMIS Developed or Purchased, Modularity, and Interoperability

Eighty-five percent of Latin American countries have custom-made IFMIS (see Table 1.2 in the first section). Behind the preference for this development modality is the idea of system flexibility, that is, the system can be adapted to meet any new legal or regulatory requirement or to the preferences of the functional administrator.

Another alternative of IFMIS implementation is to purchase a software license on the market and then adjust the system and set the parameters. Commercial off-the-shelf (COTS) systems receive regular updating services from suppliers to align them with the latest best practices in the market, but these systems are not very flexible in incorporating user-generated programming codes (Schiff, 2014). In short, an entity that chooses to purchase a license should preferably align its processes with the best practices in the market. This is a key success factor for COTS in the medium and long term but not easy to do in the public sector in Latin American countries.

There are also market alternatives for auxiliary administrative systems, especially human resources/payroll and public procurement systems, which follow more homogeneous processes and have several suppliers with specialized and market-tested products. However, to integrate one of these systems into the IFMIS core for real-time operation, in the event that the two come

from different sources, it would be necessary to at least develop interfaces for the auxiliary administrative system with the IFMIS core (be it the same custom-made core or one procured in the market) so that the expenditure stages continue to operate in real time. Several market software products for auxiliary administrative systems brand themselves as cloud-based software as a service (SaaS),[12] which also represents an opportunity for savings in computing infrastructure, support, operation, and licensing costs.

Whether or not to buy an off-the-shelf system is a strategic decision with impact on the future of public entities for years to come. A system supplier would be more than a software vendor but also an ally in improving public finances. This strategic decision must draw on economic and political feasibility studies and risk analysis. Additionally, the system must be compatible with the government's installed capacity and the degree of flexibility in the country's PFM processes.

Another important issue is the interface between the different components of an IFMIS, between the national IFMIS and the subnational IFMIS, or between the IFMIS and other ancillary systems. A key alternative is using web services,[13] which are software applications with a standardized way of enabling interoperability between different applications. As mentioned, it is possible to upgrade an IFMIS in operation that has a modular architecture and leverage added functionalities without having to rebuild the entire system.

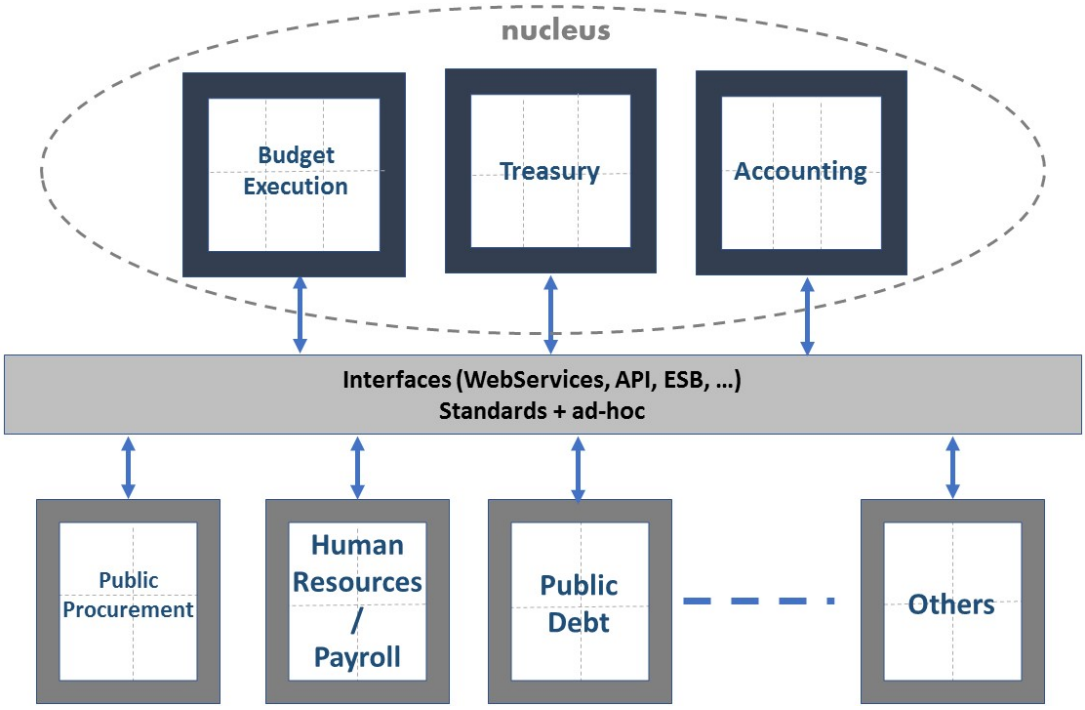
3.1.2. IFMIS as a Public Expenditure Management Platform

A platform is a product that provides or enables other products or services.[14] In this sense, the IFMIS is the core of a well-structured and well-maintained system with modular architecture in which changes and improvements can be made in one module without disrupting the rest of the system but rather lead to the development or procurement of other systems. An IFMIS "platform" must have clear rules and interfaces; custom-made and other off-the-shelf systems can coexist and interact without requiring a single modality, which also promotes the use of cloud services.

In defining the technology requirements for interoperability with in-house or external systems (systems of other public or private institutions), it is necessary to determine the business rules that the parties in each case must abide by, in accordance with the standards that enable different modules and systems to communicate with each other. Figure 3.1 shows that the modular architecture of an IFMIS can even extend to the system core.

[12] Software as a Service. Section 3.2.1 provides more detailed information on cloud computing and its use in IFMISs.
[13] Web services rely on standard web technologies such as HTTP, XML, etc., and they use an Application Programming Interface (API), a set of functions and procedures for interconnecting systems.
[14] For more information, visit: https://www.gartner.com/it-glossary/platform-digital-business.

Figure 3.1. The Modular Architecture of an IFMIS



Source: Authors' elaboration.

As part of an IFMIS implementation project, it is important to also consider creating and putting in place a management environment, preferably based on international best practice frameworks, such as ITIL and COBIT. An operating IFMIS without a management framework faces significant risks and should therefore adopt a specific framework.

Characterizing an IFMIS as a platform promotes system controls, quality, and sustainability. Under such conditions, changes and upgrades take place without disrupting the system, and there is no need for a "new" IFMIS every 10 or 15 years, thus maximizing the system's life cycle and the investment made. Therefore, the strategy used to develop an IFMIS does not matter (whether the IFMIS is custom made, developed in-house, procured on the market through license purchase, or other variations), as the key is building and operating a modular system management environment based on a best practice framework.

3.1.3. New Institutional Solutions for Promoting Adequate Flow of Financial Resources to an IFMIS

For an IFMIS to be sustainable over time, it is necessary to ensure a flow of financial resources to allow for effective maintenance with the support of a technical group paid at market rates.

However, in Latin America, technology staff in the public sector usually earn less than their private market counterparts. Hiring individual consultants with external financing only delays a resolution of the problem.

One option is to consider new institutional solutions, such as creating PFM agencies with administrative and budgetary autonomy, as is already being done with tax administration in the region. This could raise the compensation of PFM technology staff closer to market levels, in addition to promoting more modern and flexible management to address the challenges of the new digital economy.

In line with the trend that began in the 1990s, currently 65 percent (11 out of 17) of tax administrations in Latin America have administrative and budgetary autonomy. This trend has caught on all over the world: among member countries of the Organisation for Economic Co-operation and Development (OECD), 20 tax administrations (59 percent) are autonomous and 14 are not (CIAT and IDB, 2013).

Another example is found in the area of public procurement and contracting, which has seen considerable technological and functional progress in the last 20 years in Latin America thanks in part to the creation of governing bodies or units that oversee e-procurement. Currently, a third of these governing authorities have administrative and budgetary autonomy (six out of a total of 18). Additionally, five out of the six highest-ranking Latin American countries in terms of their public procurement systems according to the OECD (through the Methodology for Assessing Procurement Systems [MAPS]) have autonomy (Chile, Colombia, Ecuador, Paraguay, and Peru), which may indicate that the greater the degree of autonomy, the better the performance of these authorities.

Creating autonomous agencies makes it possible to separate policy-related activities from operational functions in PFM. It keeps the policy formulation and assessment component of PFM under direct administration (by the ministries of economy and finance), and operations activities of PFM under management by agencies, which is already the case with tax administration and is beginning to take hold in the area of public procurement. Some examples of PFM agencies in operation in other countries are the Korea Public Finance Information Service (KPFIS),[15] the Financial Information Technology Agency (*l'*Agence *pour l'informatique financière de l'État*, or AIFE)[16] in France, and the Federal Data Processing Service (*Serviço Federal de Processamento de Dados*, or Serpro)[17] in Brazil.

[15] For more information, visit: http://www.kpfis.or.kr/eng/index.do.
[16] To learn more, visit: https://www.economie.gouv.fr/aife/agence-pour-linformatique-financiere-letat-0.
[17] Visit Serpro's website at: http://serpro.gov.br/.

3.1.4. System Maintenance and Its Impact on the Life Cycle of an IFMIS

IT governance involves aligning information and communications technologies (ICTs) with the organizational process strategy. It also considers the goals and the strategy of every functional area and department of an organization, facilitates the best use of technology, and promotes the organizational structures to achieve the goals. In the case of IFMIS, their governing bodies (usually ministries of finance) set goals and strategies and define technological guidelines that consider sectoral, ministerial, and national strategic guidelines.

Using an internationally accepted IT governance model facilitates IT management arrangement in an institution. The aforementioned ITIL and COBIT best practice guides can be used together or implemented in parts. In both models, governance also includes system maintenance, which plays a critical role in achieving institutional objectives.

Like other information systems, IFMIS have a life cycle that must be observed and addressed at all stages so that their effectiveness and efficiency can always contribute to public financial management. In the ITIL model, which is the most widely used in LAC, the life cycle of a system consists of five stages: service strategy, service design, service transition, service operation, and continual service improvement.

In the life cycle, system maintenance is part of the "service transition" stage within the change management process and has an important role, given that IFMIS generally undergo constant change processes throughout their useful life, both in application programs and in their computing infrastructure. Using appropriate methods and techniques of maintenance, record keeping, and documentation of changes ensures higher system quality and a longer service life. The third version of the ITIL model (ITIL v3) breaks down system maintenance into three processes:

i. **Change management:** The goal is to establish standardized procedures to process IT-related requests for change and facilitate the assessment, planning, coordination, documentation, and evaluation of all changes.
ii. **Version management:** The goal is to manage the release of a new version of software or hardware. In terms of importance, a new version can be classified as primary or secondary importance or emergency, for which different controls apply.
iii. **Configuration management:** The goal is to identify, store, control, report, audit, and verify service and configuration item assets.[18]

[18] A detailed description of these processes, including roles, categorization, description, and performance indicators, can be found at: https://www.mitsm.de/change-management-en; https://www.mitsm.de/release-management-en; https://www.mitsm.de/configuration-management-en.

All change processes entail risks, from minor malfunctions to complete system failures. Risk prevention is a part of practically every stage of system development, but takes on critical importance in testing, especially in information systems that undergo systematic changes. Below are some key aspects of changes in a computing system:

i. The first aspect is reusing modules or routines, which is common for system development models and IFMIS. To this end, it is important to identify the possible impacts of a change on other parts of the system. Development models (such as waterfall or agile models) have rules that make it possible to do so.

ii. The second aspect is software security, which is important overall but especially so when it comes to the possibility of introducing counterfeit codes or backdoors[19] (when the bypassing of a security mechanism goes undetected) in many managed changes.

iii. The third aspect is testing the changes made. Software testing has become a specialty of technical professionals with specific skills. Due to their size and importance, it is a good idea for IFMIS to have a testing team that can verify all the documentation required for the change process and conduct the specific tests (unit and integration tests, etc.) with specialized techniques and tools that satisfy the stakeholders (developers and business units alike).

iv. The last aspect is automated testing,[20] especially integration testing, which is necessary for large systems such as IFMIS. For each change made, the specific change consistency test (unit test) is only a part of the process. All the main system use cases must be tested again to show that they are working properly even with the changes incorporated,[21] mainly for the reasons mentioned in the first point.

The aforementioned COBIT and ITIL models are benchmarks, and institutions can adapt them to their needs and according to their size.

Creating an IT governance environment, of which change management is only a part, is crucial for having successful IFMIS and can be done with specialized external support. The aforementioned governance models do not need to be implemented wholesale but can rather be done in parts, starting with the most critical processes based on the analysis of each institution. For an IFMIS already in operation, change management is probably one of the most critical processes to evaluate.

[19] For a more detailed definition, see: https://www.techopedia.com/definition/3743/backdoor.

[20] Automated testing uses a special software to control the testing process and verify that the results obtained are compatible with the ones expected. There is automated testing software available in the market, such as IBM Rational Functional Tester and Zaptest (free).

[21] Called “regression testing.”

Likewise, it is important to build IT management capacity in the public sector to guide the creation of a governance framework. Capacity building can be done through courses, certifications, or on-the-job training in collaboration with external consultants.

3.1.5. Maintenance and Useful Life of an IFMIS

An IFMIS will undergo constant changes and updates throughout its useful life, ranging from those required by legal, regulatory, or procedural changes to screen adjustments, new functionalities, and technological updates. If these changes are not made in a timely manner and guided by clearly defined procedures and documentation based on international best practices, an IFMIS could see its useful life shorten dramatically. The IFMIS can thus lose its modularity little by little, making it difficult and costly to maintain, upgrade, and scale up because few will understand its internal logic and will therefore be hesitant to change its programming codes. In these cases, it is common to create a new routine for each new case and cast aside the old one, as no one knows if others still use the existing routine or if it requires any special, unknown conditions. As a result, the system will be awash with bits and pieces of codes and data that no one will know the purpose of, making the system bloated and slow. Each round of system or database maintenance would entail heightened risks of operational interruptions and of introducing errors that are often not detected until hours or days later.

When detecting a situation similar to the one described, it is necessary to evaluate the possibility of adjusting to a new operating model, adopting best practices for software maintenance, and restoring the operational stability of the system by reviewing and documenting existing codes and using reverse engineering and analogous techniques. However, after years of operating the system in unfavorable conditions, it is sometimes more effective and less costly to define a strategy for putting in place a new IFMIS. In this case, it is necessary to take the opportunity to reconsider first and foremost the legal and procedural environment and not just the technological progress that has led to the need for a new system.

With habitual poor maintenance, an IFMIS faces heightened risks of disruption which, if this were to occur, can have detrimental impacts on the government and civil servants. Proper maintenance of an IFMIS is crucial for ensuring its good performance, contributing to user satisfaction, reducing costs in the medium and long term, and maximizing its useful life. The success of the strategy of IFMIS as a platform that allows for updates depends not only on the modularity of its functions but also on the quality of its maintenance, record keeping, and documentation.

IT managers usually use last-minute requests for changes generally submitted by functional administrators to justify skipping specific stages required in the models and international best practices. When done repeatedly, these undocumented and harmful software maintenance practices shorten the useful life of an IFMIS. This has been happening in LAC countries in recent decades and is one of the biggest problems for which people usually propose purchasing or developing a new system from time to time.

The following are a few practical recommendations for conducting effective preventive maintenance to extend the useful life of an IFMIS:

i. The starting point must be to create a life cycle management environment for the IFMIS. The COBIT and ITIL models are useful benchmarks in this regard.
ii. If an operating IFMIS lacks a working management model or if the one it has is inadequate, it is a good idea to review the entire model. It may be helpful to start by reviewing the service transition stage, especially the change management processes.
iii. Empirical observations by institutions that manage IFMIS show that even when there are established management processes, people frequently fail to follow some or all of these processes, citing the need to respond swiftly and/or the emergence of changes. The formal change management processes contain subprocesses dedicated to addressing urgent or emergency changes, but these changes still require specific controls that call for educating technicians, administrators, and clients, in addition to exercising managerial power.
iv. The proliferation of requests for change is probably a sign of a functionally obsolete system, whose most frequently modified subsystems require a functional review. Change management processes contain indicators that can inform these types of decisions.

Lastly, there is the issue of information security, which encompasses confidentiality, integrity, and availability. In this regard, user authentication plays a key role, and involves technologies and methods of delivering, authenticating, and managing system access keys. Despite the availability of safer technologies for providing access to an IFMIS (such as digital signatures), 92 percent of the 14 countries that participated in a survey conducted in Latin America on their IFMIS [22] still rely on user ID and password, and a few countries (20 percent) use a hybrid method which requires digital signatures for certain transactions. There should also be a formal process to deliver the access key of an IFMIS; in other words, users should meet certain prerequisites (for example,

[22] The IDB conducted the country survey between August and September 2018 in 14 Latin American countries to evaluate their IFMISs: Argentina, Brazil (São Paulo), Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Paraguay, Dominican Republic, and Uruguay. The country survey was part of a Technical Cooperation project with the Republic of Korea ATN/KR-16117-RG: Modernization of Integrated Financial Management Information System (IFMIS) in Latin America and the Caribbean (LAC) from the Korean Experience.

having had prior training) and sign a document agreeing to accept the rules and penalties for misuse. It is advisable to adopt the use of digital signatures for access in a gradual manner and formalize the process of granting authorization to use the system.

Internal threats are more serious than potential external threats, as the former come from users who are familiar with the IT environment and have some degree of access to components of the system. Hacking, inserting backdoor codes, and data theft are threats that are more damaging if they come from within.

On the other hand, 70 percent of the IFMIS country survey respondents use exclusively the Internet as an access network or as a supplement to their private networks. The growth of Internet use calls for increasingly sophisticated cybersecurity regimes to guard against security breaches, which are on the rise in cyberspace. The same survey revealed that only 30 percent of IFMIS use database encryption, and only 60 percent have technicians exclusively focused on system security management.

While most IFMIS in LAC are centralized, fewer than 15 percent of the country survey respondents have data centers certified by international standards, such as TIER (regulated by the TIA 942 standard which uses a four-tier classification system, TIER 1, 2, 3, or 4 based mainly on expected availability).[23] Additionally, 40 percent do not have contingency data centers or service continuity policies.

The country survey identified a need for assessing and enhancing the security aspects of IFMIS, which should be considered a priority. Having and implementing a security policy that addresses the security problems in the IFMIS environment, supported by a specialized unit in the institution, is the best way to tackle these challenges. Improving security requires consistent investments in technology, human resources, training, and procedures.

3.1.6. Focusing on the User: Training, Service, Participation, and System Usability

The operation of an IFMIS requires specialized and trained users; in other words, users must have functional knowledge of public finances and must be trained to use relevant tools to accomplish their objectives. Building an ongoing training ecosystem is the first step to ensuring the operational quality of the system, and new, emerging technologies can come in handy.

[23] The standard classifies not the information system but the IT infrastructure (data centers). Data centers that host critical systems should aim for TIER 3, in other words ensure 99.98 percent uptime availability, no more than 1.6 hours of downtime per year, and at least 72 hours of power outage protection. For a more detailed description of the standard, visit: https://www.colocationamerica.com/data-center/tier-standards-overview.htm.

There are several new experiences in this field. The National Treasury of Brazil, administrator of the IFMIS of the federal government, has a YouTube[24] channel with online training material, which includes content on financial management and IFMIS modules. Additionally, the Treasury shares content on Twitter and Facebook.

Once trained and qualified, IFMIS users need ongoing support to operate the system. They need support with technology, system use, and business processes. Traditionally, user service centers staffed with available specialists in every functional and technological area provide this support through telephone or other means of communication. It is often difficult and costly to run these centers, and they sometimes fail to deliver expected results.

Modern information technologies such as data analytics and artificial intelligence, especially machine learning, are transforming user support services. They reduce the need for assigning specialists, bring down costs, and enable 24/7 nonstop service.

The country survey conducted by the IDB shows that 85 percent of the IFMIS in LAC have some type of user service center, mostly call centers, that use the traditional model of assigning technical support staff and operate during office hours. New technologies provide ample opportunities for improvement in this area.

One of the most innovative examples is chatbot, or a virtual conversational assistant, a computer program that tries to simulate a human being to converse with people using artificial intelligence techniques designed to convincingly respond to questions in a way that creates an impression of speaking with a real person.[25] Users can ask questions verbally or in writing, and the program accesses a knowledge base with artificial intelligence (such as machine learning) algorithms, generates a response, and sends it to the user. More advanced chatbots can "learn" through operation or through the occasional intervention of a human operator, and thus expand their knowledge base.

Governments are already using these technologies in different areas to improve citizen services. In the State of São Paulo, Brazil, a chatbot-based service center helps citizens interested in obtaining state government services through agencies called *Poupatempo*[26] ("timesaver"). By using the chatbot, the system determines the service or the information a citizen needs and schedules an appointment in a service unit at an agreed upon date and time if an in-person visit is required. If the system does not know the proper answer to the user's question, a human operator will come online and answer, so the system "learns," and the next time around it

[24] The National Treasury's YouTube channel is available at: https://www.youtube.com/user/TesouroNacional/@_tesouro/@tesouronacional.
[25] For a full description, visit: https://es.wikipedia.org/wiki/Bot_conversacional.
[26] More information is available at: https://www.poupatempo.sp.gov.br/wps/portal/poupatempo/home/.

will respond without external support (machine learning). During the first 33 days of rolling out the system, the chatbot assisted an average of 5,300 users per day, exchanging over 2.4 million messages.

The Australian Tax Office developed a virtual assistant, Alex,[27] to assist taxpayers. During the first 18 months, Alex had more than two million interactions (conversations) with users and an 88 percent first contact resolution rate as of September 2017. The government of Singapore provides its agencies with a virtual assistant "Ask Jamie,"[28] which can be installed on the websites of public institutions and is trained to respond to questions in specific areas.

According to Justin Herman from the U.S. General Services Administration (GSA), the government has large amounts of data with significant use potential but is struggling to make them accessible and usable in new ways. Smart virtual assistants provide an alternative for government agencies, and the necessary technologies are available in the private sector. In this regard, the GSA is working on a virtual assistant pilot program[29] for domestic agencies.

These technologies have great potential to provide specialized help to IFMIS users thanks to the ability to overcome a common bottleneck in traditional user service systems: the growing need for specialized staff and 24/7 availability. These technologies can also bring down costs.

With smart virtual assistants providing more granular and automated statistics, IFMIS administrators can obtain subsidies to manage training programs, improve processes, and perfect system interfaces to enhance system usability.

All of this can improve user participation and enable greater focus on user needs. To better use this information, some countries such as Chile have set up user committees to encourage user participation in new IFMIS designs, partial system upgrades, system implementation, and future operation.

3.2. Impacts of Key Emerging Information Technologies on IFMIS

3.2.1. Growing Cloud Use for Data and Computing Services

The United States National Institute of Standards and Technology (NIST) defines cloud computing as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of

[27] To learn more, visit: https://www.nuance.com/omni-channel-customer-engagement/digital/virtual-assistant/nina.html.
[28] To meet this virtual assistant, visit https://www.iras.gov.sg/IRASHome/Property/Property-owners/?checkPTax=1 (tax version).
[29] Read more on this topic at: https://gcn.com/articles/2017/03/28/gsa-virtual-assistant.aspx.

configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction." The main cloud service provisioning models are infrastructure as a service (IaaS), which supplies accessible and flexible computational infrastructure managed online; platform as a service (PaaS), which provides operating systems, databases, and middleware software in addition to computing infrastructure; and software as a service (SaaS), which offers full systems, such as payroll or administrative systems such as Enterprise Resource Planning systems.[30]

The trend of cloud computing use is already a reality in the private sector, and it is estimated that 80 percent of companies use some type of cloud service. One of the reasons for doing so is cost reduction: cloud computing is estimated to save up to 50 percent in the IT budget (Figliola and Fischer, 2015). It also reduces the maintenance and update costs of systems and technologies through cloud migration, which account for 70 percent of the U.S. government's IT budget (2018), according to estimates by the Office of Management and Budget (OMB). For example, just by using cloud-collaborative solutions, government agencies saved between US$500,000 and US$10 million per year depending on size (OMB, 2018). In LAC, on average, 60 percent of government IT budgets goes toward maintaining existing capacities, while OECD countries spend about 55 percent on average in this regard (OECD and IDB, 2016). This shows a good opportunity for reducing maintenance costs.

Cloud computing changes the economic-financial model of IT expenditure from one of capital expenditure (CAPEX) to one of operational expenditure (OPEX). In the latter, an entity pays for the data stored and processed, other services, and ease of scalability, with contract billing on a regular basis. This modality reduces investment and increases recurring operating expenditure.

In most Latin American countries, the public sector is only beginning to use cloud services, while in the private sector cloud use is widespread. Between 2011 and 2016, public sector cloud service billing in Latin America grew by 26.4 percent, a rate second only to the Asia Pacific region, with 31.8 percent.[31] The IDB country survey showed that 50 percent of the IFMIS of respondent countries use some type of cloud services, albeit on a small scale. Additionally, LAC governments have been rolling out policies to use cloud services or expressing an interest in promoting cloud use.[32] In some government agencies in the LAC region, this transformation could still be seen as

[30] For more information on cloud computing models, see Erl, Mahmood, and Puttini (2013).
[31] Information based on Gartner Group's database. For more information, visit: http://evaluandocloud.com/cloud-computing-en-america-latina/
[32] To learn more about this topic, visit: https://www.cepal.org/socinfo/noticias/paginas/3/44733/newsletter19.pdf and http://portal.oas.org/LinkClick.aspx?fileticket=Z6hkABKDNfs%3D&tabid=1729.

risky due to potential budget cuts in operating expenditure. It is therefore necessary to minimize this risk by protecting cloud use contracts by considering them as an element of security for government agencies (Seco, 2018).

Another key topic has to do with current regulations and legal issues. Data centers of cloud service providers are located in geographic areas or countries that are convenient for them. While this preference may not affect private companies, the public sectors in other countries may face legal, accessibility, or data disclosure restrictions. The USA Patriot Act is a case in point, as it allows local authorities to access data stored in their jurisdiction. Local clouds and data centers can be potential solutions to this problem. Providers like Amazon Web Services (AWS) and Microsoft's Azure have already set up data centers in São Paulo, Brazil to facilitate local and regional contracts in the LAC region.

To decide on cloud use in the public sector, an important analysis is to classify the available data in a public institution: the least sensitive or non-confidential data are candidates for immediate cloud migration; the remaining data can then be evaluated, and data security and protection measures defined (Zaballos and Rodríguez, 2018). In any case, it is estimated that data stored in the cloud should be just as if not more secure than on-premise stored data, since security investments made by cloud service providers are of high quality so that large organizations can use them. Additionally, clients are protected by legal contracts.

Some LAC countries, such as Colombia, Mexico, Dominican Republic, and Uruguay, have government policies to encourage public institutions to use cloud services (GEALC, 2016).

The National Digital Strategy[33] of the government of Mexico calls for prioritizing cloud computing. For example, the Tax Administration Service (Servicio de Administración Tributaria, or SAT) put in place a "hybrid cloud," so called because it is a cloud computing environment[34] that uses a combination of public cloud services contracted from third parties and private (proprietary) clouds,[35] with coordination between the two. The hybrid cloud[36] offers institutions greater flexibility, elasticity, and more options for data use and storage.

Likewise, many developed countries already have sophisticated policies in this regard. For example, in 2010 the United States released a strategic document titled 25 Point Implementation Plan to Reform Federal Technology Management (Kundra, 2010). The document provides guidance for government agencies on adopting a "cloud first" policy that calls for using

[33] Read more about the topic at: http://cdn.mexicodigital.gob.mx/EstrategiaDigital.pdf.
[34] For the full definition, see: https://searchdatacenter.techtarget.com/es/definicion/Computacion-en-la-nube.
[35] For more detailed explanations of public and private clouds, see: https://searchdatacenter.techtarget.com/es/definicion/Nube-publica and https://searchdatacenter.techtarget.com/es/definicion/Nube-privada-nube-interna-o-nube-corporativa.
[36] For more information, visit: https://searchdatacenter.techtarget.com/es/definicion/Nube-hibrida.

commercial cloud technologies where feasible or launching private government clouds or using regional clouds with state and local governments where appropriate. In the United States, cloud service providers have created clouds for exclusive use by the public sector, such as Microsoft's Azure Government and Amazon's AWS GovCloud-US,[37] which allow for storing sensitive or classified data.[38]

The United Kingdom rolled out a "cloud first" policy for its IT initiatives in 2013. Under this policy, government institutions must consider cloud solutions before looking at other alternatives. They must also consider contracting public clouds rather than a hybrid, private, or community model. The policy encourages government institutions to use SaaS models. There are also guides for institutions to evaluate better alternatives, such as *Guidance Public Sector Use of the Public Cloud*.[39] The decision must be based on a risk analysis which specifically considers the 14 principles in the document titled Implementing the Cloud Security Principles of the National Cyber Security Centre.[40]

Analyzing cloud use policies in some LAC countries such as Brazil (State of São Paulo) and Colombia, it is clear that LAC countries start out with hybrid clouds, especially countries that already have large data centers and wish to amortize their investments in infrastructure. By using hybrid clouds, these countries are able to keep critical data and services in internal, proprietary infrastructure at least during a period of evaluation and acquiring operational knowledge about the contracted cloud environment. On the other hand, hybrid cloud deployment poses a multitude of technological, organizational, or cultural challenges to user institutions (Marks, 2018).

In a cloud computing strategy, it is important to consider changes in the profile of IT staff. The new IT team should have people trained in creating contracts by negotiating minimum service levels and service monitoring, and mitigating risks. Additionally, technical staff should have experience with technologies used for conducting systematic vendor inspections. The IT team should potentially consider hiring external experts to help manage more complex contracts and large-scale inspections.

In LAC countries, the IFMIS of central governments are often operated by relatively well-equipped data centers, many of which have standards for service continuity and security. For these cases, cloud computing can provide an alternative to making new investments in expanding or upgrading proprietary data centers. In these cases, one could assess the feasibility of using

[37] Cloud service for U.S. government agencies under rules established by the International Traffic in Arms Regulations (ITAR).
[38] For more information, visit: https://www.nextgov.com/it-modernization/2018/10/microsoft-host-governments-classified-data-early-next-year/151861/.
[39] Peruse the Guide at: https://www.gov.uk/guidance/public-sector-use-of-the-public-cloud.
[40] More information is available at: https://www.ncsc.gov.uk/guidance/implementing-cloud-security-principles.

hybrid clouds for these expansions and for ancillary administrative systems (systems for public procurement, salary payment to government workers, debt management, etc.), as well as for backup, testing, and standardization environments.

When planning an upgrade or expansion of the proprietary data center of an IMFS, it is a good idea to assess the availability conditions, costs, and impacts of contracting cloud services as an alternative to this process beforehand. Initially, a pragmatic step would be to avoid large additional investments in hardware and facilities through contracting, for example, contingency cloud data centers. By learning from contracting, monitoring, and operating processes, one can gain knowledge on how to evaluate a future migration of the main data center to the cloud.

Most subnational IFMIS in Latin America still have centralized architecture but have many operational deficiencies, mostly at the municipal level. In many places there are no data centers that could be classified as at least TIER 2 or 3, but there are "server rooms" that lack basic operating conditions and adequate human resources in terms of quantity and capacity. Cloud computing can be a feasible improvement alternative, depending on the communications infrastructure. In some countries, such as Bolivia and Honduras, the central government develops and maintains a subnational IFMIS that is accessible via the internet, which is operated directly by municipal governments.

For both central and subnational governments, feasibility studies on the option of contracting cloud services should consider the supply, quality, and cost of these services in each country or region, since this is clearly a great opportunity for IFMIS in the coming years.

3.2.2. Open Source, Free Software, and Ways of Coding Sharing

While open source[41] and free software are based on different concepts, they both refer to computing programs developed individually or by communities that then share their projects, structures, source codes, and documentation with the public, free of charge. These systems are released under proprietary licenses, which define rules that users must follow. The type of license known as GNU GPL is the basis for most free software. For example, the type of license called GNU Affero[42] establishes that software released under this license must meet the following conditions: (i) use permissions: commercial use, modification, distribution, patents, private use; (ii) limitations: there are no author guarantees or responsibilities; and (iii) terms of use: license notice and copyright must be preserved, all sources changed or created (i.e., the resulting products) must be released under the same type of license. These define some important aspects

[41] For a more detailed description, visit: https://es.wikipedia.org/wiki/C%C3%B3digo_abierto.
[42] For more information, visit: https://www.gnu.org/licenses/agpl-3.0.en.html.

for using the software: while it is free, the author cannot be held responsible or guarantee the absence of errors; the products resulting from the use of the original software must also be released under the same type of licensing. In this way, the use of free/open source software presupposes evaluating its use in other institutions and the thorough review of published codes and documentation.

One of the most popular free software is Linux, the operating system used on many servers and by large companies with their own proprietary versions (e.g., Oracle). Among personal productivity software, which are used on microcomputers, there are several free software packages, such as OpenOffice, developed by the Apache project, and OpenProj. Their purposes are similar to those of MS Office and MS Project, respectively.

The environment for free software in data analytics called R (R Studio) may have potential applications in fiscal management.[43] The environment provides an extensive set of statistical techniques (linear and non-linear modeling, classical statistical testing, time series analysis, classification, grouping, etc.) and graphs. Several OECD countries use R in fiscal management. A survey of these countries revealed that the main reasons for its use, in addition to cost reduction, are flexibility, incorporation of new algorithms, and higher speed compared to commercial packages.

There is great potential in using these types of software solutions in subnational fiscal information systems including IFMIS, mainly within the same country. The central government defines the legal and regulatory framework for the fiscal environment, and municipalities build their information systems around the framework, with few individual differences. A fiscal management system developed on the premises of free/open source software can be shared among municipalities and can be adapted with a few changes to the specific conditions of another municipality, reusing common database structures, concepts, and processes. This strategy does not require the use of an entire system: modules, routines, algorithms, or processes can be shared based on local needs. The cost of adaptation is marginal, which makes it especially easy for small municipalities to use appropriate fiscal information systems at affordable prices.

In addition to available cloud-based open source codes, there are other cases of sharing codes and systems originally developed for a specific government. For example, Brazil's 26 states and the Federal District have been sharing among themselves full IFMIS under licenses arranged with each other. The state of Alagoas implemented a new IFMIS in 2017 based on adapting the IFMIS donated by the state of Rio de Janeiro (financed by the IDB). The IFMIS in Rio de Janeiro

[43] To learn more, see: https://www.rstudio.com/.

had been developed and implemented by a company called Logus, based on another IFMIS it had in operation in the state of Espirito Santo. When Logus sold this IFMIS to Rio de Janeiro, Logus gave the source codes to Rio de Janeiro (a legal obligation in the state). Later, Logus agreed to implement the IFMIS donated by Rio de Janeiro in Alagoas.

Likewise, the state of Mato Grosso donated its IFMIS (developed in-house) to the state of Bahia, which adapted and implemented it. There are other similar cases in Brazil, and all these systems are in operation and have a track record of success. One impact of these practices was a significant reduction in the costs of new IFMIS for the 26 states and the Federal District. Currently, the cost of a new IFMIS in Brazil is much lower compared to other countries in the region, thanks to these practices of code donations and a large market of providers of these types of systems.[44]

Among LAC countries, this practice is less frequent, mainly due to the uniqueness of each country, both in terms of legal framework and PFM processes. Nevertheless, there is the case of Ecuador, which received a donation of IFMIS codes from Guatemala in 2008, which the former successfully adapted and implemented in the country and used for more than 10 years (in 2019 Ecuador still uses Guatemala's IFMIS customized to its needs, but has a contract to migrate in the future to a new system procured in the market through a license purchase).

To facilitate the sharing of information on the availability of open source or free software resources appropriate for certain areas, it would be necessary to create a specialized open access repository. The IDB created an initiative called Code for Development, which allows for exploring and reutilizing open source digital tools that can be used in the implementation of programs and projects for economic and social development in LAC countries. This initiative provides open source codes, spreadsheets, and algorithms on the portal of Code for Development: Improving Lives with Digital Tools.[45] In addition, the portal defines rules and conditions for those who wish to share their digital tools through the platform.

Using open source or free software is a feasible alternative for public institutions. It is also important to have resources to validate, adapt, and implement systems or routines, or license a packaged version from a company.

Exchanging open source or free software solutions between subnational institutions of a country is a highly attractive alternative in this regard. This exchange can take place formally

[44] Since Rio de Janeiro procured its new IFMIS, set the parameters, and deployed it in the first half of the 2010s at a cost of US$10 million, prices have fallen significantly. Alagoas implemented a version of Rio de Janeiro's IFMIS at a cost of only US$1 million. In 2018, the state of São Paulo launched a project to replace its IFMIS with a new one, with an estimated initial cost of approximately US$5 million. New IFMISs in other states cost even less.

[45] More information is available on this portal: http://code.iadb.org/es/comparte-tu-codigo.

through agreements or by other means. The probability of success is high, given the similar context in which the legal and regulatory systems work within a country. In addition, from the moment of delivery of the software and its documentation, the recipient institution becomes solely responsible for software adaptations and their subsequent maintenance and evolution. It is important to determine how to carry out these activities: whether with the institution's own human resources or by hiring a company.

3.2.3. Distributed Ledger Technology (Blockchain)

Blockchain is a growing list of irrevocable transaction records with encrypted signatures and shared by all participants in a virtual network. Each record contains a time stamp and links to references to previous transactions. With this information, anyone with access permissions can trace a transaction event to a specific participant at a specific point in their transaction history. Blockchain is a computing architecture design of distributed ledgers in the broadest sense (Gartner, 2018a). Blockchain is known as the supporting technology for cryptocurrencies, especially Bitcoin. As integral components of blockchain, decentralized consensus mechanisms (algorithms that define the transaction to be recorded in the blockchain) and smart contracts (self-executing computer protocols with strict rules and consequences similar to a legal instrument) enhance the applicability of this technology (Tapscott and Tapscott, 2016).[46]

Ranked on the Gartner Group's 2018 scale of emerging technologies for digital governance in the "Peak of Inflated Expectations" category, blockchain is considered to still need 5 to 10 years to reach productivity level (Gartner, 2018b). Whenever a disruptive technology with high uncertainty over its use cases appears, it is common to overestimate the benefits and ignore the fact that technological changes take time and require the adaptation of an entire ecosystem.[47]

Nevertheless, one can identify potential applications and even early experiences with blockchain in some cases of public expenditure management. The two blockchain applications described below were drawn from Seco and Muñoz (2018).

In the area of human resources management, creating a registry and payroll for civil servants with blockchain technology would ensure a sequential and immutable record of all events of their functional life. Ainsworth and Viitasaari (2017) consider that payrolls have important features for blockchain application: they are digitized and interact with different agencies (such as social security, tax administration, labor legislation supervisory bodies, unions, etc.) that have

[46] To learn more about blockchain, visit: https://es.wikipedia.org/wiki/Cadena_de_bloques.
[47] For more information, read the interview with Christian Catalini, professor at the Massachusetts Institute of Technology (MIT), available at: http://sloanreview.mit.edu/article/seeing-beyond-the-blockchain-hype/.

access to certain data and can perform compliance audits. In this context, they estimate that the first payroll applications with blockchain technology will probably appear between 2018 and 2021.

Using other digital technologies can enhance the application of blockchain in public procurement. One example is the FASt Lane system,[48] developed as a proof of concept by the Federal Acquisition Service of the United States General Services Administration (GSA/FAS). Currently used for purchasing certain IT equipment and services, the system has cut down total processing time by about 90 percent and automated all stages except for the final negotiation (between the lawyers of the parties) and the signing of contracts. The system uses a private blockchain based on the hyperledger[49] platform to store the most important documents, messages between participants, and contracts, thus ensuring the security, immutability, transparency, and time stamping of the data. Its consensus mechanism is based on the "proof of stake" algorithm.[50] The blockchain is built on a group of certified nodes (servers).

Other PFM-related operations may improve in the future as blockchain replaces traditional technologies. The Central Bank of Brazil and other regulatory institutions of the national financial system use a blockchain-based platform[51] for system control and real-time sharing of operational information. Previously, the Central Bank used email messages, fax, and other means that require validation and authenticity checks, resulting in difficulties in archiving and delays in inquiries. With the blockchain features of data immutability, chronological order, and the use of electronic signatures, the incidence of errors is lower, tampering is practically impossible, and searches are more effective: each institution has access to all interactions in which it is a participant, and administrative procedures take less time to complete. This is a type of blockchain application for information sharing between public entities.

The World Bank entered into an agreement with the Commonwealth Bank of Australia (CBA)[52] to launch the first global bond to be created and managed through blockchain technology throughout its life cycle. The two institutions launched the bond in late 2018 after a consultation period with large investors. Blockchain is considered to have the potential to streamline processes

[48] More information is available at: https://gcn.com/Articles/2017/09/21/GSA-looks-to-blockchain-for-procurement.aspx?m=1.

[49] Hyperledger is an open source blockchain platform launched by the Linux Foundation in 2015 to support blockchain-based distributed ledgers. More information on the Linux Foundation is available at: https://es.wikipedia.org/wiki/Fundaci%C3%B3n_Linux.

[50] In the "proof of stake" algorithm, the probability of beating the competition to record a transaction block is directly proportional to the "stake" one has. The meaning of "stake" is defined by a certain system, which could be a currency, stocks, etc.

[51] More information is available at: https://www.bcb.gov.br/en/#!/c/noticias/249.

[52] You can read more on the topic at: https://www.worldbank.org/en/news/press-release/2018/08/09/world-bank-mandates-commonwealth-bank-of-australia-for-worlds-first-blockchain-bond.

in debt markets, intermediaries, and brokers, as well as to simplify fundraising and securities trading and improve operational efficiency and regulatory oversight.

In LAC countries, national IFMIS in operation do much more than merely sharing information. These IFMIS were implemented with a TSA at the core and automated accounting as a centralized system accessible to participating entities through communication networks. In recent years, technological progress in server equipment, communications networks, and data center physical infrastructure have led to a significant improvement in the security, availability, reliability, and effectiveness of these systems, which are sometimes classified using the TIER standard. Given the centralized architecture of the IFMIS and the TSA, and the quality of the infrastructure of data centers and supporting networks, investments in radical transformations such as blockchain are less attractive in the short and medium term.

There are still no identified cases of IFMIS that use blockchain-type platforms. Nevertheless, the advantages of cloud computing could provide interim distribution opportunities at the subsystem level, with so-called ancillary administrative systems (e.g., human resources, staff payments, or public procurement), mainly operated through the cloud but integrated into the core of the IFMIS.

The use of consensus mechanisms and smart contracts in budget execution and accounting could make established rules more reliable and powerful. Consensus rules and smart contracts are also stored in blockchain; both have technologies that guard against inadvertent and fraudulent tampering and backdoors. In this context, the operational and economic feasibility of a new generation of IFMIS with distributed ledgers based on blockchain-type technology is an open-ended issue, which still lacks theoretical assessments and verification through proofs of concept and pilots.

There are more opportunities to use blockchain-type technologies in the medium term at the subnational level of government. Cloud-based solutions cannot solve all the problems, such as the timely consolidation of provincial and municipal budget execution data for the entire public sector. A blockchain-based subnational IFMIS could lead to progress on this issue, as supervisory bodies and other stakeholder institutions would have real-time access to data and could even interact with each other on budget execution based on appropriate consensus mechanisms. Again, there are no theoretical assessments of feasibility or verification through proof of concept; however, achieving feasibility at the subnational level appears more likely in the medium term.

Lastly, replacing existing systems with blockchain will only occur when its added value vis-a-vis the current technology can be proven. Theoretically, there are good use opportunities in PFM for data sharing among public entities, for some ancillary administrative systems such as

public procurement and human resource management and for subnational government IFMIS. This does not mean that in the future there will be no blockchain-based national IFMIS; rather, there seems to be no such trend in the medium term.

3.2.4. Electronic Payments and IFMIS

In the IFMIS assessment methodology proposed by Hashim and Piatti (2016), one of the five assessment categories[53] is "IFMIS coverage", which measures the extent to which government financial transactions are covered by the IFMIS budget execution processes. In this assessment, a system loses points in the "IFMIS coverage" category if certain types of financial transactions take place outside the system, such as public debt servicing, fiscal transfers, and subsidies to state-owned enterprises.

Besides coverage, the digitization of payments[54] made through an IFMIS should be a key objective. Payment digitization can enhance transparency, accountability, and cost reduction, in addition to facilitating financial inclusion.

In LAC, central government IFMIS generally rely on the banking system for transfers. Government payments are deposited into the bank accounts of each beneficiary, whether natural or legal persons, through agreements with the banking sector. Additionally, many of the subnational (provincial and especially municipal) IFMIS do not have the same level of coverage of the existing electronic payments as national IFMIS, which limits coverage to the country level.

Lund, White, and Lamb (2017) estimate that the digitization of government payments could save between 0.8 and 1.1 percent of gross domestic product (GDP) in developing countries, equivalent to 1.5 percent of all government payments and greater than the official development assistance received by emerging market economies during 2015. If one considers transfers, subsidies, payments to civil servants, and pensions, payments to natural persons represent 12 percent of GDP in developing countries (Cangiano, Gelb, and Goodwin-Groen, 2017).

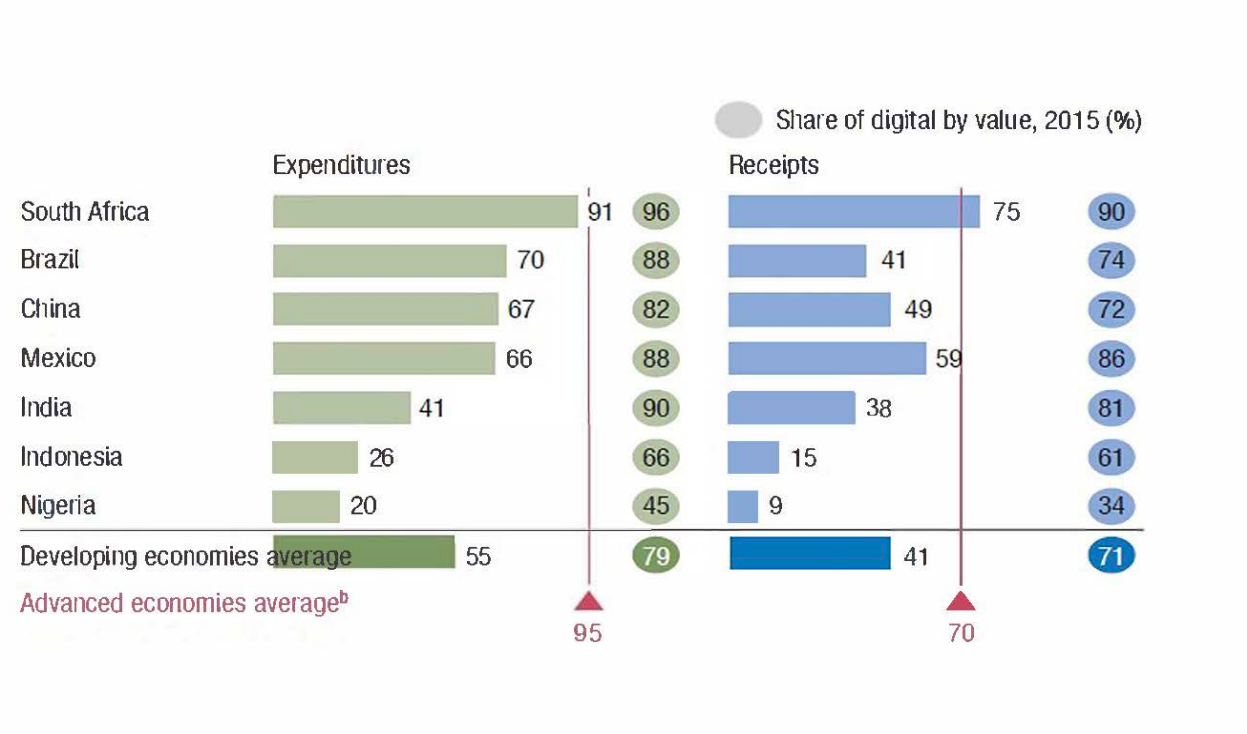
Coupled with other technologies for secure identification of civil servants and citizens (e.g., biometric identification), payment digitization can enhance outcomes, in particular through improving the targeting of social subsidy payments. For example, India and South Africa supplemented their measures to expand electronic benefit payments with the introduction of a universal biometric identification system (IMF, 2018).

[53] The assessment categories are: (i) TSA coverage (10 percent), (ii) FMIS coverage (25 percent), (iii) auxiliary features (15 percent), (iv) core functionalities of the FMIS (40 percent), and (v) technical aspects (10 percent).

[54] The digitization of payment is used in government-to-people payments (G2P), government-to-business payments (G2B), and vice versa (P2G and B2G).

In terms of regional challenges, the need for some cash transfers will still exist despite all efforts. For example, between 5 and 6 percent of the humanitarian aid delivered by the United Kingdom is in cash (Sturge, 2017). Figure 3.2 shows the gap that developing countries can leverage to catch up with advanced economies in terms of the same indicators.

Figure 3.2. Proportion of Public Sector Electronic Payments in Selected Countries[a]



Source: McKinsey Global Institute Analysis and McKinsey Payment Map 2015 (cited in Gupta et al., 2017).
Notes: [a] Total amount excluding payments in cash, checks, and paper transactions, by volume (quantity).
[b] Based on data from 20 advanced economies. Average proportion. Including all levels of government.

When several government institutions are processing payments and collecting revenues, they can often avoid the risk of developing "silos"—different IT systems and infrastructure that hinder the full reconciliation of transactions between the government and citizens (Cangiano, Gelb, and Goodwin-Groen, 2017).

The data show a need to enhance the use of electronic payments, especially in subnational government IFMIS, in order to achieve some of the potential savings mentioned by Lund, White, and Lamb (2017) and to reduce the existing gap.

IFMIS in LAC make electronic payments mainly through the banking system by making deposits into beneficiaries' accounts. However, LAC populations remain underbanked. Banking penetration rates in some LAC countries, such as Brazil, Chile, and Panama, are between 71 and

78 percent; in Argentina, Colombia, Dominican Republic, Ecuador, Mexico, Uruguay, and Venezuela, they are between 64 and 71 percent. The lowest banking penetration rates are found in Haiti, Honduras, Nicaragua, and Peru (Zaballos and Rodríguez, 2017). Promoting universal citizen access to the banking system can also enhance the use of electronic payments in IFMIS. However, as the region remains underbanked, one alternative is to use "mobile money."[55]

GSMA[56] defines mobile money as systems that meet the following criteria: (i) the service has to include at least one of the following products: peer-to-peer (P2P) transfers, bill payment, bulk disbursements, merchant payments, or international remittances; (ii) the service must rely heavily on a network of transactional points outside bank branches that make the service accessible to unbanked and underbanked people (mobile banking services and payment services linked to a current bank account or credit card are not included); and (iii) the service must offer an interface for initiating transactions for agents and/or customers that is available on basic mobile devices.

High mobile phone service penetration coupled with mobile money services can be an important factor in bridging the electronic payment gap in LAC, expanding financial inclusion and opportunities for fiscal management, facilitating tax collection from small taxpayers, and targeting social subsidy payments. In LAC, there are 37 mobile money services with 14 million registered accounts (Almazán and Frydrych, 2015).

In Mauritius Island,[57] the installation of mobile money payment facilities increased tax collection by 12 percent in the following year. In Tanzania, citizens with no history of tax payment went on to pay property taxes and income taxes for the first time. In Brazil, the Tesouro Direto[58] application allows people to buy and sell government securities.

Integrating this payment model into IFMIS is technically straightforward and could initially incorporate, for example, the direct payment of social benefits to unbanked people who receive money through intermediaries or in groups.

Besides using mobile phones to increase electronic payments, a new possibility worth considering is the use of cryptocurrencies.[59] Tax payment with cryptocurrencies is not yet envisaged for the short or medium term. The reason is that cryptocurrencies such as Bitcoin have high price fluctuations, and many consider them an asset and not a currency. In addition, there is

[55] Mobile money is a service that unbanked individuals can use to make and receive payments using a mobile phone.
[56] GSMA is an association that represents the interests of mobile phone operators worldwide. For more information, visit: www.gsma.com.
[57] For more information, visit: https://www.theigc.org/reader/regulating-mobile-money-support-scale/government-usage-mobile-payments-services-offers-significant-benefits/.
[58] You can learn more about the topic at http://www.tesouro.fazenda.gov.br/-/tesouro-direto-lanca-aplicativo-para-ios.
[59] Cryptocurrency is a medium of exchange that uses encryption to protect transactions and to control the creation of new units of the same currency with the use of tokens and in a completely virtual manner.

a dispute over the legality of these currencies and there are currently no fiat cryptocurrencies (issued by a central bank and in regular use) that could potentially be used. These facts also make it difficult for government payments to be made in cryptocurrencies.

Currently, conditional cash transfers are generally made with bank cards or in cash. Using cryptocurrencies for these payments could bring the additional benefit of greater control over how each beneficiary is using these resources, as well as enabling the public sector to leverage this emerging new technology to better understand its potential.

In conclusion, public sector payments and electronic tax collection have evolved significantly in LAC, especially at the central government level. However, there are still opportunities for improvements mainly in subnational governments and for promoting the inclusion of the low-income population, with the consequent reduction in payments by check and in cash (usually social subsidies) and the individualization of these payments, which may help LAC countries bridge the gap with advanced economies. Additionally, since LAC still has a large unbanked population but very high mobile phone penetration rates, it is possible to leverage experiences with the mobile money model as in the cases of India, Kenya, and other countries.

3.2.5. IFMIS and Data Analytics Applications

Technological progress has led to a radical transformation of the development of data analysis and research tools. Part of this transformation is the enormous growth in computer processing and storage capacity along with declining costs; increased availability of communication networks and broadband internet; cloud computing; the development of effective algorithms for data capture, storage, and mass processing; the improvement and availability of government and private data sources; and the emergence of new data sources (sensors, GPSs, social networks, etc.). The global availability of data in digital formats grew exponentially, from around 30 zetabytes[60] in 2018 to an estimated 163 zetabytes by 2025.[61]

It is in this context that the concept of advanced data analytics thrives. Data analytics is defined as the autonomous or semi-autonomous analysis of data or content using sophisticated techniques and tools, generally going beyond those of traditional business intelligence (BI) to discover hidden relationships between data, anticipate trends, or optimize decision making. Advanced analytical techniques include data or text mining, machine learning, pattern and standard matching, forecasting, visualization, semantic analysis, network and cluster analysis,

[60] 1 zetabyte = 10^{21} bytes or 10^{12} gigabytes.
[61] Data obtained from Forbes Online, available at: https://www.forbes.com/sites/andrewcave/2017/04/13/what-will-we-do-when-the-worlds-data-hits-163-zettabytes-in-2025/#4b077acb349a.

multivariate statistics, graph analytics, simulation, complex event processing, and neural networks, among others.[62]

By combining their own data with third party data, tax administrations identified great potential for applying these techniques to tax management, tax intelligence, and public expenditure.

In Brazil, the state of Amazonas performs an advanced data analysis on its public procurement system.[63] The analysis draws on elements facilitated by the Public Digital Bookkeeping System (Sistema Público de Escrituração Digital, or SPED), which uses electronic VAT invoices and other techniques to create a database with information such as inventories, balance sheets, transport tracking, and sales transaction prices, all of which are extremely valuable for planning public procurement. With such information available in a database, price searching has become automated thanks to data mining and electronic monitoring of market prices to compare them against public sector prices. The search results are evaluated, and the best are reported to the system, which "learns" to optimize its performance and prevent public procurement at prices well above market rates.

The techniques mentioned here can help deal with the enormous amount of data available in the IFMIS databases, supplemented by data from tax administrations and other institutions (national statistics institutes, central banks, etc.), which exceed the capacities of traditional database systems. The most important application is decision-making support to public finance managers, since it has evolved from a process based on intuitive insights to an approach supported by data analytics applications.

Some of the tasks that data analytics can accomplish are: (i) identify spending trends by service or product sector (overall or by institution/sector); (ii) know which types of goods or services are associated with higher spending; (iii) identify how to better control "accounts payable" and detect inappropriate payments; (iv) identify how much different regional and national institutions are paying for the same items and under what conditions; (v) determine the main suppliers of goods and services and how much each institution spends on each; (vi) identify the cheapest, highest rated supplier; (vi) identify projects with the best financial performance in previous year(s); (viii) determine where spending at the current rate will exceed the budget and why; and (ix) support budget preparation based on cost analysis and the actual contribution of programs to the objectives proposed (it would not be based solely on previous year's execution

[62] Information obtained from the Gartner IT Glossary, available at: https://www.gartner.com/it-glossary/advanced-analytics/.
[63] More information is available at: https://www.e-compras.am.gov.br/publico/.

with the addition of a growth factor) (Seco and Muñoz, 2018). Some of these issues require analyzing the data from other ancillary systems interoperated with the IFMIS, such as the public procurement system.

The Accountant General's Department (AGD) of Singapore developed a data analytics platform called Fi@Gov[64] to support decision making in public finance. The platform provides dynamic dashboards that can visualize historical spending trends and respond with graphs to questions such as: Where is the money spent? Who is spending the money and how much? What is the payment trend for the coming months/years?

In macroeconomic policy, fiscal statistics are generally obtained through official reports and balance sheets of the public sector, which are almost always released with significant delays. However, governments in many countries are investing in digitizing tax collection and government payments, which are recorded automatically, thus contributing to improving government agreements and interfaces with banks and laying down a technological foundation that allows information systems such as IFMIS to promote the automation of public financial management.

In these cases, fiscal data may be available in real time (nowcashing) and can contribute to improving macroeconomic oversight. Similarly, one of the applications for these data obtained in real time is better forecasting of economic activity. For example, trends in daily variations in taxes can reflect in real time a large number of macroeconomic developments. The results of an assessment conducted in the United States with data on payroll taxes (60 and 180 days accrued) are consistent with one conducted with data on real-time changes in industrial production.[65] Specialists believe that in the future, such an approach can be disruptive for how macroeconomic oversight operations are conducted, given that using large amounts of real-time data requires automated processes to update macroeconomic analyses (IMF, 2018).

Equally important is choosing the appropriate advanced analytics tools. The market offers several options, such as SAS, BAE, IBM (various tools), Oracle Data Miner, and Stata. Based on an OECD survey conducted in 15 member countries, most governments use a combination of tools, most of which are purchased on the market (OECD, 2016: 49). Free software is also available, such as R Studio. The New Zealand Tax Administration is a special case in using R as the foundation of its advanced analytics strategy. To this end, it has created external partnerships with academia and nongovernmental organizations (NGOs), among others, to improve its models, which has yielded successful results.

[64] Watch a video presentation of the platform at: https://info-motiongraphics.com/figov-launch-video/
[65] For more technical details and conditions of this assessment, see IMF (2018: 73).

Data analytics tools may include other important graphical tools, such as dynamic dashboards[66] that help decision makers visualize trends in a timely fashion. Previously rare, complex, and expensive, software for creating dynamic graphics and dashboards now offers a wide range of possibilities,[67] as does free software.[68]

The use of data analytics in PFM is growing, with results that have proven effective in many countries. With the growing availability of internal[69] and external data in a plethora of structured and unstructured formats, coupled with algorithms and highly effective tools, the application areas of these concepts are constantly growing. Trailblazing tax administrations are seeing positive results and promoting new organizational models to better apply these tools.

Many institutions start out with an exploratory approach, with data analytics groups working in many areas and on small projects. Over time, they begin to focus on projects that are likely to bring about better results (OECD, 2016).

It is critical to bring the knowledge of data analytics deeper into government institutions, by hiring new professionals with the relevant skills and/or training civil servants. It is also becoming popular to form small project groups consisting of business specialists and data analytics technicians. Choosing the appropriate tools is part of this process, for which one can consider the availability of commercial tools, free software, or a mixture of both.

3.2.6. Fiscal Transparency and Data Analytics of IMFS Data

The data available in the IFMIS databases, including those in the auxiliary systems, are important sources of information for fiscal transparency. The potential of these sources increases when they are associated with additional information both internal and external to the tax administration.

Currently, measures aimed at promoting fiscal transparency rely heavily on data integration using three main technologies: data analytics (for data organization, association, and inference), data release standards (to ensure uniformity and comparability of information), and smart portals (to facilitate searches, improve usability, and enhance user experience in the presentation of information).

Examples include the presentation of the Estonian government portal, which provides a lot of information on the budget and its execution through two sections: "overview" and "where is

[66] In addition to the graphical modules specific to each data analytics tool.
[67] See the best products at https://www.softwareadvice.com/bi/dashboard-comparison/.
[68] To learn more about these products, visit: https://www.predictiveanalyticstoday.com/open-source-dashboard-software/
[69] The most relevant internal data for data analysis in support of PFM are the ones provided by the tax administration.

your money going?" Another example is the Irish government portal,[70] where citizens can verify all the taxes they have paid and see the amount allocated to each segment of public expenditure (education, security, state administration, social programs, etc.) based on the current budget, after entering the amount of their salaries.

In countries of the Americas, examples of important initiatives include Canada's Treasury Board Secretariat (TBS) Infobase system,[71] which consists of a database and online search tools that provide financial and human resource information on the government of Canada. TBS InfoBase combines contextual information and data from multiple sources into a single repository, providing an overview of the government of Canada and its departments and agencies. The system allows users to create customized reports and provides a variety of perspectives and tools to analyze government operations. A high percentage of users indicate that they found what they were looking for in the database and consider it very useful. In addition, government workers use the database to plan and track financial transactions. The system also provides a glossary of terms and metadata.[72]

Meanwhile, the government of Mexico developed a computing platform called Transparencia Presupuestaria (Budget Transparency), which gathers information on accountability from the entire budget cycle.[73] The information can be viewed individually or in aggregate form, with displays in easy-to-read graphical formats or in detailed tables that users can download, and with query filters for choosing relevant data and other query capacities. The platform provides information in five main groups: (i) budget (download budgets in international format with open fiscal data, descriptive brochures summarized with the proposal, expenditure approval and execution), (ii) open public works (with quarterly data of 2017, query on ongoing investment programs and projects in the 2018 federal budget, with indicative map displays and data download options), (iii) programs (display of maps that categorize programs and projects by area, with progress indicators and data download options), (iv) federal entities (federal transfers and monitoring of allocated resources in graphical displays), and (v) open data (queries to the open budget database through various indicators and downloads).

Another Mexican government initiative in the area of fiscal transparency is Contrataciones Abiertas MX (Open Contracting MX). It is designed to disseminate information on public procurement processes in accordance with the global Open Contracting Data Standard (OCDS),

[70] For more information, visit: http://www.publicpolicy.ie/where-does-your-tax-go/#middle-link.
[71] To learn more, visit: http://www.tbs-sct.gc.ca/ems-sgd/edb-bdd/index-eng.html#start.
[72] More information available at: https://www.oecd.org/governance/observatory-public-sector-innovation/innovations/page/tbsinfobase.htm.
[73] Visit the website at: https://www.transparenciapresupuestaria.gob.mx/.

which seeks to promote government integrity and increase transparency in public procurement.[74] The government also created infrastructure in the Amazon cloud to store these data using blockchain technology, with open access tools that allow any citizen to visualize the data.

4. Conclusions and Recommendations

This is a moment of transformation for IFMIS in Latin America. These systems were fundamental for economic stability in the 1990s and for greater fiscal efficiency and transparency in the past two decades. However, many are becoming obsolete and in need of modernization. At the same time, technology is developing at an exponential rate, and the use of IT systems and services is becoming more accessible and less costly.

While there are still challenges in process improvements and functional requirements, such as implementing protocols that do not allow transactions outside the system, continuing to expand TSA coverage, further integrating PFM processes, and continuing to implement IPSAS in IFMIS, this paper focuses mainly on the technological aspects of IFMIS modernization. In Latin America, most of the current versions of IFMIS in operation were custom developed during the past 20 years, and many did not have adequate preventive maintenance, which has been shortening their life cycle.

Successful IFMIS strategies take a gradual and modular approach to system development, implementation, or updating, with proper maintenance and user focus. The availability of enough technical and budgetary resources for system maintenance, together with the implementation and institutionalization of best practices in IT management based on international frameworks, are essential to ensure service quality and extending the useful life of the system. Funding for new IFMIS projects or modernization of existing ones should strengthen the implementation and institutionalization of a system management environment based on international standards and practices, to guarantee the effectiveness of the system.

In addition, it is a good idea to consider new institutional arrangements. These include establishing PFM agencies with administrative and budgetary autonomy, as is the case with tax administrations, so as to promote the long-term sustainability of an IFMIS.

To better leverage emerging technologies in the IFMIS modernization processes, it is advisable to adopt a new IFMIS strategy as a public expenditure management platform, with a modular approach to system implementation, maintenance, or updating. In addition, it is preferable to properly maintain existing systems using international best practices in information

[74] For more information, visit: http://standard.open-contracting.org/latest/es/.

technology management such as ITIL, to avoid the need to rebuild the entire system from time to time. In this context, the availability of protocols and rules for control, record-keeping, and documentation of processes and the codification of the system are a priority, with effective testing in all the developments and changes of the IFMIS.

The concept of IFMIS as a platform proposes a robust and modular core around which auxiliary administrative systems and support subsystems are implemented in a coherent architecture with standardized interfaces to form an environment of public finance information systems that can incorporate functional upgrades and new technologies that only require better maintenance of the system without the need to rebuild the entire system from time to time. An IFMIS platform must have clear rules and interfaces so that custom-made and off-the-shelf systems or modules can coexist and interact based on the needs of each government.

Proper maintenance of an IFMIS is essential to ensuring its performance, contributing to user satisfaction, reducing costs in the medium and long term, and maximizing its useful life. The success of the strategy of using an IFMIS as a platform for updates depends not only on the modularity of its functions but also on the quality of its maintenance, record-keeping, and documentation.

It is common that IT managers use requests for changes in the very short term, usually submitted by functional managers, to justify skipping stages in models and international best practices. The ongoing practice of these undocumented and harmful behaviors of software maintenance ends up shortening the useful life of an IFMIS. This has been happening systematically in LAC in recent decades and is one of the main problems for which people frequently suggest purchasing or developing a new system from time to time.

Information security is another issue that IFMIS administrators must prioritize in order to address the growing internal and external threats. To do this, IFMIS administrators can expand the use of encryption techniques, monitor the system environment, and strengthen the user authentication process.

On the other hand, IFMIS user support, traditionally provided by specialized technical staff, can benefit from machine learning technologies and chatbots to interact with users online to answer questions and resolve issues. These “virtual technicians” can improve their performance through practice and by collecting information that can be used to enhance user training, in addition to perfecting IFMIS functionalities and interfaces.

At the same time, the current technological transformation helps to provide opportunities and consolidate trends from new emerging technologies, such as using cloud-based data and services, sharing programming codes, using new distributed ledger technologies (such as

blockchain), collecting taxes and making electronic payments using mobile phones, and using data analytics, among others.

Cloud computing offers important alternatives for reducing investments in proprietary computing centers and promoting IFMIS as a service (SaaS) that can be less costly, more efficient, and more secure. It is recommended to scale up the use of cloud-based data and cloud computing services in the public sector in LAC. This could be done through the “cloud first” policy, under which government institutions must always consider cloud solutions as an alternative, and at least adopt a “hybrid cloud” concept, which combines cloud services and proprietary data centers with coordination between the two to offer greater flexibility, elasticity, and more data use and storage options for institutions.

Other innovations, such as open source and system sharing, also merit better application, drawing from successful stories in Brazil and other countries in the region. The IDB created a repository of open source programs, processes, and algorithms to support this initiative on its portal Code for Development: Improving Lives with Digital Tools. Although there are currently examples where open source systems or modules are shared among countries, such as Guatemala's donation of its IMFS to Ecuador in 2008, there is still great potential at the subnational level, given the similarity in the processes and rules that these entities must follow.

New distributed ledger technologies (DLT/blockchain) are seen as promising, mainly for auxiliary administrative systems such as public procurement, human resources management, payroll, and also for IFMIS at the subnational level. Additionally, DLT has been used to share information quickly and securely among public entities. In the context of national IFMIS, given their centralized architecture, the TSA, and the quality of the infrastructure of data centers and supporting networks, investments in radical transformations such as implementing blockchain are less attractive in the short and medium term. This does not mean that in the future there will be no blockchain-based IFMIS, but it does not seem to be a trend in the short and medium term. This remains a pending issue, which still lacks theoretical assessments and verification through proof of concept and pilots.

IFMIS process their electronic payments through banks, but there are still gaps to be filled due to low banking penetration rates in some countries of the region. One way to bridge the gap for the unbanked population is to use mobile money by relying on the mobile phone infrastructure, learning from experiences with using mobile money models such as those in India, Kenya, and other countries. The widespread use of cryptocurrencies is not yet feasible in the short run, but there is great untapped potential.

The use of data analytics based on IMFIS databases combined with data from other sources promises enormous potential for fiscal management, be it in supplying real-time management tools (dashboards) or in real-time macroeconomic forecasts (nowcashing), among other uses. It is essential for fiscal administration staff to acquire knowledge of data analytics to identify new opportunities and launch research projects to bring together business know-how with available techniques and tools.

Improving fiscal transparency can contribute significantly to data release standards and tools for public procurement and fiscal data, coupled with data analytics techniques (to identify and group relevant information), smart portals (to create web portals attuned to user experience), mobile device applications (apps to allow for data search and visualization on mobile devices), and API (to enable data exchange between application programs of fiscal administration and civil society organizations).

In addition, it is important to keep abreast of progress in other artificial intelligence applications in public finance, which can have a significant impact in areas such as risk analysis in bond issuance, collection forecasting, audits, macroeconomic scenario analysis, and others.

There are many technological opportunities for the IFMIS as a platform in LAC in the years to come. Although the private sector is moving faster than the public sector in becoming early adopters of new emerging technologies, governments should also make progress in identifying and adopting new experiences. This would be crucial for modernizing IFMIS in the region.

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