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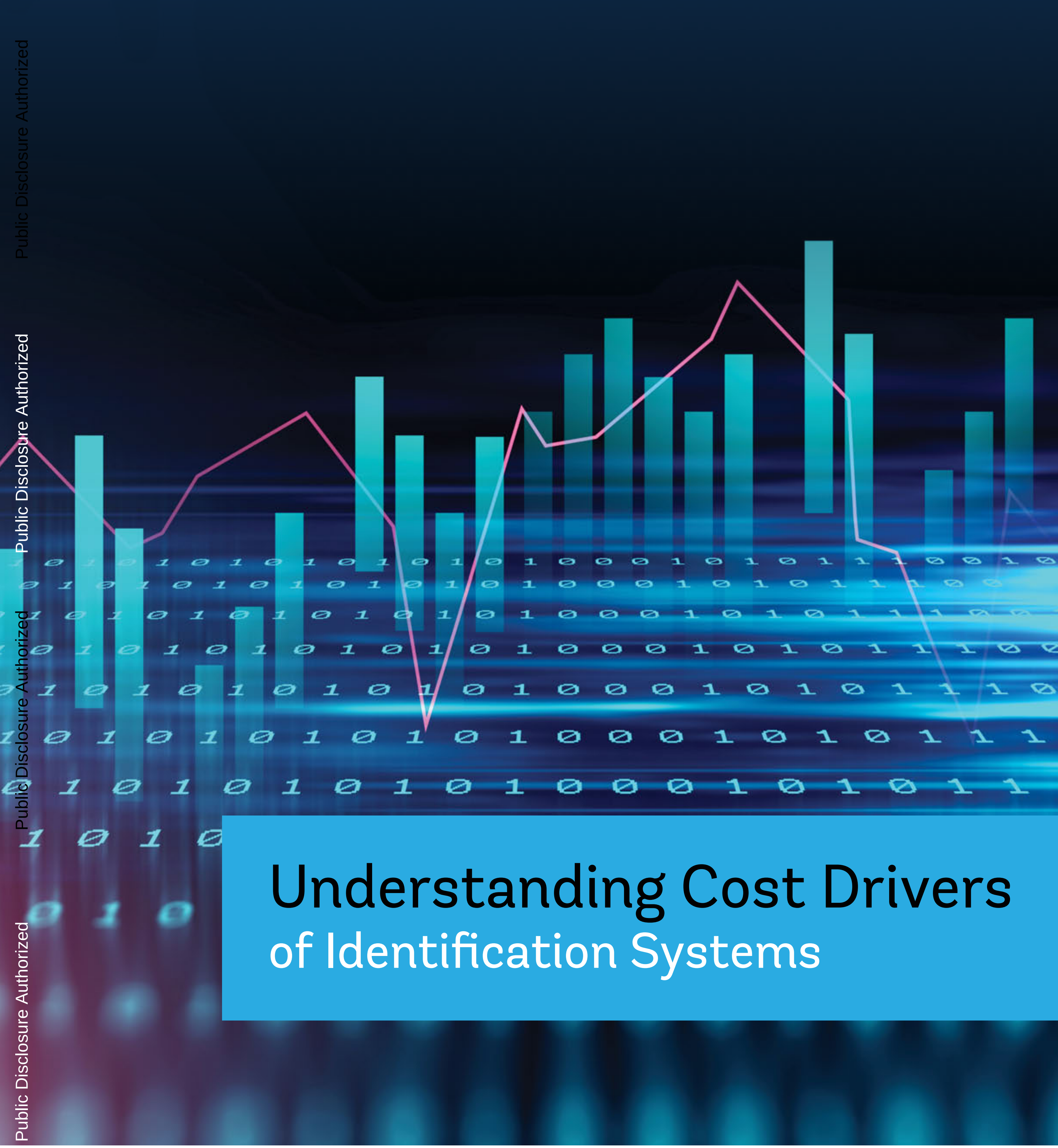

Understanding Cost Drivers of Identification Systems

WORLD BANK GROUP

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About ID4D

The World Bank Group's Identification for Development (ID4D) initiative leverages global knowledge and expertise across sectors to help countries realize the transformational potential of digital identification systems to achieve the Sustainable Development Goals (SDGs). It operates across the World Bank Group with global practices and units working on digital development, social protection, health, financial inclusion, governance, gender, and legal aspects, among others.

The mission of ID4D is to enable all people to access services and exercise their rights, by increasing the number of people who have secure, verifiable, and officially recognized identification. ID4D makes this happen through its three pillars of work:

- Thought leadership and analytics to generate evidence and fill knowledge gaps;
- Global platforms and convening to amplify good practices, collaborate, and raise awareness; and
- Country and regional engagement to provide financial and technical assistance for the implementation of robust, inclusive, and responsible digital identification systems that are integrated with civil registration.

The work of ID4D is made possible through support from the World Bank Group, Bill & Melinda Gates Foundation, Omidyar Network, and the Australian government.

To find out more about ID4D, visit id4d.worldbank.org

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Abbreviations

ABIS	Automated Biometric Identification System
AFIS	Automated Fingerprint Identification System
BOT	Build-Operate-Transfer
COTS	Commercial Off-The-Shelf
CR	Civil Registration/Civil Registry
CRM	Customer Relationship Management
DC/DR	Data Center/Disaster Recovery
ECOWAS	Economic Community of West African States
FAR	False Acceptance Rate
FNIR	False Negative Identification Rate
FPIR	False Positive Identification Rate
FRR	False Rejection Rate
FTE	Failure to Enrol Rate
HQ	Headquarters
ICAO	International Civil Aviation Organization
ICT	Information and Communication Technology
ID	Identity
IEC	Information, Education, Communication
IJEST	International Journal of Engineering Science and Technology
IMSA	Identity Management Systems Analysis
ISO	International Organization for Standardization
IT	Information Technology
LMIC	Low and Middle Income Countries
MSP	Managed Service Provider
NID	National Identity Card
NPR	National Population Register
PC	Polycarbonate

PKI	Public Key Infrastructure
POS	Point of Sale
PPP	Public Private Partnerships
PVC	Polyvinyl Chloride
SDG	Sustainable Development Goal
SI	Systems Integrator
SLA	Service Level Agreements
UN	United Nations
USD	United State Dollars
UV	Ultraviolet

1. Executive Summary

1.1 Introduction: Why Evaluate the Costs of ID Systems?

Approximately one billion people globally lack government-recognized identification.[1] As a consequence, they face barriers to accessing critical services and exercising their rights. Robust, inclusive, and responsible foundational identification (ID) systems[2] can be transformative for a country's development and for the welfare of its poorest and most vulnerable populations by enabling financial inclusion, the empowerment of women and girls, access to basic services, social safety nets, and political participation. Moreover, at a systemic level, leapfrogging traditional paper-based approaches in favor of digital identification systems can generate significant benefits across the public and private sectors by increasing efficiency and accountability (chiefly through the reduction of fraud, leakages, and waste in public programs) as well as driving innovation in service delivery (through the use of mobile or digital payments, for instance).

As governments across the globe are implementing new, digital foundational identification systems or modernizing existing ID programs, there is an urgent need to develop accurate estimations of the associated costs. There are a handful of existing analyses that have attempted to estimate the overall cost of foundational ID systems: for instance, Gelb and Diofasi Metz (2018) estimate that it is likely to cost a low-income country roughly 0.6 percent of GDP to build a foundational ID system, or about $4–11 investment per registrant for enrolment and credential issuance.[3] The same study cites figures for a few countries suggesting recurrent costs of around 0.06–0.1 percent of gross domestic product (GDP). As the authors point out however, few data points exist and these figures may not apply to different types of systems or to all countries.

The detailed, segmented analysis of the costs associated with ID systems in varying country contexts undertaken for this report and the accompanying reference cost model can assist policymakers and other stakeholders involved in the design and implementation of digital ID systems in several ways:

1. It highlights the significant **cost differences across various system design options,** and provides costs which account for **specific country characteristics** to help governments make informed decisions on design;
2. The existence of cost standards can empower governments with a reference base which can be used to **evaluate procurement bids** and better avoid **vendor lock-in;** and
3. Understanding and accounting for the cost of implementing the system in a specific country context (rather than a general estimate) is the first step to **developing a sustainable business model** for a foundational ID system.

1 World Bank ID4D Global Dataset 2018. http://id4d.worldbank.org/global-dataset

2 Foundational identification systems are primarily created to provide general identification and credentials to the population for public administration and a wide variety of public and private sector transactions, services, and derivative credentials. Common types of foundational ID systems include civil registries, national IDs, universal resident ID systems, and population registers.

3 Gelb, Alan, and Anna Diofasi Metz (2018), *Identification Revolution: Can Digital ID Be Harnessed for Development?* Center for Global Development, Washington DC (Chapter 5).

Thus, this report can play a key role in facilitating a transparent dialogue on the investment case for different types of foundational ID systems, particularly when utilized in conjunction with existing World Bank ID4D publications on emerging technologies[4] and the public[5] and private sector savings[6] associated with ID systems.

1.2 Approach, Objectives, and Scope

This study takes a data-driven approach to answer key questions about the cost of foundational ID systems, by **integrating learnings across 15 countries** that have implemented or transitioned to systems. The objectives of the study include the following:

Help governments, development partners, and other stakeholders to make informed decisions regarding the design and implementation of foundational ID systems.

Identify the **typical cost components** of building such systems, to help countries identify and plan the expected investment areas

Provide insight on which factors are the **largest drivers of the costs** of these systems in different types of countries

Showcase a companion **reference cost model** to help countries better estimate the expected cost under various scenarios, and enable informed strategic decisions on the selection of one type of solution over another

This study covers a group of 15 countries across Europe, South America, Africa, and Asia. These countries were selected to reflect the diversity across different regions, country characteristics, government policies, varying maturity levels of foundational ID systems, and different design choices and institutional arrangements. This study draws on both detailed secondary research based on publicly available information pertaining to individual country ID programs and consultations with relevant private and government stakeholders who oversee ID systems in these countries. The analysis of this data informed the identification of common themes on cost determinants associated with ID systems, as well as specific areas of variation across these countries.[7]

A typical foundational ID system has two distinct phases. Investments in the start-up phase (or mass enrolment phase) lead up to the enrolment of a majority (up to 90 percent) of the eligible population, while the steady state (or post-enrolment) operations phase of the ID program involves ongoing maintenance and registration of new entrants. **The analysis of key cost determinants covers both steady state and start-up phases.** One limitation of this study is that it does not cover the costs of designing and implementing a civil registration system. The rationale for this exclusion is that there have been at least two other attempts to estimate the cost of strengthening civil registration and vital statistics (by the World Bank and World Health Organization in 2014, and by the Health Metrics Network in 2012). In practice, many countries are taking a 'stock and flow' approach to rolling out integrated civil registration and foundational ID systems,

4 World Bank. 2018. *Technology Landscape for Digital Identification.* http://pubdocs.worldbank.org/en/199411519691370495/ID4DTechnologyLandscape.pdf

5 World Bank. 2018. *Public Sector Savings and Revenue from Identification Systems: Opportunities and Constraints.* http://pubdocs.worldbank.org/en/745871522848339938/PublicSectorSavingsandRevenueIDSystems-Web.pdf

6 World Bank. 2018. *Private Sector Economic Impacts of Identification Systems.* http://pubdocs.worldbank.org/en/219201522848336907/PrivateSectorEconomicImpactsIDSystems-Web.pdf

7 Some of the countries included in this study chose to share data on the condition of remaining anonymous.

through which the existing population is enrolled in the foundational ID system and future newborns are enrolled through continuous civil registration. The reference cost model does take into account, however, the significant savings that can be had from the integration of civil registration and digital ID systems, including savings from shared infrastructure and human resources, as well as from reduced data collection costs for the 'flow'.

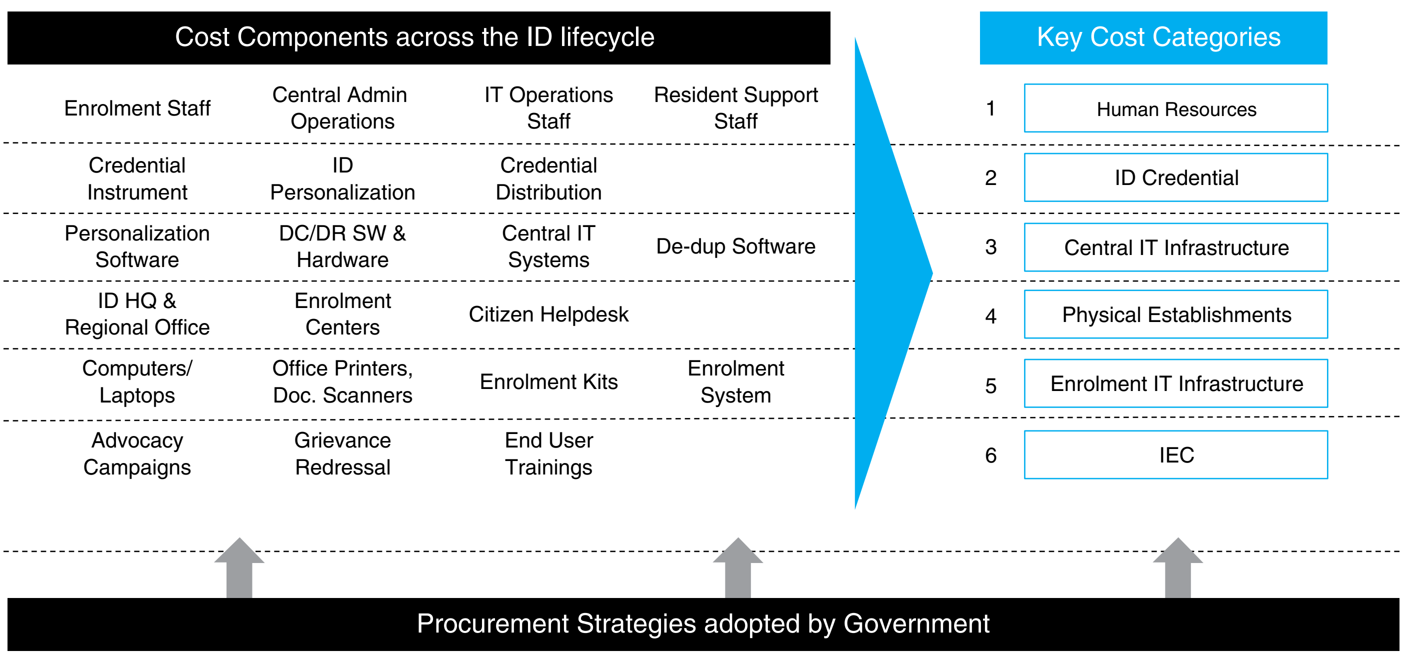
Finally, the cost estimates and operational recommendations featured in this study should be used only as guidance, one among many different inputs, to guide cost-related decision-making for foundational ID systems. Each country faces unique circumstances and challenges in the design and roll-out of their ID systems and cost models and recommendations will need to be adapted accordingly.

1.3 Results: Key Cost Determinants across Countries

Despite the varying political priorities and national contexts in which foundational ID systems are implemented, this evaluation revealed a common set of important cost components and major cost drivers.

1.3.1 Cost components of a foundational ID system

There are six key cost categories that have the biggest contributions toward the overall cost of an ID system, across the start-up phase and steady state.



- These six categories together contributed to over 90 percent of the overall costs in countries in the start-up phase.
- For countries in steady state, the Human Resources component contributed an even larger share (often greater than 80 percent of the annual program cost), with a relatively smaller share from the other categories.
- Procurement strategies adopted by governments were a critical factor that influenced ID system costs significantly.

- While most components relating to the ‘ID credential’, ‘Central IT infrastructure,’ and ‘Enrolment infrastructure’ are often sourced from global suppliers, the cost components pertaining to ‘Human resources’ and ‘Physical establishments’ are dependent on local situations within each country.
- Human resources-associated costs were the largest cost contributor across the countries studied, followed by the ID credential and information technology (IT) infrastructure categories. The share of Human resources in annual program costs increased even further in steady-state countries.

Countries had varying political and development priorities when establishing foundational ID systems, resulting in a diverse set of design choices and implementation strategies. Moreover, many of the countries assessed were at varying maturity levels (i.e., in terms of population coverage and scope of the program) and adopted different design choices in their respective ID systems. These and other factors result in the significant cost variation seen across these programs, both across the initial start-up phase and over the ongoing steady state.

1.3.2 Major cost drivers of a foundational ID system

Individual country characteristics and ID system design choices drive the amount spent in each component.

1

ID system design choice:

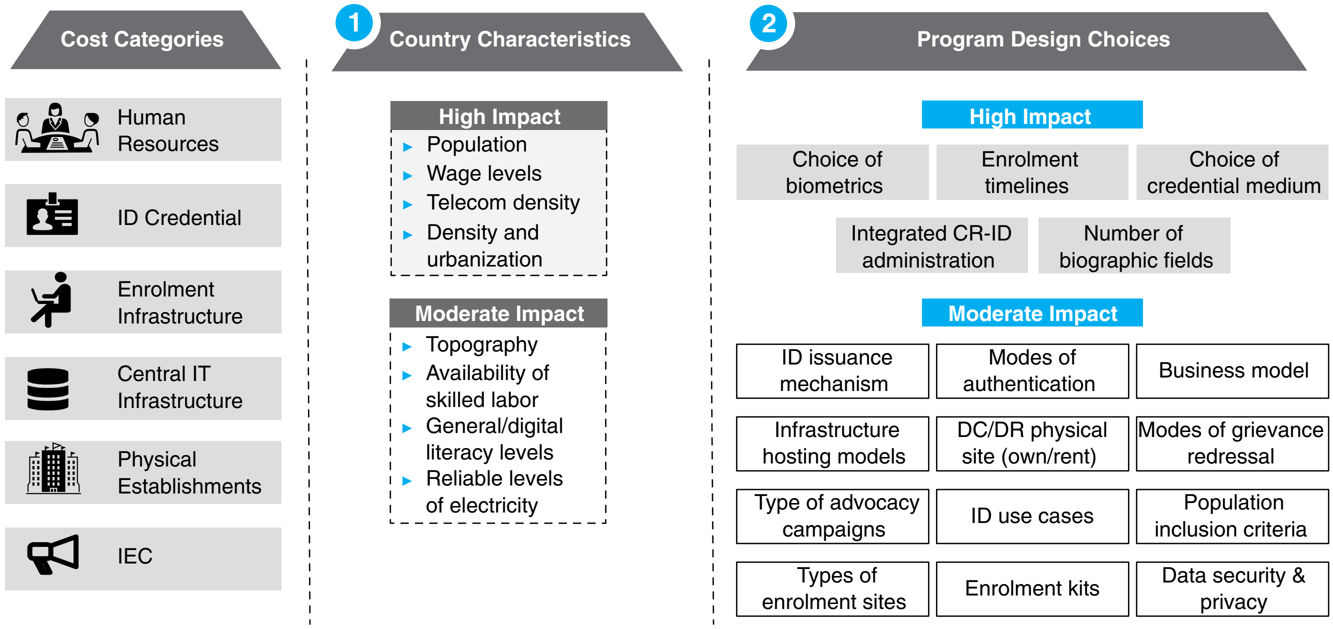
Technology or institutional architecture decisions which influence cost across the ID system’s lifecycle (e.g., the type of hardware and software used; the agency and number of personnel responsible for the project, etc.)

2

Unique country characteristics:

Relevant physical, demographic, or socioeconomic features of the country which are difficult to amend in the short run and influence aggregate costs (e.g., population, topography, connectivity, etc.)

- The overall costs of foundational ID systems are primarily shaped by two types of cost drivers—unique country characteristics and ID design choices.
- These drivers influence not only the overall costs of an ID system, but also the proportion of costs which are dedicated to investment vs. which are recurring.
- Around eight country characteristics and eighteen ID system design choices were commonly observed as key cost determinants across most countries studied.



Based on the observations from 15 countries, there are primarily four high-impact country characteristics: population, wage levels, teledensity and urbanization levels. There are four moderate impact country characteristics: geography, availability of skilled labor across different experience levels, literacy levels, and the availability of power/electricity.

There are five ID system design choices that play the greatest roles in shaping the cost accrued on each of these components—across start-up and steady phases.

- The 5 key design choices were:
  1. Choice of credential
  2. Mass enrolment timelines
  3. Integrated administration of civil registration and identification
  4. Choice of biometrics
  5. Number of biographic fields
- Other program choices that had a moderate role in determining program costs include: technology architecture and software types, as well as the choice of standards' operating model.

The ID credential is the cost driver with the highest variation, ranging from as low as 3% to over 40% of total ID system cost.

- At the lower end, country experience shows that credentials can cost as little as 3 percent of overall ID system cost if they are a 'paper' ID cards, and the focus is on online authentication using the ID number rather than an ID card or other physical token. Such solutions are, however, difficult to implement in low connectivity environments where 'offline' verification of identities is needed.
- Credentials can account for a greater proportion of cost if they are multipurpose smart cards (i.e., cards with an integrated chip to store electronic data). Most of the countries included in this study have used smart cards as the ID credential.

The enrolment timeline was a key cost driver: countries with shorter time frames experienced inflated costs associated with more widespread distribution of personnel and equipment.

- Most countries in the study opted for moderate or longer enrolment periods (e.g., 3–6 years) in order to achieve their target population coverage. However, a few countries opted for shorter timelines (e.g., 2 years), due to government priorities, such as elections, social programs, or specific development targets.
- Shorter enrolment time frames required a higher number of enrolment stations, trained staff, and more extensive technological solutions to be deployed in a large number of locations simultaneously, leading to higher costs.
- Longer enrolment timelines are also associated with a more uniform distribution of costs.

Close integration between the civil registration and identification operations demonstrated considerable savings in total cost of both these systems.

- There were a number of different integration models across countries studied. Some countries had tightly integrated civil registration and ID systems, whereas others opted for minimal or no integration between the two systems.
- In countries where CR and ID systems were closely integrated—e.g., through the issuance of the unique ID number at birth (complemented with other data and biometrics at an appropriate age), sharing of human resources, physical establishments and underlying ICT infrastructure—considerable cost savings were observed for both the start-up and steady state phases.

Each additional biometric modality increases accuracy and inclusion, and is estimated to increase enrolment costs by only about 5–10%.

- Fingerprints remain the most widely used biometric recognition technology in ID systems around the world. However, the use of multimodal biometrics (i.e., fingerprints and other forms of biometrics such as facial or iris recognition) is growing because they provide increased flexibility for enrolment and authentication, and improve the accuracy and efficiency of biometric deduplication. Sixty percent of the countries studied were observed to have employed a single biometric technology (fingerprint biometrics in all such cases) in their foundational ID system, while 40 percent of them opted for multimodal biometrics (fingerprint, iris and facial biometrics). The capture of high quality fingerprints can be a challenge, particularly in the case of population segments involved in manual labor.
- Overall, adopting multimodal biometrics has demonstrated improvements in 'Failure-to-Enrol' (FTE) rates by 10 to 25 times.[8] Countries that have adopted multimodal biometrics have demonstrated low 'False Rejection Rates' (FRRs) and 'False Acceptance Rates' (FARs) in deduplication. These improvements are particularly relevant for countries with large populations.
- The False Negative Identification Rate (FNIR) and False Positive Identification Rate (FPIR) are generally higher in cases of countries adopting single biometrics.
- All the countries in the study had implemented proprietary biometric solutions provided by vendors. Locally-developed or open-source–based biometric solutions were not observed in any of the countries.

8 https://www.nist.gov/sites/default/files/documents/2016/11/30/220_nadhamuni.pdf

Overall, a number of good practices have emerged from the implementation experience of the 15 countries studied, which could be applied in the design and roll-out of future foundational ID systems. Some of the most pertinent learnings around the five key design choices are the following:

- The choice of **biometric technology** deployed plays a vital role in making the ID systems robust and efficient. This design choice also impacts the accuracy and deduplication throughput for an ID system, which in turn has a considerable impact on overall costs.
- Although **multimodal biometrics** may represent an added cost (compared with single mode biometrics, e.g., fingerprints), their use can—depending on population size and other characteristics—reduce overall costs because it will reduce the rate of manual adjudications during deduplication, as well as improve the accuracy and flexibility of authentication.
- An ID system should be designed to facilitate the adoption of newer types of credential technologies and authentication channels that may emerge in the future, and hence should keep the ID system loosely coupled with the credential type. The **form factor of the ID** could be an exercisable choice for a country, based on local considerations and government priorities.
- If a digitized civil registration system with high coverage exists in a country, adopting an **integrated approach** for the design of a foundational ID system may lead to cost savings in the near term as well as in the long term.
- Capturing a minimal number of **biographic data fields** not only aligns with best practices in terms of privacy and data protection, but the less data are being collected (in volume and complexity), the quick and simpler the enrolment process, which can reduce costs significantly.
- Adoption of **open technology standards** in the foundational ID system could be a strong safeguard for countries against overreliance on vendors, as well as enabling interoperability. By designing a vendor-neutral architecture for ID systems, governments could maintain control over the overall design and avoid vendor lock-in.

1.3.3 The wild card: procurement strategy

Impact of procurement strategies adopted by individual countries is a critical cost determinant on the overall system cost.

- The procurement process followed by a country can have a signification impact on the overall cost and sustainability of a foundational ID system, irrespective of other system design choices—the impact of procurement strategies on overall cost can vary from 25 percent to over 100 percent. Because the impact of this potential driver was so highly variable and dependent on countries' political economy, it was separated from the core analysis.

There are a number of elements within a typical procurement process for a digital foundational ID system that could impact the total system implementation cost, as outlined below:

- Availability of sufficient in-house technical expertise:
    - If the entity managing the ID system does not have sufficient in-house technical expertise, the solution developed may not be optimal. There is a risk of the procurement being heavily influenced by interested vendors, thereby leading to higher costs and potential vendor lock-in.
    - As a risk mitigation measure, countries that lack in-house expertise could consider leveraging international technical expertise to provide inputs to bid process management, or a full-time program manager. In such cases, care should be taken to ensure that the consulting support is independent and not directly or indirectly an extended arm of the IT service provider.
    - Lack of local expertise for system implementation could require the engagement of large integrated service providers, which itself adds to the price premium. This may get further compounded by the need for an international workforce, contributing to greater system implemention costs.

- Vendor qualification process: In case the vendor qualification criteria and process are limiting (sometimes driven by risk aversion or by other considerations), the bidders are able to charge higher premiums by limiting the competition.
- Overspecifying technical or process requirements: this could lead to higher investments that could be avoided.
- Appropriate use of global standards: this could improve the quality of supplies, premium pricing, and vendor lock-in.
- Import restrictions and duties: as in most cases, for the import of technical infrastructure, restrictions on imports and duties would impact the system's cost.

There are a few global best practices that can help countries develop effective procurement strategies for foundational ID systems:

- It is critical to have a procurement model which allows for significant government ownership over key technology components, as well as facilitation of seamless transfer of system management from one systems integration/managed service provider (SI/MSP) to another.
- When dealing with an evolving technology field such as biometrics where only a few niche players exist, innovative procurement strategies can be leveraged when designing foundational ID systems.
- Provision of performance-linked procurement models (e.g., outcome-based contracts for private enrolment agencies in India) in certain complex foundational ID systems is an efficient way of improving vendor accountability, as well as maximizing the use of external program resources.
- It is essential that governments undertake an open and competitive procurement process that gives no special advantage to any specific vendor or set of vendors. Competition reduces costs and promotes innovation in bids and proposals.
- Opting for an open source solution, or at least one based on open standards, may allow governments enough flexibility to easily upgrade critical system components with minimal vendor dependency, minimizing longer term costs. Also, embedding the right technical support requirements from vendors in the initial contract is an important procurement consideration for governments—surprise fees for maintenance later on as a result of a poorly designed procurement processes can prove to be very costly.

1.4 Summary of Cost Study Findings

There are **six key cost categories** that make up the biggest contributions toward the overall cost of an ID system, across the start-up phase and steady state.

The **enrolment timeline** was a key driver cost: countries with shorter time frames experienced inflated costs associated with more widespread distribution personnel and equipment.

There are **five ID system design choices** that have demonstrated the greatest cost-impact across the key cost categories across start-up and steady phases.

Individual **country characteristics and ID system design choices** have a considerable influence over investments made across the key cost categories.

The cost associated with the ID credential is the cost driver with the highest variation, ranging from **as low as 3% to over 40%** of total ID system cost.

Tight **integration between the civil registration and identification operations** demonstrated considerable savings in total cost of both these systems.

Incremental biometric modalities increase accuracy and inclusion, and were associated with only a **5–10% increase** in total cost of countries studied.

Impact of **procurement strategies** adopted by individual countries is a critical cost determinant on the overall program cost.

1.5 Building a Reference Cost Model

The learnings derived from the cross-country study have been used to outline a reference cost model. The model and its guidance note have been published separately for reference.

This reference cost model is designed to assist in understanding the financial implications of the different ID system design choices (e.g., issuing a chip-based ID card vs. a paper-based one, short mass enrolment period vs. a long mass enrolment period, a single biometric recognition technology vs. multimodal biometric technology). It provides an estimate of costs incurred by a country through both the start-up phase and steady state.

The salient points of the cost model are illustrated below:

Feature 1

Estimate cost ranges with identification system development and steady phase cost separately with multiple scenarios

Feature 2

Comparison of various cost estimates generated from multiple scenarios

Feature 3

A simple user input driven model, where the user can select the option for a number of design choices and generate cost estimation

Feature 4

Allow user to manually adjust various nonmandatory (default) input parameters/coefficients to customize model as per country and increase the accuracy of estimation

This reference cost model serves as a tool to estimate baseline costs for countries implementing new ID systems from scratch, and thereby assists ID authorities in making effective cost-based program decisions. It does not predict the actual costs that will eventually be incurred by the country.

2. Methodology

2.1 Objectives

The intent of this evaluation of foundational ID systems is to gain a better understanding of the costs associated with establishing and maintaining digital identification systems at the national level. To this end, this report provides an analysis of the factors related to different choices in terms of system design and technology that impact cost. It evaluates the impact on costs of different choices made by a diverse set of countries that have implemented digital identification systems. Finally, this study develops a reference cost model to benchmark costs and allow users to simulate different design and technology choices to better anticipate cost implications.

This study presents an opportunity for authorities in different countries engaged in developing or modernizing ID systems and funding agencies to learn from the global experience, to use it as a guidance tool for channelling system design choices and cost considerations in a manner that suits national priorities and program financing.

The objectives of the study are summarized in Figure 2.1:

Figure 2.1. Objectives of the Study

Analyze cost structure (both capital and recurring) of an ID system across multiple countries with diverse implementation models

Crystallize the key design choices made by each ID program and elaborate the impact of each design choice over the total cost of an ID system

Leverage cross-country learnings to build a reference cost model for 'greenfield' digital ID system implementation

It's important to note that this report is not intended to be an alternative for more in-depth ID system costing studies or cost-benefit analysis to inform government investments. Rather, it should be viewed as a guide for policymakers and ID authorities in answering the following questions: ***What are the cost-intensive design choices involved in implementing digital ID systems? What factors drive cost-based decisions across these design choices for governments?***

2.2 Participating Countries

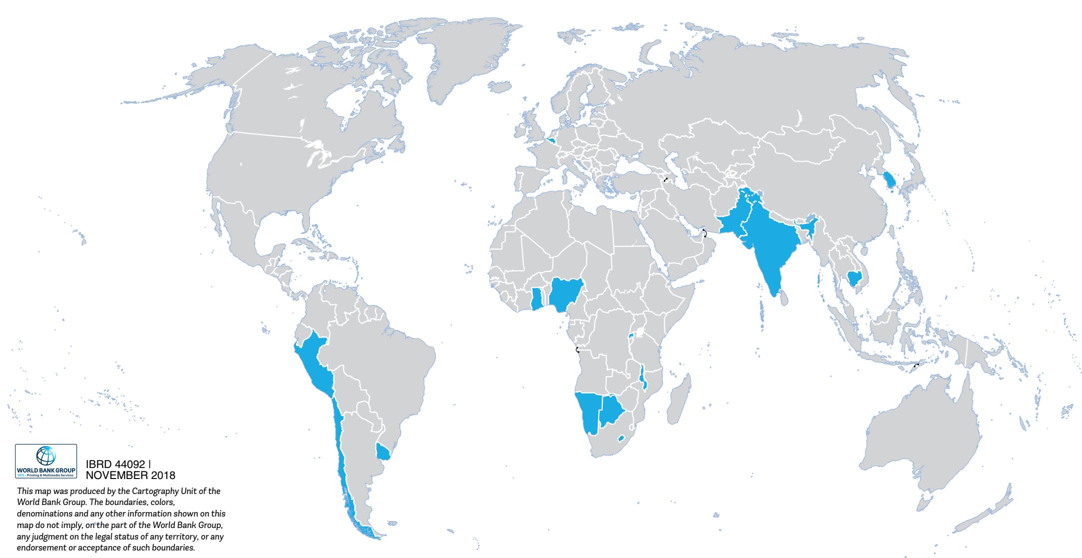
Information was gathered on a sample set of countries across different geographic locations that are at different stages of economic development, and that have followed diverse implementation models. A number of areas of diversity were taken into consideration while selecting these countries:

- ID system maturity levels
- Technology design choices in investment and the steady state of an ID system (e.g., smart card based; digital number based; fingerprint based; iris based; multimodal; differing modes of authentication, etc.)
- Operating and business models associated with an ID system
- Income and literacy levels of the population covered by the ID programs
- Individual country performance across development indices and telecom technology infrastructure indices
- Diversity of program financing models and institutional structures
- Intended role of the ID system in strengthening the governance and social agenda of the country (e.g. policy priorities for legal identification, public service strengthening, private sector innovation).

In many instances there was limited publicly available information, and in other cases ID authorities were not at liberty to disclose sensitive cost information. Eventually, a sample of 15 countries (see Figure 2.2) was shortlisted for the study, across four continents—Asia, Europe, Africa and South America—which included high-, middle- and low-income countries.

In addition to the in-depth learnings from these 15 countries, experience from ID system implementations in other nations and a series of interviews with global experts were also leveraged to further corroborate their findings and arrive at a consensus for the key cost drivers of an ID system.

Figure 2.2. Participating Countries



2.3 Approach for the Study

The team performed a detailed study on the selected country ID systems and their costs. It collaborated with ID authorities in each country to collect the information required to conduct the assessment of ID system cost structures. The approach undertaken for this study is illustrated in Figure 2.3.

Figure 2.3. Approach for the Study

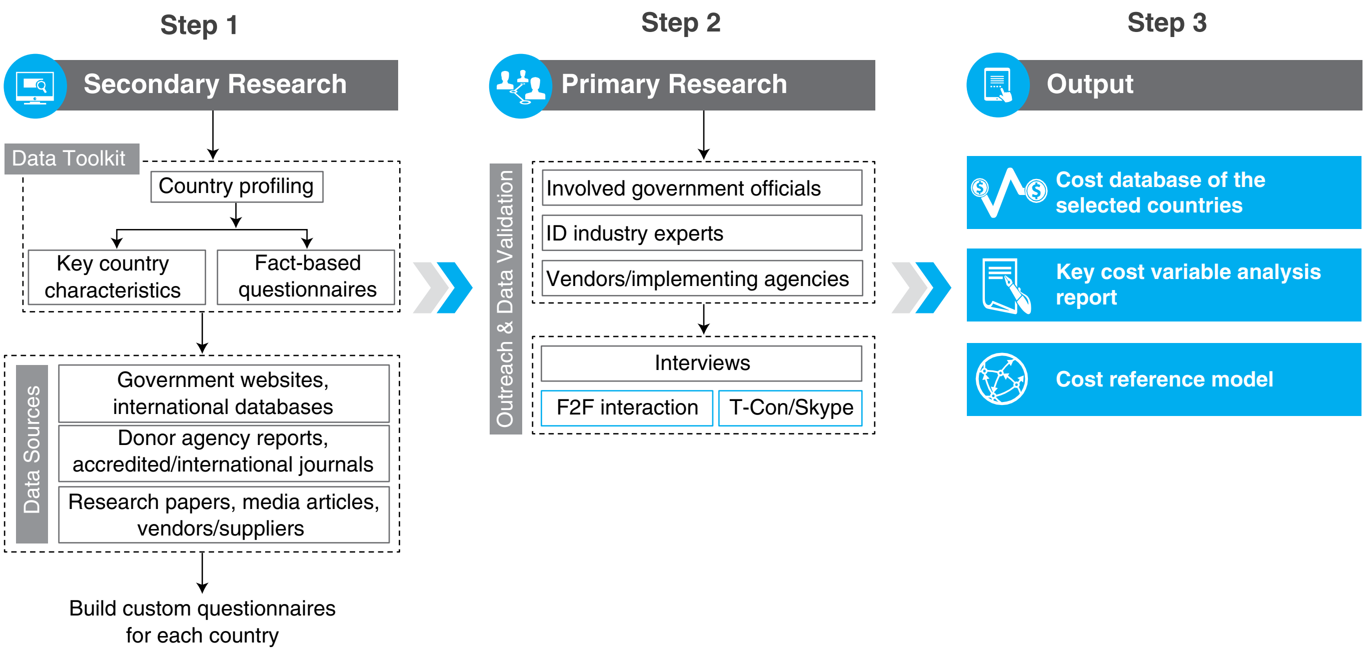


Table 2.1. Activities Performed in the Study

No.	Activity	Description
1	Secondary Research	■ Preliminary study of each country's incumbent ID system based on published research materials and secondary data. The secondary research materials and data banks sourced included public reports and research studies published by individual governments, individual and cross-country benchmarking studies conducted by multilateral agencies (e.g., World Bank's Identity Management Systems Analysis [IMSA] studies), and country case studies published by ID card vendors and ID Solution providers in the ID industry. ■ Established key points of contact within the authorities responsible for ID system budgets, implementation, and operations.
2	Primary Research	■ Developed data collection tools to be used for direct stakeholder interviews with individual country ID authorities. These tools were customized for each country and were based on its distinct biographic, socioeconomic, and ID system attributes. ■ Conducted detailed interviews with country ID authorities. ■ Assimilated individual country stakeholder responses from the interviews and questionnaires to prepare individual profiles of each country's ID system and the high level cost structure. Each individual country profile emphasized longitudinal views of a country's ID system, spanning legislative inclusions/exclusions, system design and technology infrastructure, operating and business models, data access and governance mechanisms, public sector and industry use cases of the ID system, and a top-down view of the ID system's cost structure.
3	Data Validation and Analysis	■ Performed a comprehensive validation of the data collected from individual countries. ■ Developed a draft report elaborating the key cost determinants associated with an ID system and the impact of critical ID system design choices—this was shared with experts from industry, development agencies, and ID authorities, to collect their feedback.

The activities (shown in Table 2.1) were performed by the team with the selected countries.

2.4 Limitations of the Study

There were specific limitations in the collection and compilation of comparable ID system cost data. These are shown below:

- The findings in this study are based on observations from only those 15 countries whose relevant authorities were willing to share their program costs with the assessment team.
- In most cases, ID systems were implemented by government departments that did not separately maintain information relating to individual cost components of these systems.
- As the systems were implemented in different countries, the definitions and scope of various cost elements were diverse, and normalization across the countries could not be precise; it had to be based on assumptions, estimations, and approximations.
- There were confidentiality clauses in government contracts with vendors and service providers, which prohibited release of sensitive cost-related information in the public domain.
- This study focuses on the costs for building and maintaining the 'core' functions of an ID system, that is enrolment, issuance, authentication, and maintenance. Costs pertaining to functional ID systems that rely on the services of the foundational ID system (e.g., point of sale (POS) devices for authentication, data seeding, and digitization costs) have not been factored into this study.
- In cases where there were data gaps in the individual country cost assessments (e.g., missing unit costs), the team employed local country indices and industry intelligence to derive reasonable estimates of unit costs. For instance, staff wage levels (either permanent or temporary staff) are often confidential and were not released by certain ID authorities for the benefit of this study. Given the considerable impact of staff wages on an ID system's overall cost, appropriate estimates were derived based on specific country characteristics related to labor costs. These estimates were discussed with ID authorities prior to their use in this study.
- Cost components across countries have not been normalized using a common methodology for this study. Components such as IT infrastructure could not be normalized due to multiple factors that were unique to each country (e.g., locally procured vs. procurement through cross-border transactions, impact of duties/taxes). For a more realistic comparison, the focus was on the component contribution to the overall program cost (in percentage terms) for each country and the comparisons of the component-by-component cost shares across countries.

3. Design Choices for a Digital ID System

3.1 Lifecycle View of an ID System

Countries across the world have often chosen different visions for establishing a foundational ID system. For instance, some countries are looking to increase the coverage of civil registration; others have put in place an ID system with a view of strengthening voter registration and identification; and again others have conceived the ID system as a platform to streamline delivery of services from the public and private sector to residents. The government's vision determines design choices and thereby impacts program costs for the ID system.

When countries are thinking of an investment in a new ID system, the spending is typically done across two phases:

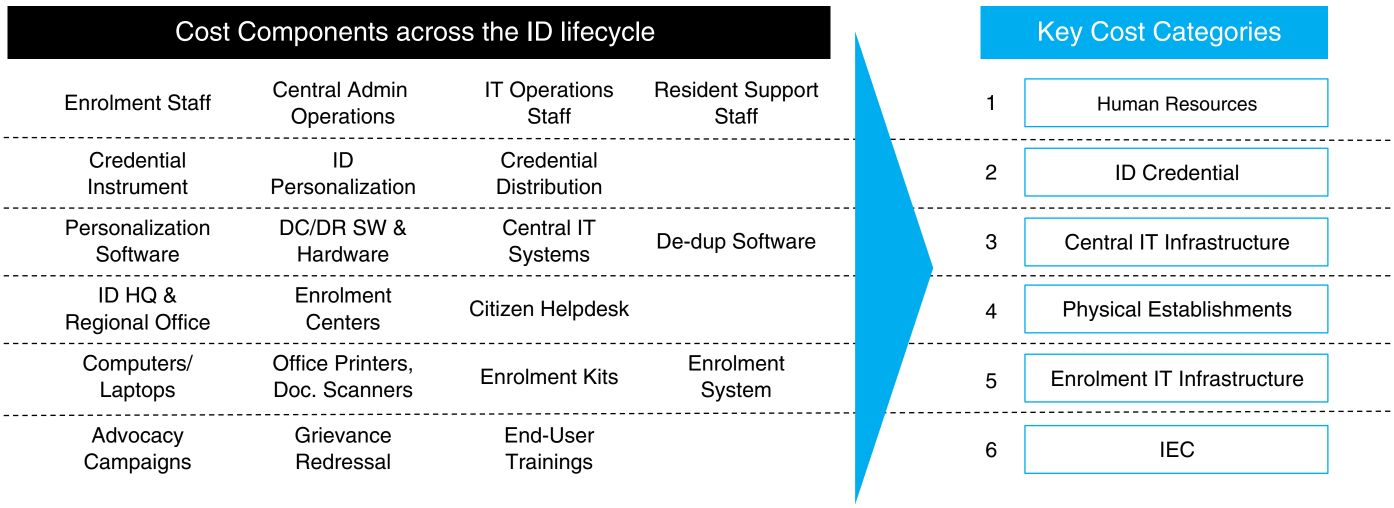
- The initial 'start-up' phase: when the ID system is conceptualized, designed, developed, and rolled out nationwide. This can be considered as the period from the initial design to the stage when the system achieves greater than 90 percent coverage of the eligible population in a country. Specific design choices like the target enrolment period for achieving this level of enrolment (e.g., 2 year/5 year/10 year) can significantly influence the start-up investments made and the subsequent deployment of program resources (e.g., human resources, IT infrastructure, devices, and number of ID cards).
- The subsequent 'steady' state: when the system has reached a high level of coverage and the government incurs an annual operating cost to maintain the system. Costs incurred in this phase largely revolve around maintaining some of the deployed program resources and addressing ongoing needs of the population enroled (e.g., replacements and reissuances of ID cards, new enrolments, authentication, etc.).

3.2 'Core' Cost Categories for an ID System

The capital and operating costs incurred by a country during the start-up phase and steady state of an ID system vary on a number of implementation options.

Based on the study, the most high-impact cost components observed across the start-up phase of an ID system have been compiled and categorized into six core cost categories: Human Resources, ID Credential, Central IT Infrastructure, Enrolment IT Infrastructure, Physical Establishments and IEC. These six categories remain the most pertinent even in countries with mature ID systems (i.e., ID systems effectively in the steady state), though the cost impact of one or two of these categories has at times significantly surpassed that of the others. The various components of cost that have been clubbed under the above six categories are as illustrated in Figure 3.1.

Figure 3.1. Key Cost Categories

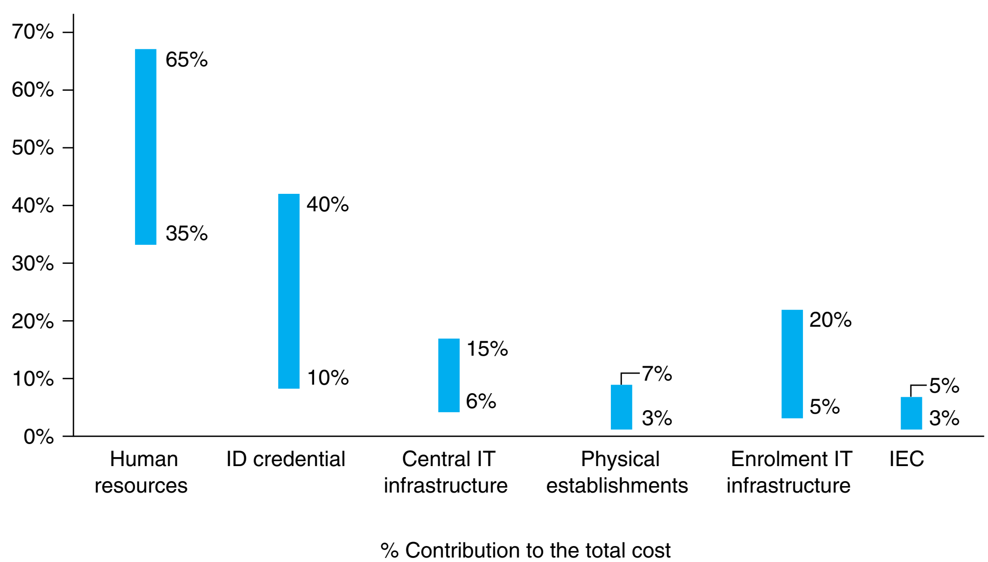


The distribution of costs across these six key cost categories (for the start-up phase) observed across the countries is shown in Figure 3.2.

While most of the components related to the ID Credential, Central IT Infrastructure, and Enrolment Infrastructure categories are often sourced from global suppliers, the cost components pertaining to the Human Resources and Physical Establishments categories are very dependent on the local context. As depicted below, the costs incurred against the Human Resources category tend to be the biggest contributor across the countries studied, followed by the ID Credential and Central IT Infrastructure (both central and enrolment IT software and IT hardware components) categories.

The study has also demonstrated that for countries in the steady state, the human resources category contributes an even larger share (often greater than 80 percent of the annual program cost in a number of countries). More detailed analysis around the design choices that contributed to this cost distribution, along with specific country insights, is outlined in subsequent chapters of this report.

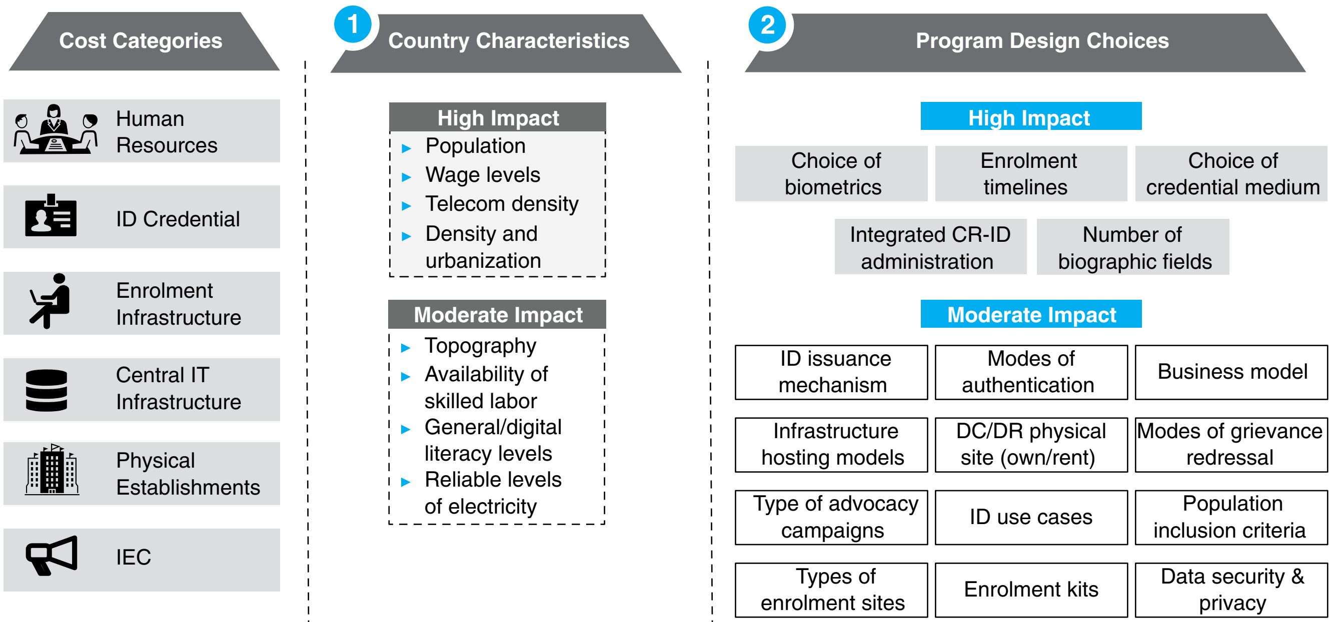
Figure 3.2. Distribution of Costs across Categories for the Start-up Phase



3.3 Factors Influencing the 'Core' Cost Categories

The cost of an ID system is primarily driven by two critical factors—unique country characteristics and ID design choices, as illustrated in Figure 3.3.

Figure 3.3. Factors Influencing ID System Costs



3.3.1 Country characteristics

Every country has certain characteristics that influence the cost structure; these are exogenous elements over which program designers have no control. These country characteristics often determine the allocation of resources (e.g., skilled human resources, number and share of mobile enrolment units) deployed by a government in the ID program. The impact of each individual country characteristic over each key cost category varies by country. These characteristics are often interlinked with the ID system design choices that a country decides to adopt.

Some of the most relevant country characteristics for an ID system include those in Table 3.1.

3.3.2 ID design choices

The cost for each of the six cost categories shown in Figure 3.3 varies widely across countries in the study, because of the different design choices undertaken for the ID system. For instance, a design choice with significant cost impact is the use of chip-based smart cards as an ID credential. When compared to other types of ID credentials, chip-based smart cards incur higher costs for design, printing, and distribution. Based on the nature of the ID system being implemented, a country may have a number of design choices spanning key functions like resident enrolments, ID credential issuance and distribution, resident engagement mechanisms such as IEC campaigns, and helpdesk support, among others. Some of these choices are more capital cost intensive (e.g., hardware and software procurements), while others incur steady operating costs year on year (e.g., staff wages, maintenance of enrolment establishments). The selection of a design can have considerable bearing on the overall program cost, and governments have to choose carefully to ensure that the ID system will not only be financially sustainable in the long term, but also inclusive, robust, and responsible.[9]

The common design choices adopted by governments in their national ID systems include the design choices discussed in Table 3.2.

Table 3.1. Impact of Country Characteristics

High Impact		
1	Size of Eligible Population	Countries with a higher eligible population base often require a greater investment toward critical program resources in order to adequately meet the enrolment targets and timelines for the ID program. A greater population size could also result in reduction of program cost per person (e.g., central infrastructure costs) due to economies of scale. The minimum or mandatory age for enrolment will significantly affect the size of the eligible population. For example, one country provided ID cards to children starting from age 6, in addition to ID cards for the adult population. In certain African countries, the government had mandated 16 years as the age for an individual to receive an ID card.
2	Urbanization and Population Density	High urbanization levels and population density have a considerable impact on the distribution of human resources, enrolment centers, and enrolment kits for the ID system. Along with population size, a high degree of urbanization is a critical factor for estimating program costs. The larger the population size and the more urbanized the country, the lower the cost per ID-holder for the country's ID system.
3	Telecom Density	For a digital ID system, telecom density has a bearing on a number of key cost-intensive design choices (e.g., online authentication mechanisms). In cases where there is reliable Internet connectivity across the country, online authentication is possible. However, in the absence of this, offline authentication has to be provided, which could increase the program cost.
4	Wage Levels	Human resources (e.g., program staff for central administration, enrolment, and resident engagement) are among the greatest contributors to overall program cost. Therefore, the prevalent wage levels in the country will have a significant impact on the operating cost, across both the start-up phase and steady state of the ID program.
Moderate Impact		
1	Availability of Skilled Labor	Implementing digital ID systems often requires strong technical expertise. At times, governments have engaged third-party agencies from the private sector to address the shortage of skills necessary to manage key system functions (e.g., technology operations).
2	Topography	Geographical features can affect resource deployment for the ID system. Countries with diverse topographic barriers (e.g., rainforests, mountainous zones, arid lands) can implement innovative, albeit potentially cost-intensive, solutions to address this challenge and ensure last-mile outreach. For instance, some ID authorities have used alternate modes of transport (e.g., horses, boats) to overcome geographic hurdles.
3	Overall Literacy Levels (general/ digital)	General and digital literacy levels may impact the ability of various arms of the government and service providers to utilize the ID system and its identity verification and authentication capabilities. This factor also impacts the government's capacity building efforts to equip program staff to manage operations adequately.
4	Reliable Supply of Electricity	Reliable electricity is imperative for the optimal performance of many functions of a digital ID system (e.g., authentication, ensuring consistent and adequate uptime of all systems, along with seamless synchronization of data with the central ID registry) and hence affects a number of key cost categories.

9 World Bank. 2018. *Principles on Identification for Sustainable Development: Toward the Digital Age.* http://documents.worldbank.org/curated/en/213581486378184357/Principles-on-identification-for-sustainable-development-toward-the-digital-age

Table 3.2. ID System Design Choices

High Impact		
1	Choice of Biometrics	The type of biometrics captured during the enrolment process (e.g., fingerprints, iris and facial scan) is often a critical design choice for the ID system. Given the nature of the enrolment targets (e.g., population size of the country, biometric characteristics of the various segments of population), the biometric chosen (e.g., no. of fingers, iris, facial image) will have a high impact on the cost.
2	Mass Enrolment Timelines	Based on the priorities of the government, the roll-out of an ID system can be either time-bound for achieving almost universal enrolment (e.g., within 2 years, 5 years), or provide gradual coverage over a longer time period across the country. The choice of the target enrolment period sometimes driven by the specific vision of the government—for example, strengthening the electoral process by leveraging the ID system to build a robust voter registry. Target enrolment timelines will significantly impact the volume and distribution of enrolment points, which is a key cost category.
3	Choice of Credential	The form factor and technologies used for the ID credential issued to the population (e.g., polycarbonate-based ID card with microchip, PVC card with 2D barcode, SIM-based mobile ID) are critical design choices for a digital ID system with a high impact on cost.
4	Integrated Civil Registration—ID Administration	Many countries have looked to leverage the existing physical and technology infrastructure of their civil registration systems as well the operating model (e.g., common staff to manage both operations) to seamlessly introduce a digital ID system in the country. This approach has led to considerable savings, as well as to improvements in the overall utilization levels of resources across both systems.
5	Number of Biographic Data Fields	A high number of biographic data fields to be captured as part of the ID enrolment process can impact the time taken per enrolment (i.e., more time for data entry and verification). This could lead to the need to deploy more enrolment staff and IT assets (e.g., biometric kits) to achieve coverage targets within the enrolment timeline.
6	Type of Software	The choice of employing either open-source or proprietary, commercial off-the-shelf software (COTS) has a considerable bearing on a number of the core cost categories. For example, using open-source software may lower the overall costs associated with the central IT infrastructure as compared to COTS, but it could also require additional human resources to build/deploy and maintain many of the system components.
7	ID Issuance Mechanism	There are a number of ways countries have handled the distribution of personalized ID cards to enrolees. Some request enrolees to physically visit enrolment centers to collect their ID cards. In a few countries, multiple delivery channels have been adopted (e.g., by post/couriers) for doorstep delivery of ID cards, thereby adding to the cost.
8	Modes of Authentication	Countries have been flexible in adopting multiple modes of point-of-service ID authentication to streamline service delivery (e.g., online/match-on-card modes of authentication).

High Impact		
9	Business Model	Governments may have different models of program financing (e.g., direct federal budget-driven, public-private partnerships, and outsourced models) to manage the budgets of the ID program. Some countries also design effective revenue strategies (e.g., service fees for ID and ID linked services to citizens) to ensure long-term sustainability of the ID program.
10	Infrastructure Hosting Models	Governments can opt for cloud-based hosting models or on premise dedicated hardware to host the ID system and registry.
11	DC/DR Physical Sites	The data center/disaster recovery (DC/DR) sites used to manage IT software and hardware for the ID program can have a bearing on capital/operating costs of the Central IT Infrastructure category. If the country has already invested in national data centers, the ID system can operate out of these at marginal cost instead of having to invest in exclusive facilities.
12	Modes of Grievance Redressal	Different grievance redressal mechanisms (e.g., online support, 24/7 helpline, and contact center) can have varying impact on costs.
13	Type of Advocacy Campaigns	Given the importance of a strong resident outreach for the program, countries have considered multiple modes of public advocacy campaigns (e.g., traditional door-to-door campaigns as well as digital broadcast mediums), which can add to implementation costs.
14	Number of ID Use Cases	This often governs the complexity of the ID ecosystem that a government has to develop for the program, and thereby has an impact on the underlying technology infrastructure (e.g., authentication infrastructure) and program resources (e.g., central staff to design new public sector use cases).
15	Program Criteria for Inclusion	Criteria like age, nationality, and other status (e.g., permanent resident, refugee, etc.) have an impact on the overall coverage of the ID program. This design choice determines the deployment of adequate program resources to achieve enrolment targets.
16	Type of Enrolment Sites	Many countries have permanent enrolment centers with dedicated staff to conduct enrolment operations. This does incur considerable up-front capital and ongoing operating costs. In some countries, alternative enrolment modes such as mobile units (e.g., via vans/motorcycles) are used to optimize costs and enable better reach of the ID system enrolment to far-flung areas.
17	Enrolment Kits	Enrolment kits are a significant cost component during the enrolment phase of an ID system. These kits can include multiple devices such as a computer/laptop, biometrics data capture devices (e.g., fingerprint/iris scanners), camera, webcam, and a signature pad.
18	Data Security and Privacy	ID systems are a critical national asset for any country and thereby require strong data privacy and security measures and adequate investment for keeping systems safe from internal and external threats to maintain a high degree of confidence across the population.

3.4 Design Choices with the Greatest Cost Impact

From the evidence gathered through the ID system cost study across fifteen countries, there were five specific design choices that demonstrated the greatest impact on the implementation of foundational ID systems in terms of cost incurred across the six key cost categories (outlined earlier). In broad terms, the impact was visible across both the start-up phase and steady state of ID systems to varying degrees across countries. The five key design choices were as follows:

- Choice of biometrics
- Choice of ID credential
- Enrolment timelines
- Number of biographic fields
- Integrated administration of civil registration and identification

In the subsequent sections we will elaborate each of these five design choices, the factors that drive decision making around these design choices, the impact each of these design choices demonstrated across the key cost categories, as well as other relevant design choices for the ID system, illustrating the impact of each of them. However, it must be stressed that the cost analysis of these design choices is based on foundational ID systems, and not any functional ID systems (e.g., the driver's license system).

Along with the key design choices that will be discussed in subsequent sections, the procurement process followed by a country is a key determinant for the sustainability of an ID system. There are a number of elements within a typical procurement process for an ID system that could impact the total system cost, as outlined below:

- In-house technical expertise
    - If the entity managing the ID system does not have sufficient in-house technical expertise, the solution developed may not be optimal. There could also be the risk of the procurement being heavily influenced by interested vendors, thereby leading to higher program costs and potential vendor lock-in.
    - As a risk mitigation measure, countries that lack in-house expertise could consider leveraging international technical expertise to provide inputs to bid process management, or a full-time program manager.
    - In such cases, care should be taken to ensure that the consulting support is independent and not directly or indirectly an extended arm of the IT service provider.
    - Nonavailability of local expertise for system implementation may require the engagement of large integrated service providers, which adds to the price premium. Moreover, the need for an international workforce can also lead to greater program cost.
- Vendor qualification process
    - In case the vendor qualification criteria and process are limiting (sometimes driven by risk aversion or by other considerations), the bidders are able to manage higher premiums by limiting the competition.
- Over specifying technical or process requirements
    - This could lead to higher investments that could be avoided.

- Appropriate use of global standards
    - This could improve the quality of supplies, premium pricing, and vendor lock-in.
- Import restrictions and duties
    - Restrictions on imports and duties would likely increase program cost.

The impact of these elements on overall system costs could vary from 25 percent to 100 percent. Across key cost categories, the Central IT Infrastructure and Enrolment IT Infrastructure are likely to be impacted most, given the proprietary nature of many technology components used in ID systems. Hence, the procurement process adopted becomes more critical for governments in developing countries. There are a few global best practices to be considered while designing procurement strategies for ID systems:

- International experience suggests that there are many advantages to a procurement model that allows for significant government ownership over key technology components, as well as facilitation of seamless transfer of system management from one SI/MSP to another.
- When dealing with an evolving technology field such as biometrics where only a few niche players exist, innovative procurement strategies (such as feasibility of a multi-vendor arrangement as part of the overall procurement) should be considered.
- Provision of performance-linked procurement models in complex ID systems is an efficient way of fostering greater vendor accountability, as well as maximizing the use of external program resources.
- An open and competitive procurement process that gives no special advantage to any specific set of vendors is critical for governments to consider when designing national ID systems. Such an approach tends to be advantageous for the government implementing the program, as it could propel vendors bidding for the ID implementation to reduce their price margins, resulting in lower implementation costs.
- Often, vendor lock-in inhibits the government's ability to adequately modernize a legacy ID system over time. Having a primarily open-source technology stack will allow governments enough flexibility to easily upgrade critical system components with lower vendor dependency. Also, since implementing an ID system often involves considerable technical expertise, embedding the right technical support requirements from vendors becomes an important procurement consideration for governments.

4. Analysis of Key Design Choices

Figure 4.1. Key Design Choices

Design Choice # 1—Choice of biometrics	Design Choice # 2—Choice of credential
Design Choice # 3—Enrolment timelines	Design Choice # 4—Number of biometric fields
Design Choice # 5—Integrated CR-ID administration	Other design choices that influenced ID system costs

4.1 Choice of Biometrics

Biometrics provide a highly accurate mechanism to uniquely identify individuals and are used by many governments across the world for their ID systems. Biometrics are being used to address two critical requirements for a robust ID system—unique identification and reliable authentication. In the last few years, better sensors, algorithms, and advancements in technology have helped increase the accuracy and reduce the cost of biometrics-supported service delivery. The performance of a biometric system can be primarily affected by three kinds of errors that may occur when an individual enrols into the system:

- "Failure to capture (FTC)"—where the biometric devices cannot capture an image of high enough quality. This usually happens because of technical issues like low quality scanners, poor lighting, or a missing biometric (e.g., missing fingers).
- "False positive identification rate (FPIR)"—where the biometric deduplication system incorrectly identifies a unique new enrolment as a duplicate enrolment.
- "False negative identification rate (FNIR)"—where the biometric deduplication system fails to detect a duplicate enrolment.

The accuracy of a biometric during authentication is estimated with the False Acceptance Rate (FAR) and False Rejection Rate (FRR).

In a POC study conducted by the Unique Identification Authority of India (UIDAI), it was understood that the FNIR was 0.035% based on 84 million individual records. The FPIR was 0.057%. The study also mentioned that the FTC was 0.14%, thereby implying that 99.86% of the population can be uniquely identified through biometrics and the remaining could be de-duplicated through demographic data as well as manual verification.

Source: http://www.dematerialisedid.com/PDFs/role_of_biometric_technology_in_aadhaar_jan21_2012.pdf

There are three key aspects of the biometric technology that influence the accuracy of identification/authentication and cost of implementation:

- Biometric identifiers
- Algorithm for de-duplication
- Technology implementation

4.1.1 Biometric identifiers

The fingerprint modality was the earliest biometric used and is still one of the most widely used across the world. Iris recognition provides greater acccuracy, with a FAR of 1 in 1.2 million for one eye (1 in 1.44 trillion for two eyes),[10] irrespective of the number of records in the central database.

Multimodal enrolment enables more accurate de-duplication on a much larger scale. For example, in India, using multiple modalities improved the Aadhaaar system's 'Failure-to-Capture (FTC)' rate by **10–25** times.[11] The combined score of two uncorrelated biometric modalities will provide better accuracy than any single modality and could achieve target accuracy for an ID system to the tune of **10x–100x**. Multimodal enrolment also makes it possible to maintain low FPIR/FNIR over a wide range of gallery size.[12] More information about the FAR, FRR, and FTE for some biometric technologies used globally can be found in the 2018 World Bank/ID4D report, 'Technology Landscape for Digital Identification'.[13]

4.1.2 Algorithm for de-duplications

According to the 2009 edition of the *Encyclopedia of Biometrics,* biometric algorithms are defined as: "automated methods that enable a biometric system to recognize an individual by his or her anatomical/behavioral traits. They consist of a sequence of automated operations performed by the system to verify or identify ownership. These operations include quality assessment, enhancement, feature extraction, classification/indexing, matching, and fusion, as well as compression algorithms often used to reduce storage space and bandwidth."[14]

Every biometric technology has its own specialized algorithm. Not many vendors have algorithms for each biometric technology. It is difficult to ascertain an accurate FNIR and FPIR for each algorithm with publicly available material. Although many algorithms for biometric de-duplication are available in open source, most of those used by ID systems across the world are proprietary solutions fine-tuned by vendors who provide technology.

4.1.3 Technological implementation

This covers both software and hardware (for computing and for biographic and biometric information capture) in the central system and enrolment/verification centers. In addition to the software implementation of the biometric algorithm, the specification of the biometric devices used at enrolment points will also have a considerable impact on FNIR and FPIR with the same biometric technology and de-duplication algorithm.

10 https://www.researchgate.net/publication/233746922_Iris_Based_De_duplication_Technology
11 https://www.nist.gov/sites/default/files/documents/2016/11/30/220_nadhamuni.pdf
12 https://www.nist.gov/sites/default/files/documents/2016/11/30/220_nadhamuni.pdf
13 http://pubdocs.worldbank.org/en/199411519691370495/ID4DTechnologyLandscape.pdf.
14 Chen, Y. and Fondeur, J-C. 2009. Biometric Algorithms. *Encyclopedia of Biometrics* online. https://link.springer.com/referenceworkentry/10.1007%2F978-0-387-73003-5_208

Biometric solution vendors have developed customized solutions (often with proprietary software solutions and sometimes in combination with proprietary hardware) with their own claims on accuracy, throughput, and cost. The technology providers normally use two kinds of pricing models for their biometric solutions—the more popular model is the "license fee per enrolment," while the other model is an "annual license fee."

4.1.4 Insights from the global study

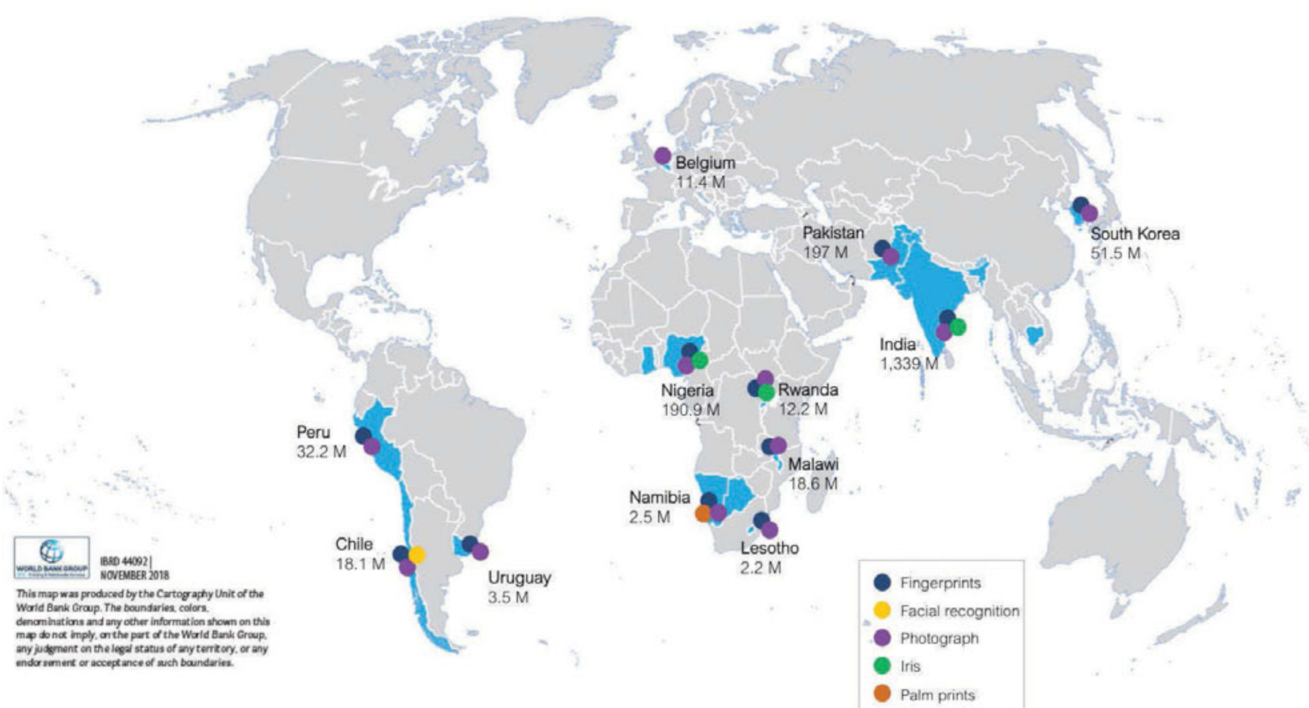
The study has demonstrated a high percentage of countries opting for a single biometric modality (predominantly fingerprint technology). A few countries, especially those that have implemented/modernized their systems fairly recently, have adopted iris technology and/or face recognition as additional biometric identifiers in multimodal implementation. All the countries in the study have implemented proprietary solutions provided by their solution vendors.

> From the 15 countries analyzed in this study, 5 have opted for multimodal biometrics in their foundational ID systems (Chile, Nigeria, India, Namibia and Rwanda).

The FNIR and FPIR is generally higher in cases of countries adopting single biometrics. Especially in the case of populations involved in manual labor, capture of high quality fingerprints for enrolment has been a challenge—for example, the fingerprint-based ID program of an East Asian country experienced this challenge with a high rate of de-duplication errors requiring additional verification to complete the enrolment activity.

Some countries have opted for multimodal biometrics to increase the de-duplication and authentication accuracy of their ID systems. Figure 4.2 illustrates the type of biometric techniques used across countries from different geographies.

Figure 4.2. Type of Biometric Techniques Used across Select Countries



According to some estimates, the cost of enrolment using multimodal biometrics is about **5–10 percent** higher when compared to enrolments using a single biometric technology.[15] This is true for biometric technologies like ‘Iris’, where the associated unit costs (e.g., iris scanners for data capture, software for iris-based de-duplication) increase the overall cost of the program as well. A cost analysis report from UIDAI highlighted that capturing and de-duplicating IRIS data of residents was found to increase the cost of each enrolment by around Rs 4.40 (0.06 USD), although this is likely to be at the lower end of the cost scale given the magnitude of India’s Aadhaar program. However, these technologies bring about greater inclusiveness of residents as the accuracy of identification increases.

4.1.5 Impact on cost categories

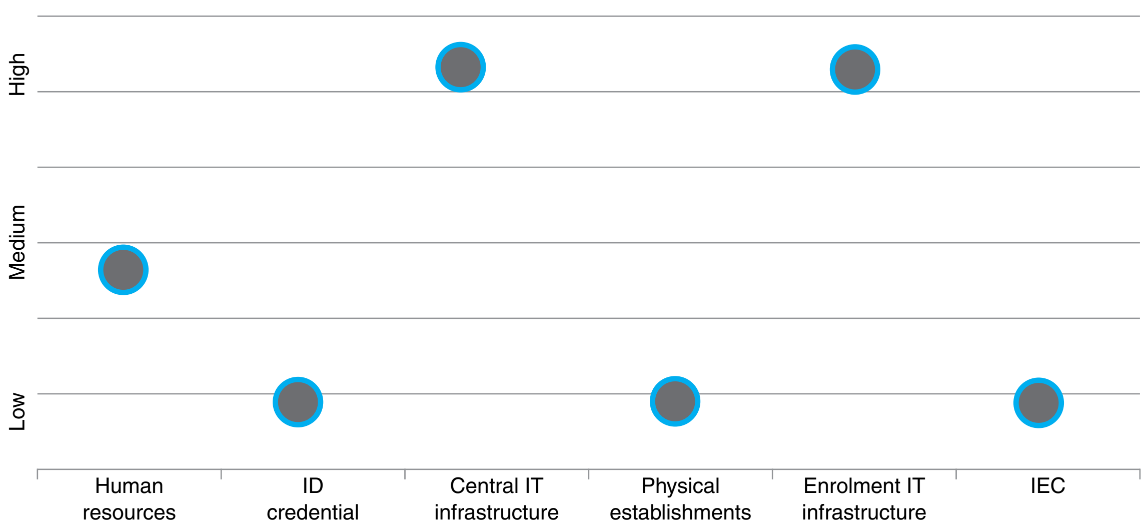
Governments implementing ID solutions try to optimize the cost of the biometric solution across various options of biometric modalities, algorithms, and technology, and at the same time maximizing accuracy and throughput.

This study shows that biometric design choice (both type of technology and opting for multimodal) has a high impact on two specific cost categories—“Enrolment IT Infrastructure” and “Central IT Infrastructure,” whereas the impact is fairly limited on the other major cost categories (e.g., Human Resources, ID Credential), as illustrated in Figure 4.3.

Adding an additional biometric modality to an ID system has considerable bearing on the total cost of the system, depending on the biometrics being considered. This is because certain biometric-based solutions such as fingerprints are mature, while certain others, like iris- and face-based solutions are still evolving for larger-scale implementations. In a biometric-based ID system the costs discussed in Table 4.1 may increase depending on how many and which biometrics are considered.

De-duplication algorithms are specialized software that typically have a ‘license-based’ or ‘per unique deduplication-based’ pricing model. The cost of the de-duplication software does not change much in either of these cases.

Figure 4.3. Impact on Cost Categories



15 Yadav, A. K., Rani, A., and Tadisetty, S. 2012. Multimodal Biometric Based Deduplication for Biometric Databases. *Proceedings of the International Conference on Innovation in Electronics and Communication Engineering* (ICIECE—2012).

Most of the cost items mentioned in Table 4.1 will remain the same in two common implementation scenarios (described below). However, the cost of data centers will vary substantially (as depicted in the following two scenarios below) with all critical design choices such as enrolment timelines, throughput, number of biographic fields, number of centers, etc.

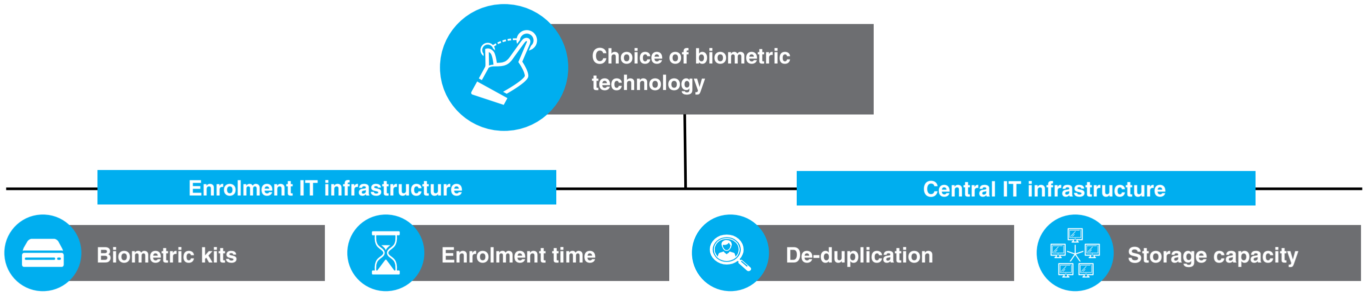
- Scenario 1: De-duplication is carried out on a primary biometric, and a second biometric is used only when the threshold results (probability of a record being 'unique') of the primary biometric is inconclusive. In such a case, the cost at the data center will not increase substantially, but the first four costs listed in Table 4.1 will still increase.
- Scenario 2: Every record is de-duplicated using a fusion of both biometrics. In such a case, the cost of computing and storing, and network cost at the data center may almost double. The rest of the cost will remain the same as in Scenario 1.

Even under Scenario 1, the cost of an additional biometric in the ID system may increase the cost of an overall ID system by 5–10 percent. Scenario 2 will incur higher costs, but will also have a better FTE, FPIR, and FNIR compared to Scenario 1, which in turn will reduce the cost of manual adjudication.

Table 4.1. Impact on Cost Categories

No.	Impacted Cost Category	Cost Items	Increase for Dual Biometric
1	Enrolment IT Infrastructure	Cost of biometric device to capture the additional biometric. Cost of maintaining and technology refresh of the device	May increase the cost of enrolment kit by 20–25 percent depending upon the type of biometric
2	Human Resources and Enrolment IT Infrastructure	Time taken to capture the additional biometric that would translate into the additional cost of human resource time and additional enrolment stations required to complete the enrolment time in the stipulated time frame	May increase the human resource cost by 5–15 percent depending upon increase in time taken per enrolment
3	Central IT Infrastructure	Customization of workflow and automated biometric identification system (ABIS) solution to perform de-duplication and authentication	May add almost 5 percent to the software development cost
4	Central IT Infrastructure	Cost of de-duplication by additional biometrics	May add US$0.05–0.10 per de-duplication
5	Central IT Infrastructure	Cost of enabling authentication for additional biometrics	Cost increase depends on number of biometric for each verification. If only one biometric is used for each authentication the cost increase will be negligible
6	Central IT Infrastructure	Cost of computing, storing, network cost, among others, at data centers	May add 5–10 percent to the data center cost
7	IEC	Cost of training enrolment operators on usage of new biometric devices	Negligible
8	Other Categories	Cost of POS devices for authentication	In this study this cost element has not been considered as this is a user entity cost and not an ID service provider cost

Figure 4.4. Impact of Biometric Technology



As evidenced in the study, the choice of biometric technology employed can impact several decisions relating to Central IT Infrastructure and Enrolment IT Infrastructure in the start-up phase of an ID system, such as procurement of enrolment kits, de-duplication software, designing the adequate compute capacity in the DC/DR sites and so on. Based on the scale and complexity of the program, a number of these critical program design choices impacted by the choice of biometric technology has shown to result in considerable up-front capital costs for the ID system. There are specifically four design parameters that had the greatest impact, as illustrated in Figure 4.4.

4.1.5.1 Impact on enrolment IT infrastructure

The choice of biometric technology adopted determined the types of biometric devices that would be necessary during resident enrolment, as well as point-of-service authentication. Likewise, using multi-modal biometrics has shown to increase the time taken for each enrolment and thereby impacts the rate of resident enrolments per day (leading to potentially more enrolment stations to meet the targets set by a government). Depending on the number of biometrics captured, the time for enrolment as well as cost of biometrics devices increases. The cost of biometrics is also dependent on functional specifications and the robustness of the devices. Robustness is measured by subjecting the biometric devices to simulated environmental conditions like temperature, humidity, and dust for consistency and output compliancy.

For similar types of biometric devices, the unit cost also depends on a number of other factors (such as functional specifications, the nature of government-vendor contracts, certifications, and type of sensors used). Based on industry pricing, a small USB fingerprint scanner can cost as little as USD 50, and a sophisticated 10-fingerprint scanner (with live finger detection ability) can cost around USD 2,500 or more. However, mass procurement of such devices has helped to lower unit costs across countries in the study. For instance, in one of the countries studied, a 10-fingerprint scanner cost approximately four times as much as a similar 10-fingerprint scanner in another country within the study. However, this could have been due to differences in technical specifications for the devices and local procurement processes.

A higher number of biometrics results in more time taken in completing an individual resident enrolment. This has a downstream impact on the overall enrolment rate in the program (e.g., number of per-day enrolments), which ultimately increases the need for more enrolment stations, kits, and human resources. It must be noted that the time taken per enrolment is not just a factor of the number of biometrics captured, but also includes the number of biographic fields captured, as well as the time taken for verification of supporting documents.

In two African countries in our study, the average time taken per individual enrolment for capturing 10 fingerprints, facial image, and biographics were around 8–12 minutes. However, at the same time, the average time taken per enrolment with almost the same number of fields in a third African country was around 20 minutes. This seems to imply that the time per enrolment varies on the number of biographic and biometric fields as well as the efficiency of the operator, thus influencing the number of enrolment stations required to enrol residents.

4.1.5.2 Impact on central IT infrastructure

The complexity of the biometric solution which increases with the volume of de-duplication and authentication leads to an increase in the computing requirements of the Central ID Infrastructure. Another key impact on the central technology infrastructure is the overall storage requirements for the biometric files captured and maintained. Every biometric collected is stored in the form of a proprietary template (whose size varies as per the type of biometric technology), and the raw image is also stored to avoid vendor lock-in. The combination of a higher population base (e.g., India) and the type of biometric technology used (e.g., fingerprint and iris) lead to high storage requirements in data centers.

4.1.5.3 Impact on human resources

Although the biometric technology used has the highest impact on the IT infrastructure, it also affects the costs related to Human Resources, primarily in the area of training. Further, the choice of biometric technology has an effect on the accuracy of the search results and time taken for de-duplication. The lower the accuracy level (high FNIR and FPIR), the greater the chances of false identity matches, thereby leading to manual intervention and more time for error resolution.

4.1.6 Key takeaways

4.1.6.1 Country insights

- Sixty percent of the countries studied used a single (i.e., unimodal) biometric in their national ID system, and 40 percent have opted for multimodal biometrics. The prominent biometrics combinations observed in countries using multimodal biometrics included fingerprint and iris recognition. India, Nigeria, and Rwanda have opted for both fingerprint and iris, whereas Chile has opted for fingerprint and facial recognition.
- Ninety percent of the countries studied opted for fingerprint as one of the biometrics captured.
- Countries chose multimodal biometrics to lower the FRR and FAR. This becomes critical for countries with a large population in order to ensure better inclusivity and accuracy, and effective de-duplication.
- The FNIR and FPIR are generally higher in cases of countries adopting single biometrics.
- The choice of biometrics is often dependent on the country's anatomy and characteristics of the population.

4.1.6.2 Considerations for making program decisions

- The choice of biometric technology plays a vital role in making ID systems robust and performance efficient.
- The choice of biometric technology impacts the accuracy and throughput which, in turn, has a considerable impact on program cost.
- Adopting multimodal biometrics improves the FTE rate by 10–25 times.
- An increment of each biometric modality has demonstrated an increase of 5–10 percent of the overall program cost across the countries studied.
- As most technology solution providers for biometrics use proprietary solutions, there is a risk of technology/vendor lock-in.

4.2 Choice of Credential

An ID credential is a document, object, or data structure that vouches for the identity of a person through some method of trust and authentication. The ID credentials for foundational ID systems can take a physical form like a paper certificate, a simple paper or plastic card or a smart card, or a digital form like a token or chip embedded in a mobile phone. The credential also varies in terms of the information embedded and security features built into it. The choice of credential impacts multiple aspects of the ID system, such as the overall system architecture, personalization, issuance, and logistics. This choice also impacts the cost of third parties who use ID credentials for service delivery.

4.2.1 Type of ID credentials

Some of the popular ID credentials used globally include the following:

4.2.1.1 Card-based ID credential

These credentials are usually in the form of a plastic card that stores the unique attributes of an individual (biographics and/or biometrics) using various storage mechanisms. There are two forms of physical ID credentials commonly used in national ID systems:

4.2.1.1.1 Cards with cryptographic chips

These ID cards are used by many countries and enable the storage of greater volumes of identity and other data locally, on the microchip, which can then also be accessed in off-line settings. However, they do incur high costs and can potentially be an expensive design choice for any country implementing a card-based ID system. There are three types of chip-based ID cards used globally:

- Contact-based cards—where the cards have a metallic chip contact pad embedded on the surface, for interfacing with a card reader.
- Contactless cards—where the cards employ radio frequency identification (RFID) to communicate with card readers, without physical insertion. This is gaining prominence in a number of countries, especially where the ID card is also used as a valid travel document.
- Hybrid cards—where the ID card has both a contact-based and a contactless interface via two chips in the same card. For example, Uruguay uses hybrid cards, where the ID card functions both as a identification instrument inside the country, as well as a legal travel document within the Mercosur member states.

4.2.1.1.2 Cards without chips

- Paper-based ID card—this is the most basic type of ID document, which can be used in combination with more robust, online authentication and identity verification methods against the registry. India, with its large population, opted for an ID solution that emphasized the use of the ID number, combined with biometrics, for authentication, and thus did not need to rely on a card as a credential.
- Plastic (or other, more durable material-based) ID card—a nonelectronic ID card that can be used as a photo identity proof and may contain added features, such as barcodes or magnetic strips, to enable the local storage of identity data.

4.2.1.2 Mobile ID credentials

A country with high mobile/smartphone penetration may use the mobile phone as the medium of ID credentials.

Mobile-based ID credential—is managed on a mobile communication device (e.g., smartphone) carrying a digital credential of the individual. Mobile ID-based credentials can be either server-based (i.e., online only) or SIM-based.

- SIM-based mobile ID—This model includes SIM cards with public key infrastructure (PKI) capabilities that allow an individual to carry digital signatures on a mobile device using a SIM card as the cryptographic device, with the handset employed for PIN entry and the mobile operator's network used as a backchannel. In the ID system of an East European country, private keys (PIN and PUK) were stored on the mobile SIM card along with a small application for authentication and signing. In another east European country, an individual's SIM card carried the functionality of producing digital signatures using a mobile phone.
- Server-based mobile ID—In these models, there are no electronic signatures carried on the mobile phone. The phone acts as a second authentication channel, and the digital certificates are stored using a hardware security module on the central server (accessible using a PIN-based mechanism). Some ID system implementations in European countries had used an 'ID-on-server' model, where the ID can be used by both the ID card and the mobile device. The identity data of an individual is stored only in the mobile ID system's central database (and not in the mobile phone) and can be accessed after successful authentication using the phone number, password, and OTP.

4.2.2 Insights from the global study

Many countries in the study (especially Africa and South America), use a chip-based ID card. The unit cost of the credential depended significantly on the solution implementation of the vendor, as is seen from the considerable disparity in cost for similar deployment of the ID credential across geographies (e.g., Europe/South America vs. Africa).

The cost of the credential varied within a range of 3% to 40% across the 15 countries.

India is a notable example in this study, where the credential cost is negligible on account of the use of a paper document as the credential. In countries that adopted non-chip ID cards, the percentage contribution of ID credential cost was below 10 percent of the overall program cost, whereas for many countries that adopted chip-based ID cards, the ID credential represented a contribution of 25–40 percent. Some countries had a higher unit cost of ID credential, mainly on account of the use of multipurpose chip-based ID cards.

4.2.3 Impact on key cost categories

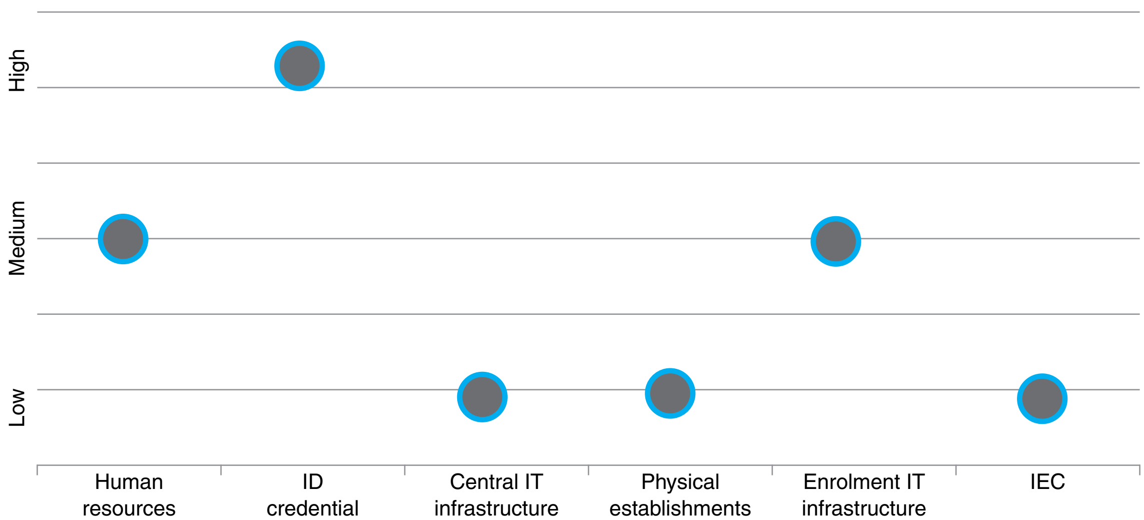
Country-specific characteristics (as discussed in section 3.4) influence the choice of ID credential. Some key country characteristics that determine the choice of credential are:

- Spread of digital connectivity: If a country does not have widespread digital connectivity across its geography, it becomes more important to offer a card that will allow offline authentication, in addition to potential online authentication or mobile-based ID solutions, to ensure that identities can be verified with a reasonable degree of assurance in many different contexts.
- Size of population: The credential type (e.g., paper based, smart card) is an important consideration, particularly for countries with large populations, because it can have a very significant impact on the overall program cost. The cost savings achieved by careful choice of ID credential can be substantial.
- Validity of the ID credential: Countries often define a validity period for the ID credential issued to a population. Sometimes this validity period is driven by the type of ID credential issued and the underlying raw material used in it (e.g., 10 years for a polycarbonate (PC) card). This duration

becomes a significant recurring cost consideration for the ID program, as it entails costs pertaining to reissuance of the ID credentials to the enroled population.

While the choice of credential primarily impacts the cost category relating to ID credential, it also affects others to a certain extent (see Figure 4.5). For instance, in the case of the smart card, in addition to special devices, more staff is needed for personalization, printing, and issuance of the card. This will increase the cost of the Human Resources and Enrolment IT Infrastructure components. On the other hand, for a digital, number-based ID, the additional staff and devices for printing, personalization, and issuance will be minimal, but there will be an impact on the Central IT Infrastructure, as it will require integration with other systems. In case of mobile ID, most operations are taken care of by the mobile operator.

Figure 4.5. Impact of Choice of Credential on Different Cost Categories

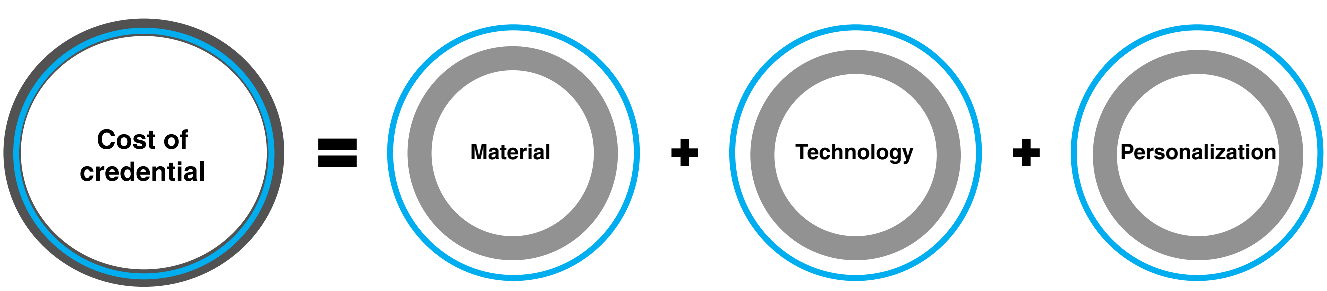


4.2.3.1 Impact on the ID credential cost

The costs incurred for an ID credential is a summation of the individual unit costs pertaining to various subcomponents—such as the credential material used, underlying technology and data personalization (see Figure 4.6).

The various subcomponents (e.g., type of card material, interfacing technology, security levels, data storage modes, personalization and printing modes) determine the cost of a card-based ID credential. Hence, it is important for a government to carefully consider these sub-components when designing an ID system. For instance, selection of printing and personalization technologies, properly matched to the choice of card body materials, chip insertion, and interface methods can influence the life of the ID card significantly.

Figure 4.6. Cost Breakdown of ID Credential



In some countries, the cycle of card procurement and data personalization is outsourced to specialized vendors, whereas other countries procure cards from vendors but set up the personalization infrastructure in house. This has a bearing on the up-front capital and operating costs for a government. The study has shown that in certain countries the ID program is financed through a public-private partnership (PPP) arrangement with a specialized card/biometric vendor and the fee is a function of successful delivery of personalized ID cards. The material used for the ID card is a significant contributor to the overall cost of the credential. Based on the study and general market intelligence, there are five popular materials used for ID cards across national ID systems globally, as illustrated in Table 4.2.

Table 4.2. Type of Credential

No.	Material Used	Description	Country Examples from Our Study
1	Paper	Paper cards have an advantage on the cost front, but are not durable. They can be forged easily and thereby may not provide a sufficient level of assurance if the card is used for identity verification on its own, without additional online verification or authentication mechanisms utilizing the unique ID number.	India
2	Polyvinyl Chloride (PVC)	PVC is the least expensive plastic used for ID cards. However, it is the least durable option (life of 3–5 years). PVC-based cards have lower resistance to heat, UV, and bending stress, which can cause premature delamination and module separation.	South Korea, Namibia, Botswana
3	Polyester Film (PETF)	A PETF card is generally more robust and durable than a standard PVC card. PETF is tear proof.	None
4	Polycarbonate (PC)	PC is a robust thermoplastic material with higher resistance to damage from heat, flexing, and ultraviolet (UV), thus increasing the durability of the ID card (generally 10 years).	Belgium, Uruguay, Nigeria, Chile
5	Teslin	Teslin-based cards use a synthetic paper that is flexible, highly printable, waterproof, and tear resistant. It is often used, due to its flexible surface that can receive dye-based ink jet printing and other options for offset and laser printing.	Rwanda

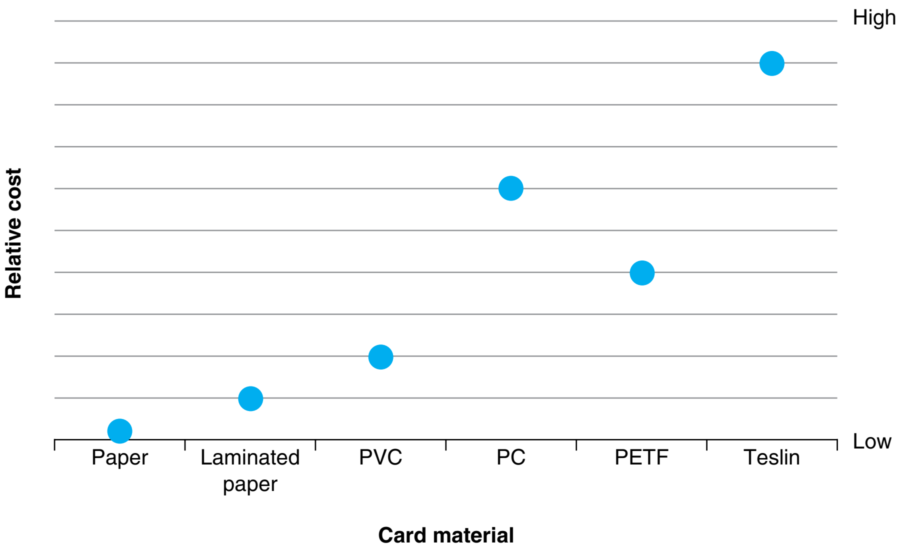
Based on industry-based insights and popular vendor-based pricing, the baseline costs for these 5 different ID card materials are illustrated in Figure 4.7.

4.2.4 Key takeaways

4.2.4.1 Country insights

- Most countries included in this study used chip-based smart cards as the ID credential. Smart card technology can support multiple applications that enhance citizen convenience and/or government service efficiency, but are costly and more complex to manage than other credential mediums.
- Most countries studied have issued secure national ID cards with secure personalization by using laser engraving and a polycarbonate card.

Figure 4.7. Comparative Cost of Credential Material



Note: The illustration above only considers the raw material of the ID card and no other credential-related features that would incur further cost (e.g., embossing, level 1/2/3 security features, chip implant, single vs. bulk printing).

4.2.4.2 Considerations for making program decisions

- A digital ID, with an emphasis on the ID number and biometrics for authentication, or mobile ID solution can have zero or minimal costs for the ID physical credential. However, these provide most accurate authentication and highly flexible means for integration for third-party service providers.
- The ID system should allow easy adoption of newer credentials and channels that may emerge in the future, and hence should keep the ID system loosely coupled with the credential. The form of the ID could be an exercisable choice for the customer. This will nurture innovation around ID services that will make them in demand and self-sustainable.

4.3 Mass Enrolment Timelines

In the start-up phase, the mass enrolment timeline is an important cost driver. Various factors can impact the enrolment timelines, such as individual country characteristics (e.g., existing IT infrastructure, literacy rate) and program design choices (e.g., choice of biometrics envisioned, linkage with the civil registration system, and availability of funds). A government's priorities on use cases like elections, and socio-development targets also drive the decision around enrolment timelines. Due to the numerous benefits of an identification system, many countries aim to enrol the majority of the population as soon as possible, in spite of the greater cost.

4.3.1 Insights from the global study

Across the countries studied, the enrolment timelines and associated costs have varied widely. Most have followed a longer enrolment time frame, with enrolments and costs distributed fairly evenly (with both gradually reaching a peak state and later tapering down for the steady state). Malawi had a short enrolment timeline during the start-up phase, leading to a very large number of enrolments and resultant higher costs in the initial year, with operating costs dropping in the following steady state. Some key observations from individual countries around enrolment trends and cost distribution are outlined below:

4.3.1.1 Cost distribution

The distribution of costs incurred in the start-up phase of an ID system varies significantly in accordance with the timelines planned by the government. For programs with shorter timelines, the procurement of more enrolment kits, setting up enrolment stations, and employing additional staff adds to capital and operational costs in the early years.

A comparison of costs incurred in the start-up phase across three different countries in our study clearly confirm these findings, as illustrated in Figure 4.8. A European country (Country B) took an enrolment cycle of 5 years to achieve their coverage targets (greater than 90 percent of their eligible adult population). A southeast African country (Country C) had planned 2 years to complete enrolments because the incumbent government had defined an ambitious timeline (2 years) to complete all ID enrolments. In the case of Country C, most of the program capital cost (approximately 90 percent) was incurred in the first two years. In Country B and a south Asian country (Country A), the distribution of costs were more even, with gradual growth in ID coverage.

Figure 4.8. Distribution of Start-up Costs across Countries

These learnings imply that moderate and longer timelines for the start-up phase generally support a more uniform distribution of costs, thereby reducing up-front capital costs for the system. However, longer timelines also require higher operational costs year on year to sustain the system. The trends for cost distribution observed across various countries (with different timelines) in the study are illustrated below.

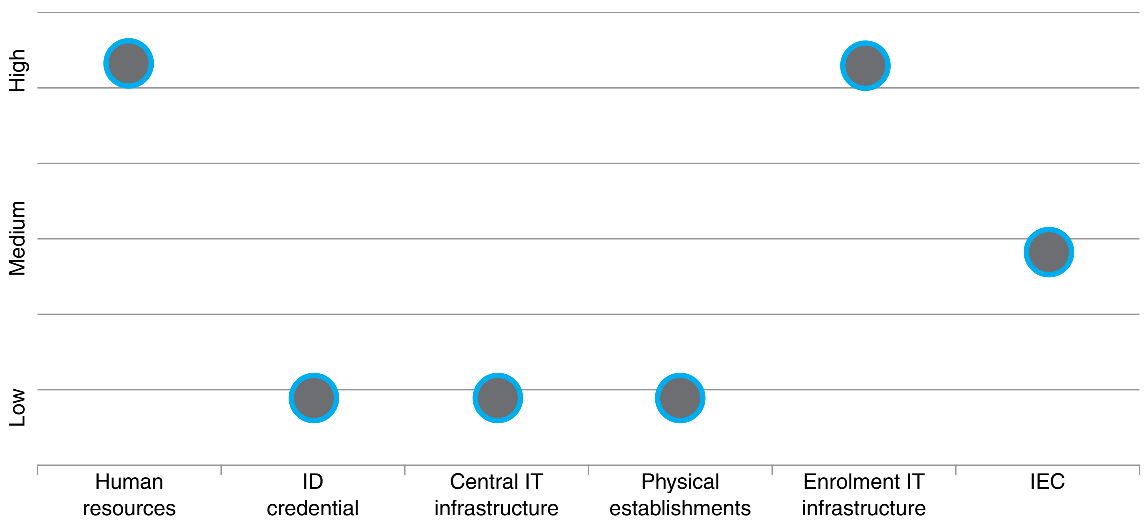
A rapid enrolment cycle typically incurs significant up front costs on IEC activities (e.g., public campaigns for advocacy, staff trainings), whereas a gradual enrolment cycle can more evenly spread the IEC costs. For example, in the case of Country C from the illustration above, the incumbent government has spent significantly on public education and advocacy campaigns in order to achieve the targeted population coverage in the short enrolment timeline. Of the total cost incurred on IEC in their ID program, approximately 95 percent was spent in the first year itself.

4.3.2 Impact on cost categories

The enrolment timeline has a high impact on the cost incurred against the Enrolment IT Infrastructure and Human Resources categories, and a moderate impact on the remaining key cost categories, as illustrated in Figure 4.9.

The planned enrolment timeline determines the enrolment rate targeted per day. This in turn influences the number of kits, staff, enrolment stations, and centers (mobile or fixed centers) that must be procured or established. A shorter enrolment timeline for covering the majority of the population results in greater costs due to the higher number of enrolment kits and higher data center capacity required in the early stages. Similarly, to maintain the high number of enrolment centers and stations, more enrolment staff needs to be deployed. Staff utilization was also found to be higher in countries that followed a target-based enrolment model.

Figure 4.9. Impact of Timeline on Other Categories



4.3.2.1 Impact on enrolment IT infrastructure

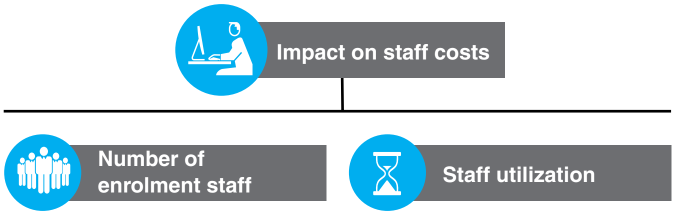
The distribution of enrolment stations/kits will vary according to the timelines. For implementing an ID system in a short time, more stations, kits, and staff must be acquired to accommodate the enrolment volume.

4.3.2.2 Impact on human resources

Human resource costs for enrolment centers will also vary according to the timelines planned. The impact of this Human Resources cost is two-fold—number of staff and utilization of staff (see Figure 4.10). The number of staff (either permanent employees or temporary contract staff) deployed in a program directly impacts cost in a major way. Enrolment targets also affect staff utilization across centers and hence optimization of centers for user convenience significantly impacts Human Resource costs.

Enrolment staff training is a critical success factor to enable the rapid enrolment of registrants in ID systems with shorter enrolment timelines. In these cases, a high number of staff may require accelerated training. In programs with longer enrolment timelines (or no specified timeline targets), training can be more evenly paced, as the number of staff required will not vary substantially over time.

Figure 4.10. Impact of Human Resources



Utilization of staff deployed for enrolment generally increases in ambitious target-based enrolments. For example, in the case of a southeast African country in our study, the enrolment per staff per year was around 4,500, whereas it was around 300 in another African country and around 1,100[16] in a south Asian country, for their respective start-up phases. Ambitious enrolment targets, policy mandates to accelerate enrolments, and specific incentives seemed to foster higher staff utilization.

4.3.3 Key takeaways

4.3.3.1 Country insights

In many countries across the globe, especially where ID systems go back several decades, high population coverage was achieved gradually. However, certain countries have chosen shorter timelines because of pressing development, political, and economic objectives, like elections, financial inclusion, and the effective delivery of social benefits that can offer cost savings and other benefits quickly, if the ID system achieves high coverage and can be used widely more quickly.

4.3.3.2 Considerations for program decisions

- A short time frame to enrol a large part of the population requires the widespread availability of enrolment stations, trained staff, technology, and connectivity, leading to higher costs.
- Longer enrolment timelines offer an even distribution of costs. However, the adoption of the ID system for service delivery could be negatively affected, resulting in an opportunity cost associated with foregone (delayed) benefits.
- A key implication of a long start-up phase is that any intended financial benefit from the use of the ID system will be delayed. If rollout is phased in a way that the most beneficial applications can start before the ID system has achieved high coverage may help optimize the balance of costs and benefits.

Shorter enrolment timelines can help achieve higher coverage more quickly. Longer timelines may result in loss of momentum, on account of delayed realization of benefits. For example, in one African country, only 10% population coverage had been achieved for the time period of 5 years (2012–2017).

16 Inputs received in the structured questionnaire from the government agency.

4.4 Integrated Administration of Civil Registration and Civil Identification

Civil registration (CR) is performed primarily to establish the identity of a person and to issue the corresponding legal documents to verify the person's civil status. The civil register is also the main source of vital statistics, which are used to plan and monitor national development plans. The integration between ID and CR systems has been varied across nations.

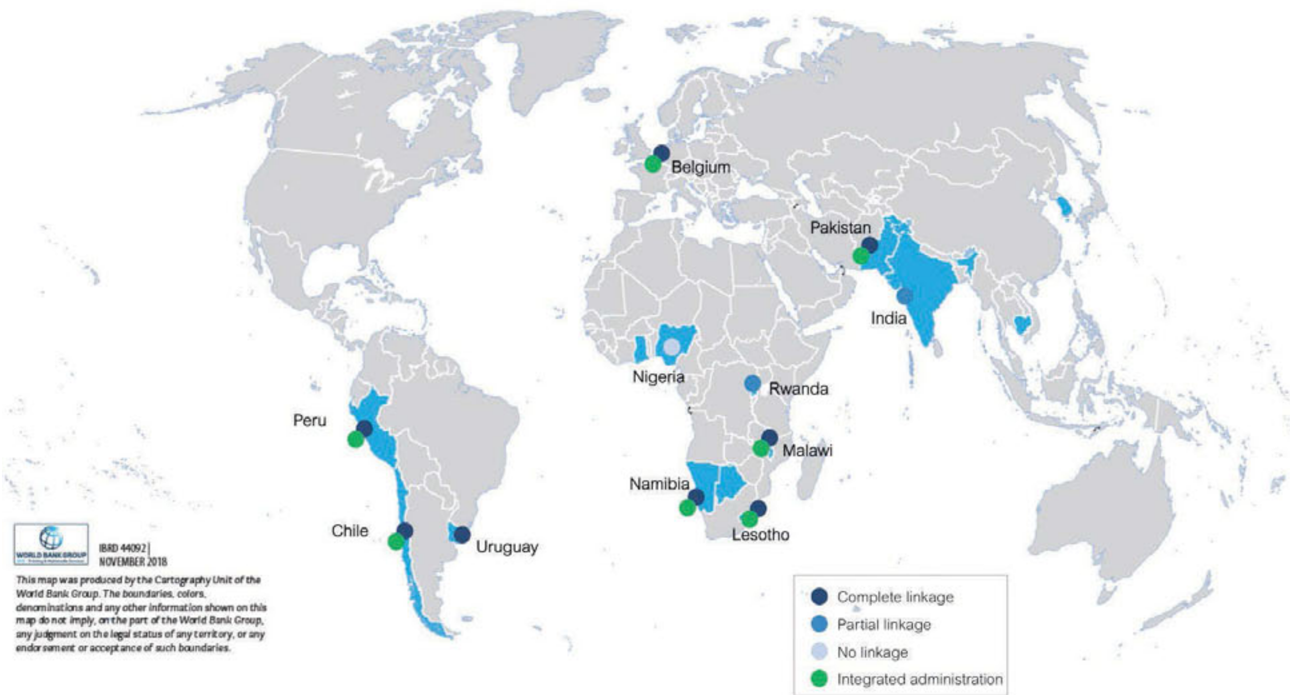
In case of resource-level integration, which involves sharing of costs for implementation of the CR and ID systems, the ID system can make use of existing CR resources like physical establishments (e.g., enrolment centers, DC/DR sites), central infrastructure (e.g., central databases, network and IT security) and Human Resources (both at the central office and enrolment centers). Thus the marginal capital and operating costs of ID implementation may be reduced significantly, especially since the human resource-related costs form a significant part of ID implementation.

Data exchange between the CR and the ID system on continuous birth and death registration is critical for keeping the ID registry accurate and up-to-date. An organic link between the two systems can be established through a unique identifier. Ensuring that the ID numbers and records of deceased persons are distinguished from those still living is important for the robustness of the ID system. Death registration can be incentivized in a number of ways, including by requiring a death certificate as a prerequisite for issuance of burial permits and incentivization of death certificates for execution of will and insurance claims, or revoking licenses of undertakers. Monetary incentivization measures like funeral assistance can also increase coverage of registered deaths. Regulation and licensing of undertakers can be made contingent upon compliance to these rules. In one of the African countries studied, the death registration rates are at the same level as birth registration rates (around 60 percent) because of these measures. The ID record is not deleted after death registration of a resident, but the status will be changed from "live" to "deceased," and the ID is deactivated so that no one else can avail further services.

4.4.1 Insights from the global study

A well-integrated CR and ID system was not common across countries in the study. This was the case especially in countries where many of the CR and ID operations were decentralized at a local level (e.g., at a state/province/city administrative level), and where separate legislative and institutional frameworks for CR and ID existed. However, in recent years there has been considerable emphasis from governments to simultaneously develop/strengthen the national CR and ID infrastructure through institutional, technology-based, and operational linkages. This is also being reflected in new legislative frameworks and institutional models being advocated to support such inter-linked CR-ID environments. Many low and middle income countries (LMIC) are pursuing a modern tightly integrated CR and ID system, and have outlined the requisite legislation and administrative integration between the two functions. Figure 4.11 illustrates the different levels of linkage between the CR and ID systems, as observed in the study.

Figure 4.11. Levels of Integration between CR and ID across Select Countries

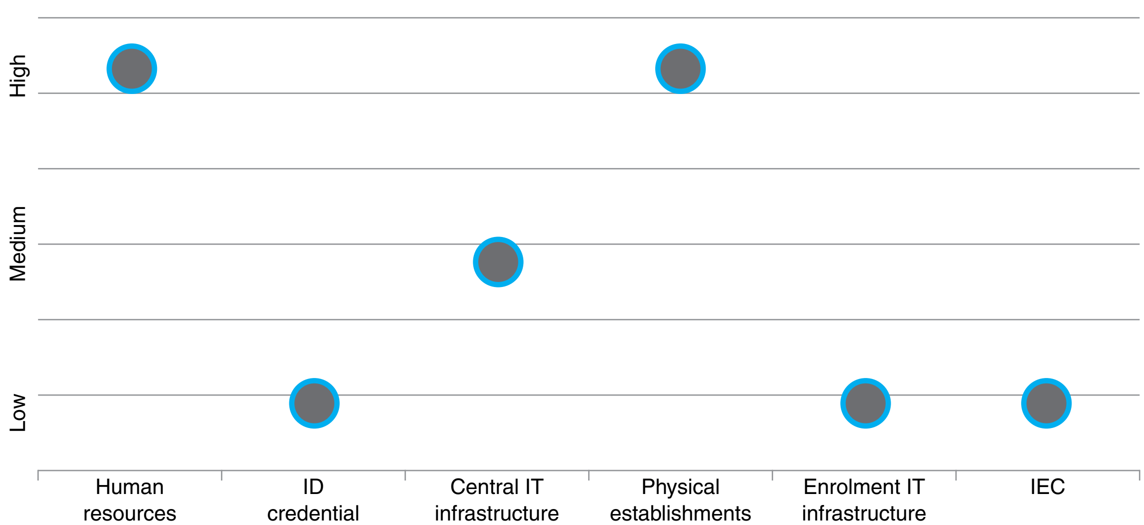


4.4.2 Impact on cost categories

Building an integrated CR and ID system has a high impact on three specific cost categories—Human Resources, Physical Establishments, and Central IT Infrastructure—and limited impact on other cost categories (see Figure 4.12).

A large share of ID system costs are incurred for enrolment operations (especially in the start-up phase), which includes establishment of enrolment centers, hiring and training of enrolment staff, and procurement of IT infrastructure. It is in this area that the largest cost savings are possible through resource integration.

Figure 4.12. Impact of Unified System on Other Cost Categories



4.4.3 Key takeaways

4.4.3.1 Country insights

- Even though most countries had some kind of CR system in place, coverage was often far from complete and incentives for residents to register key events was limited.
- The levels of integration between CR and ID systems have been diverse across countries with respect to both data and resources. Few countries have mandated a birth certificate as a prerequisite for issuance of ID; few other countries have introduced this requirement to new births after the ID system has begun operation.

4.4.3.2 Considerations for making program decisions

- When the ID system is able to leverage existing program resources (staff, offices, and technology infrastructure) of the CR system, there could be significant cost savings.

4.5 Number of Biographic Data Fields

The type and volume of data collected by foundational ID systems differs greatly between countries. Some collect extensive information with respect to each person enrolled, with a view to facilitate different use cases using a single, centralized registry. The data collected may include citizenship status, economic status, details of various benefits received, and details of other identification (numbers) available—passport, driver's license, and so on. Many countries also collect biometric fields to facilitate de-duplication and more accurate authentication.

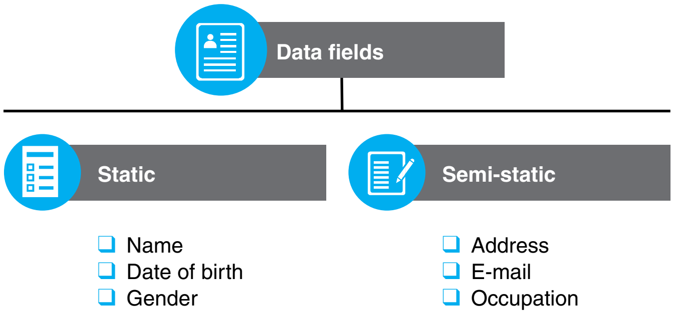
The specifications related to data fields captured (such as mandatory or optional, number of fields that require supporting documents or can be self-attested) will determine the time taken for data entry and verification, thus influencing the resource requirement for enrolment. Further, a higher number of semi-static fields (e.g., address, contact details) collected during enrolment will increase the possibility of a higher number of update requests coming in during the steady state. This may also involve reissue of the credential. The Central IT Infrastructure will have to be adequately provisioned, considering the number of data update requests that may come from residents. All these factors have a significant impact on the cost for implementation and operation of the ID system.

4.5.1 Insights from the global study

There are primarily two types of biographic data captured as part of enrolment process across countries—static data fields, which don't change over time, and semi-static data fields, which were likely to change over time, as illustrated in Figure 4.13.

Some countries capture and maintain only a minimum data set in the central ID repository. A few countries captured a larger biographic data set to support multiple use cases of the ID card using a single registry, along with basic identification of an individual. This decision in turn impacted the time taken for an individual enrolment per station, and thereby the number of enrolment stations and staff required to conduct these operations. Collecting more data about individuals in a single registry can also increase the risk of misuse and may pose a greater threat to privacy. The type of ID card issued and use cases associated with the ID also had a bearing on the number of fields captured during the enrolment process of an individual.

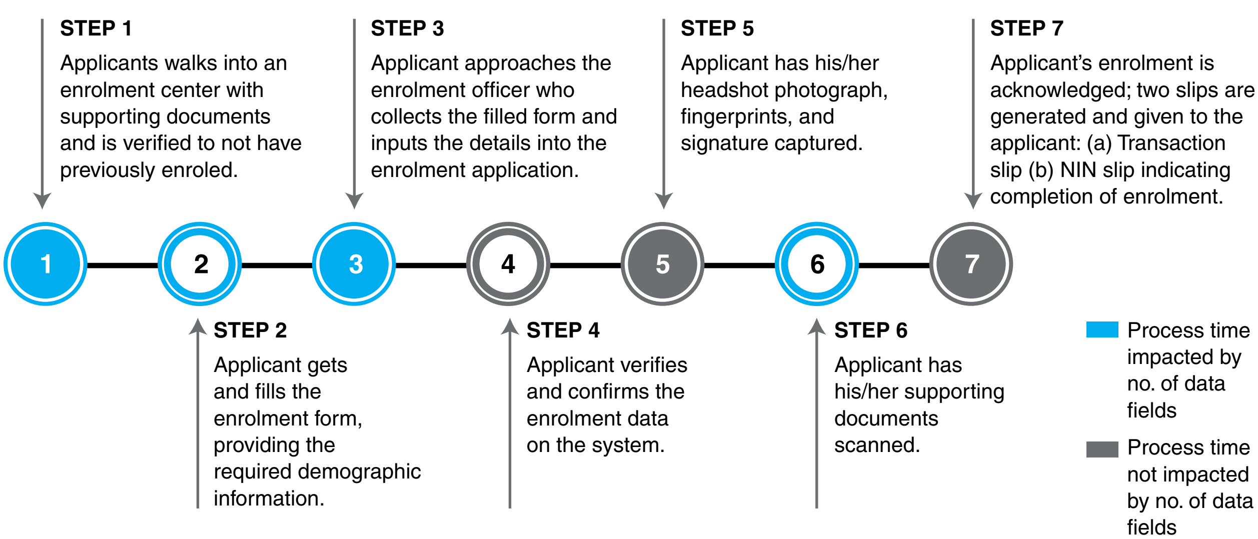
Figure 4.13. Type of Biographic Data Fields



Some country-specific observations from our study include:

- In one of the African countries in our study, the process of enrolment (including capture of biographic and biometric data) took an average of 20 minutes per person, whereas if the registration form was filled in online in advance and the applicant brought a 2D barcode slip generated after the form was filled in online, the enrolment process took less than 10 minutes.[17] An online pre-enrolment portal was created to encourage biographic data entry in advance, to reduce time spent at enrolment centers. This country has a seven step process for enrolment (as illustrated in Figure 4.14) and, in most of these steps, the number of data fields has an impact. In about four of these seven steps, the processing time and staff required were dependent on the number of biographic fields.
- In the ID system of a European country, the ID card contains the name of the individual (i.e., including the family name, up to two given names, and the initial of a third name), title, nationality, place and date of birth, gender, and a photo of its holder. All this information is stored in an identity file within a chip on the ID card. In addition, there is also a separate address file saved independently, as the address of its holder may change within the validity period of the card.

Figure 4.14. ID Enrolment Process in the Country Example

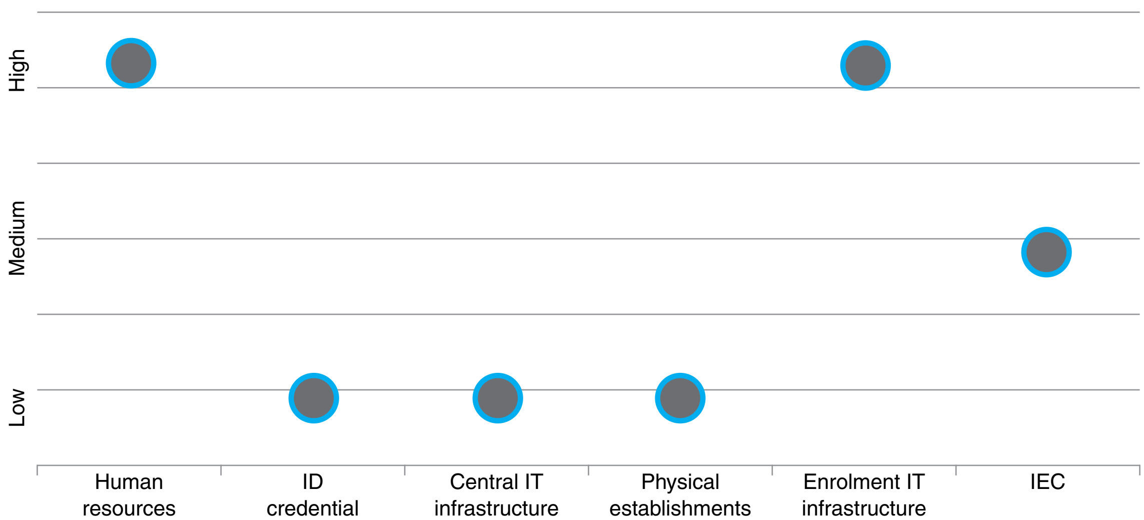


17 World Bank IMSA Report for the country.

4.5.2 Impact on cost categories

On the basis of evidence gathered across countries in the study, the number of biographic data fields primarily impacts enrolment IT Infrastructure and Human Resources–related costs (see Figure 4.15). The impact on other categories is fairly limited. Each biographic data field that is collected (whether mandatory or optional) has to be verified and will need to be accurately entered into the digital system. With a higher number of fields to be captured and verified, the rate of enrolment, facilities for update of more data fields, and computing and storage capacity of the DC/DR environment was seen to be impacted in a number of countries.

Figure 4.15. Impact of Number of Fields on Cost Categories



4.5.2.1 Impact on enrolment IT infrastructure and human resources

As the number of data fields increases, more time will be required to fill in the enrolment form, verify data, and enter data into the system. This will increase the time for completing an enrolment, and potentially reduce enrolments per day. In many countries the enrolment process also entails collection and verification of many supporting documents from an individual, which could translate into the deployment of more staff to manage the task. Cumulatively, the collection of biographic and biometric data from an individual, along with verification of supporting documents, will determine the time taken per enrolment. Therefore, for completing the enrolments in a given time frame, the number of enrolment stations, kits, and staff will accordingly be impacted. As the number of biographic data fields increase, a higher number of enrolment stations will be required to complete the process in a given time frame.

In a study ("Re-thinking Enrolment in Identity Card Schemes," *International Journal of Engineering Science and Technology (IJEST)*) about the UAE's national ID program, the time-consuming and cumbersome initial enrolment process was identified as a key bottleneck to the program's success. UAE began to roll out the program in mid-2005, and managed to enrol a population of 1.1 million over a 4-year period. The registration process was symbolized by long wait times and complex enrolment procedures. In 2009, the Vice Chairman of the Board of Directors at Emirates ID articulated the need for a radical change in the program to address these issues, which resulted in the redesign of the registration process. There was a reduction of the enrolment processes from a 6-step to a 4-step process, and standardization of biometrics capture technology from a maximum of 3-unit workstations to a standard 1-unit workstation.

As a result of the above changes, the average time for enroling each applicant was reduced by 23 minutes per ID card application. Key drivers for this change were an average 10-minute reduction in average time to fill out an ID card application and a 13-minute reduction in average time for biometrics capture and data verification. As a result of the above changes, the average labor overhead for biometrics capture and data verification was reduced by 30 AED (about US$8) per application. In a little over one year, the organization achieved strong results such as—increased intake capacity by 300 percent, reduced registration time by 80 percent, reduced applicants waiting time by 1,000 percent, reduced staff turnover by 60 percent, lifted customer satisfaction by over 52 percent, increased revenues by 400 percent, and overheads cut by 300 percent.

4.5.2.2 Impact on IEC

With an increase in the number of biographic data fields during enrolment, some countries also deployed extensive information, education, communication (IEC) activities. This was considered necessary by their governments in order to adequately explain the enrolment process to residents and support them in any ID program-related needs (e.g., guidance on supporting documents). In some cases, this translated to deployment of additional customer service staff to assist residents.

4.5.3 Key takeaways

4.5.3.1 Country insights

The volume and type of biographic information collected has been a major determinant of the enrolment cost, quality of data collected, and acceptance by residents.

4.5.3.2 Considerations for making program decisions

- The number of biographic data fields captured for a program could be what is required at a minimum in order to uniquely identify a person and enable access to basic services and transactions. This will also help simplify and increase the accuracy of efforts to capture and verify the information recorded for the entire population.
- Adopting supplemental processes like pre-filled online form(s) can help in expediting the enrolment process and make it more convenient for applicants, with reduced time for the enrolment process.

4.6 Other Important Design Choices That Influence ID System Costs

In addition to the five key design choices with high impact on the cost, as discussed in earlier sections, there were a few other design choices that also influenced the cost of ID systems across the countries analyzed in the study. The two prominent ones were 'Technology Architecture and Software' and 'Operating models' (see Figure 4.16).

4.6.1 Technology architecture and software

Technology architecture and software choices have impacted the cost of the ID system of the countries involved in the study. The two major software choices that ID systems across countries took into consideration were the choice of proprietary, or open-source technology solutions. This is a key decision

Figure 4.16. Other Important Design Choices

Technology architecture and software

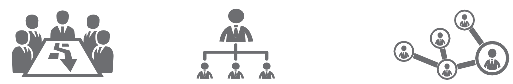
The two major software choices that ID systems across countries took into considerations, were the choice of proprietary or open-source technology solution for ID systems. This was a key decision in designing the technology architecture including selection of the biometric de-duplication, DC/DR infrastructure components, the central ID repository, enrolment systems, resident engagement systems for addressing grievances, and so forth.

Proprietary	Open-source	Standard interfaces

Operating model

The type of operating model employed by a government does have impact across all the 'six' cost categories (elaborated earlier) of an ID program. The type of model employed seems to have been influenced by specific program decisions for a government, like reducing the up-front capital costs (in a PPP) or higher operational control (in a federal government-run program, with their own staff).

In-house	Outsource	Hybrid



in designing the technology architecture, including selection of the biometric de-duplication, data center and disaster recovery infrastructure components, the central ID repository, enrolment systems, resident engagement systems for addressing grievances, and more. Generally, software solutions in ID systems based on open standards and open Application Programming Interfaces (APIs) facilitate interoperability between the ID system and other systems of the government and private sectors. As evidenced in the study, some countries (e.g., India) leveraged open-technology standards in core parts of the ID system architecture, except for the biometric de-duplication and authentication modules (ABIS/AFIS). The benefit for the countries that adopted this model was that they had strong control over the overall architecture design and limited vendor lock-in. However, this also translated to investment in the Human Resources category during the start-up phase, since the technical support and skills required to develop such open-source–based solutions may not be available locally in certain geographies.

Adopting a vendor- and technology-neutral and open-source strategy allows governments to further customize the ID system from time to time, based on changing program requirements. In effect, the biggest advantage such a strategy can give a country is flexibility over the ID solution. In contrast, proprietary technologies often leave countries with multiyear contracts with high on board costs for technology components in the program (e.g., annual license fees), with possible vendor lock-in.

4.6.1.1 Insights from the global study

Many of the countries analyzed in the study opted for proprietary technology solutions in ID system implementation. There were a number of reasons why different governments chose proprietary solutions provided by vendors instead of open source solutions:

- Convenience of a 'one-stop-shop' approach: Many of the leading firms that offered specific, ID technology solutions (e.g., biometric technologies like AFIS/ABIS) also played a key role in the implementation of other components of ID systems across countries in the study.
- Ongoing support to manage the technology needs of the system: This was a key consideration for most the LMICs in the study, as they often experienced skill shortages in key technology staff roles. Therefore, management of a complex ID system by in-house program staff became difficult. This skill gap was often addressed by vendors and their technical teams.

However, the use of proprietary technologies resulted in long-term dependency on the vendor by many of these countries. Some countries in the study have put in place checks and balances to ensure that the underlying technologies (for the ID system) procured from vendor(s) are certified as per international standards and have standard interfaces to support interoperability with other public delivery systems.

There are specific technology components (e.g., ABIS, enrolment applications, process workflow automation tools), for which very few or no good open-source alternatives exist, or for which existing open-source solutions had limited capabilities and required heavy customization. At the same time, an open-source strategy for specific technology components like customer relationship management (CRM) or interface engines is increasingly common in ID system implementation. Adopting open-source technologies often require governments to deploy a greater number of skilled human resources, which can be a challenge. When evaluating the appropriateness of open-source technology components for the ID system, solutions with a proven deployment portfolio (i.e., installations in a number of scenarios). Untested technology components can increase the probability of cost increases due to deployment of more skilled human resources and greater need for customization.

4.6.2 Operating model

The operating model adopted by a government was another factor that influenced financial and operational arrangements for an ID system. There are primarily two key considerations for governments when outlining an operating model for an ID system:

- Financing for the program—A foundational ID system is often capital cost-intensive, and substantial costs are incurred in building and managing the technology infrastructure and services ecosystem. For a government (more so for governments in LMICs), the financial arrangements for the system will be critical to ensure sustainability.
- Availability of skilled resources—ID systems for countries are large scale in nature and technically complex programs. Often, governments (especially in LMICs) face a shortage of the requisite skilled workforce and may have to depend on partners from the private sector (either local partners or international firms) to execute such programs.

The type of operating model employed by a government does have an impact across all the six cost categories (elaborated earlier) of an ID system. The type of model employed seems to have been influenced by specific program decisions for a government, like reducing the up-front capital costs (in a PPP), or higher operational control (in a federal government-run program, with its own staff).

In recent years, several leading technology firms in the ID industry have entered into Build-Operate-Transfer (BOT) agreements with governments, where the technology firm takes on the responsibility of building the necessary technology infrastructure, conducting enrolment, providing the skilled workforce to oversee different operations, issuing ID cards to enrolees, and maintaining the ID system overall. In some countries, these arrangements have time-bound/target-based contracts and a payment model in which the government pays a fee for every ID card delivered.

4.6.2.1 Insights from the global study

The three popular operating models seen across the countries in the study were:

- Government owned, operated, and funded

In this model, the government financed and operated the ID system on its own, with specific complex technical components being implemented by third-party service providers. In many countries in the study, central government ministries or departments run these systems, as well as manage the overall financing of the program. In some other countries, the central/federal government collaborated with provincial or local municipal governments, where the operational and financing responsibilities were split between the central and local governments.

- Public private partnerships

Sustained program financing and operational oversight to successfully implement long-term ID systems was an important program consideration for countries in the study. In this context, public-private partnership (PPP) models were adopted by a few countries with the aim of boosting the operational efficiency of the system and reducing the initial financial burden. Some countries successfully utilized a PPP model for implementing an ID system, where the private sector partner made substantial investment toward the system (e.g., installing/upgrading the national digital infrastructure, deploying skilled human resources to manage critical enrolment functions); the government paid the private partner through outcome-based fees (e.g., successful enrolment of residents and issuance of an estimated volume of ID cards in a year), or lump-sum contracts. In such models, the government sometimes had limited control over the design and technology-related decisions during the start-up phase of the program.

- Outsourcing models

In some countries across the study, governments have taken on the management and financing of the ID system, but established separate outsourcing contracts with private firms to implement and manage certain key operations. This enabled governments to bring in the requisite skills and solutions from the industry (to build a 'best of breed' ID system), while maintaining overall strategic and administrative control of the program. Countries have often adopted the outsourcing model for their ID systems based on their individual priorities across the implementation phase. The study observed a number of different models, with select operations outsourced to a single managed service provider, or outsourced to a number of vendors for fulfilling individual functions.

5. Reference Cost Model

The learnings from the cross-country study have also been used to develop a reference cost model based on the learnings from the countries studied and additional research on current system component costs. This reference model is designed to assist in estimating costs associated with different ID system design choices (e.g., issuing a chip-based ID card vs. a paper-based ID, a short enrolment period vs. a long enrolment period, fingerprint biometric technology vs. multimodal biometric technology and so on).

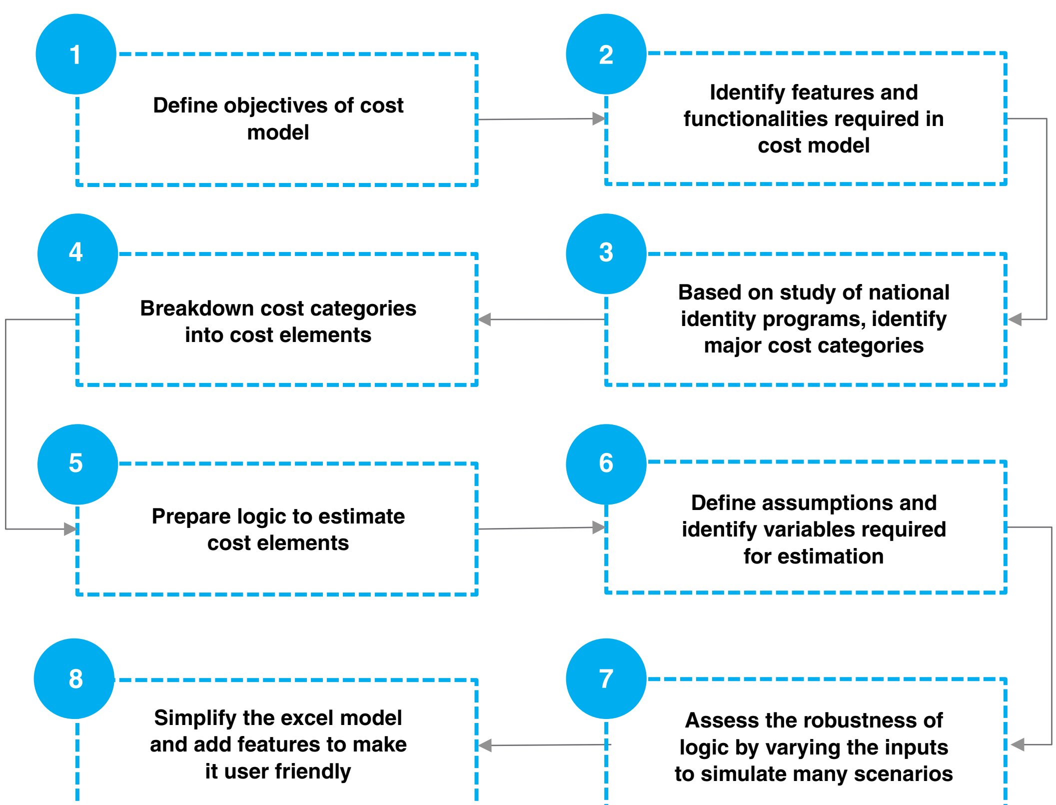
5.1 Overview

The reference cost model estimates the expected cost of developing and sustaining a foundational ID system using a number of different scenarios. Figure 5.1 summarizes the high-level approach adopted to prepare the model.

5.1.1 Objectives

The reference cost model seeks to estimate cost ranges for a foundational ID system using different scenarios, which countries could use to approximate the expected cost of implementing a foundational ID system.

Figure 5.1. High-Level Approach of Cost Model



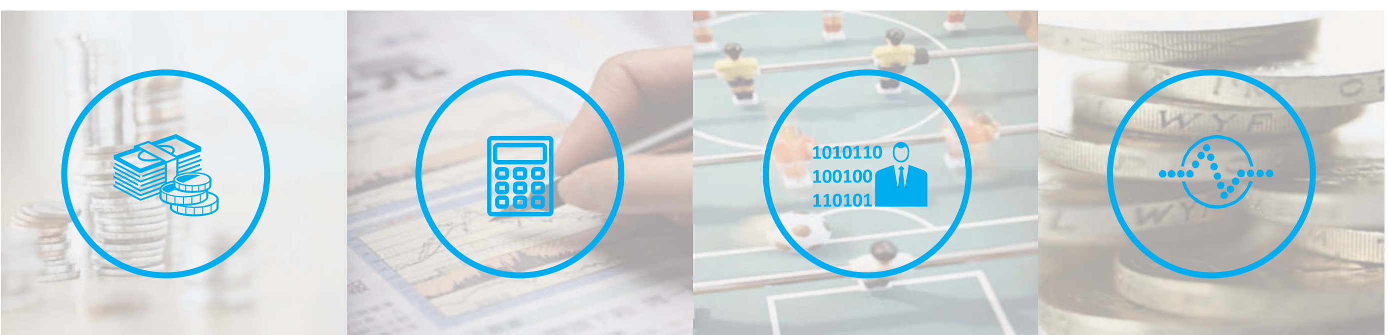
5.1.2 Key features

The features of the reference cost model are shown in Figure 5.2.

5.1.3 Limitations of the reference cost model

- The cost estimation for implementation of a foundational ID system based on a particular set of design choices is indicative only and may be influenced by other parameters not included in the cost estimation.
- The cost estimation is for a green field implementation and does not take into account the technical and physical infrastructure that may already be available with the ID agency.
- The cost of capital is not included in the cost estimation. This may increase the cost of the system.
- The model does not optimize resource allocation. In reality, human resources and physical and technical infrastructure can be further optimized to reduce the system's cost.
- All the estimations are done in US dollars (USD), and countries should use appropriate projection of exchange rates to estimate costs in local currency units.
- Total cost of the system may significantly change with the procurement strategy adopted. A country with limited technical expertise may procure more services from large SI/MSP, which may result in an increase in the total project cost. Apart from available expertise in the form of human resources, risks associated with the country (political/financial), bidding process (open/close) and tax laws can all affect overall system costs. As most of these situations cannot be parameterized for each country, the model will not be able to account for the impact on overall cost due to such variations. Hence, the model assumes a competitive bidding procedure that will enable the cost of system components to reflect market pricing. Taxes are not included in the cost estimation and should be added separately as per country-specific tax laws.

Figure 5.2. Key Features of the Cost Model



Feature 1	Feature 2	Feature 3	Feature 4
Estimated costs associated with developing and sustaining a national ID system under different design choices	A simple user input-driven model (excel-based), where the user can select from different options for a number of design choices and generate corresponding estimates	Supports side-by-side comparison of cost estimates generated from multiple scenarios, thereby allowing the user a clear view of the impact of different design choices on the overall cost of the ID system	Allows user to manually adjust variables to refine the model to incorporate country-specific variations and increase the accuracy of estimation

5.2 Methodology

A detailed cost estimation methodology for each of the above categories and how it can be used to adequately project costs for a 'greenfield' ID system based on prevailing country characteristics and design choices selected by a government is elaborated in the Reference Cost Model tool (this can be accessed via the ID4D website).[18] The section below briefly outlines the capabilities and design features of the cost model.

5.2.1 User inputs for the cost model

The cost model has three primary data input categories:

- Key design choices
- Country characteristics
- Predefined variables

5.2.1.1 Key design choices

From the evidence gathered through the cross-country study, there are five specific design choices that demonstrated the greatest impact on the overall sytem cost. In broad terms, the impact was visible across both the start-up phase and steady state of ID systems, to varying degrees across countries. These design choices are mandatory variables for the model. The five design choices are as follows:

- Choice of biometrics
- Choice of credentials
- Enrolment timelines
- Number of biographic fields
- Linkage with civil registration

5.2.1.2 Country characteristics

Defining the individual country characteristics is critical for the reference cost model to provide reasonable cost estimations. The country characteristics that have a high impact in costs are included as mandatory parameters in the cost model. They include:

- Population
- Average population growth rate
- Average birth rate
- Percentage of rural population
- GNI per capita USD PPP, 2016
- Number of regions/provinces
- Number of districts/municipalities

18 https://id4d.worldbank.org/

5.2.1.3 Predefined variables

To keep the cost estimation customizable as per different country scenarios and amenable to future modification, a number of parameters/coefficients are defined and listed separately. These values were predefined on the basis of industry experience, interaction with experts, and learnings from various global study reports. Though these inputs are not essential to be modified in the cost model, it is recommended that a user refine these values in order to get more accurate estimations for the country.

These predefined variables are further divided into three categories:

- **Unit cost variables:** This outlines all the assumed unit costs of various elements required for estimating capital and recurring costs, for example, the cost of software systems and enrolment kit components, expenses related to office facilities, and so on. The unit cost of these components varies from country to country because of many factors, such as location of manufacturer and buyer, key service level agreements (SLAs), functional and technical requirements, procurement strategies, local country taxes, and so forth. Hence these values may be refined by the user to represent actual costs in the country under consideration.
- **Human resource costs:** This outlines wage levels on the basis of a three-tier organizational structure (commonly observed across countries). As discussed in earlier sections of this report, the human resource cost is a significant component in the ID system. Hence, it becomes essential that the organization structure in the model depicts a realistic scenario for estimating human resource requirements and wages.
- **Default parameters:** This outlines a number of standard parameters used in formulae for estimating costs across categories. This provides flexibility to the user to customize formulae as per country characteristics. For instance, the percentage of people using call center facilities to register grievances, the percentage of the population to be enrolled by employing mobile enrolment stations, and so forth.

It must be noted that cost estimations provided by the model are indicative and merely a reference guideline for governments planning a foundational ID system. Actual implementation costing with a similar set of design choices may result in variation from the model output cost, due to different on-ground realities and country characteristics.

5.2.2 Cost categories

For the purpose of cost estimations across key system components, the ID lifecycle is divided into seven core categories. Cumulatively, these address most of a foundational ID system's implementation costs. The seven categories are as follows:

- Enrolment
- Human resource
- Software development
- IEC, helpdesk, training, and capacity building
- Administration facilities
- Identity credential
- Central IT infrastructure: data center and disaster recovery

For more information, please see the Model Guidance Note on the ID4D website.

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