



# FINTECH

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## NOTES

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### **Capital Flow Management Measures in the Digital Age (2): Design Choices for Central Bank Digital Currency**

Dong He, Annamaria Kokenyne, Tommaso Mancini Griffoli, Marcello Miccoli, Thorvardur Tjoervi Olafsson, Gabriel Soderberg, and Herve Tourpe

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September 2023

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**Capital Flow Management Measures in the Digital Age (2): Design Choices for Central Bank Digital Currency**

Note 2023/009

Prepared by Dong He, Annamaria Kokenyne, Tommaso Mancini Griffoli, Marcello Miccoli, Thorvardur Tjoervi Olafsson, Gabriel Soderberg, and Herve Tourpe

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## Glossary

CBDC ..... central bank digital currency

CFMs ..... capital flow management measures

## Introduction and Summary of Findings

**Central banks are exploring the issuance of central bank digital currency (CBDC) to modernize payment systems and to future-proof central banking in the digital age.** CBDC is a digital liability of the central bank, which can be accessible by the general public for retail purposes (retail CBDC) or only by selected financial institutions for large value payments (wholesale CBDC). The issuance of CBDC is generally intended to promote domestic policy goals, such as access to payments and financial inclusion; to facilitate payment system competition, efficiency, and resilience; and to maintain the demand for central bank money in the digital age to safeguard monetary sovereignty and monetary policy effectiveness. But, increasingly, central banks are also considering CBDC to enhance cross-border payments and transfers.

Cross-border payments, especially at the retail level, are often slow and costly, relying on long chains of intermediaries located in different time zones and following different technical and legal standards. CBDC promises to complement traditional rails for cross-border payments, significantly increasing speed and decreasing costs. CBDC could offer a “clean slate,” allowing transfers of money through new arrangements and networks that can be designed from the outset for seamless cross-border payments.

Still, using CBDC for cross-border transfers entails potential risks. Lower transactions costs, faster speed of transfers, and expanded access to foreign currencies could lead to larger and more volatile gross capital flows among countries and faster transmission of global shocks as well as easier avenues for currency substitution in countries with weaker economic fundamentals (IMF 2020). These possibilities add to the potential risks of using CBDC domestically (Soderberg and others 2023).

Many IMF member countries rely on capital flow management measures (CFMs)<sup>1</sup> to limit risks arising from sudden and volatile capital flows. Some countries have only a handful of CFMs (even only targeted ones),<sup>2</sup> whereas others rely extensively on such measures. They come in a variety of forms, including authorization requirements, taxes, fees, or quantity limits on capital inflows or outflows. Countries rely on CFMs to help contain financial sector vulnerabilities, manage the exchange rate, stabilize macroeconomic conditions, avoid large external imbalances, and respond to large economic shocks, even crises. CFMs can also have disadvantages because they could lead to misallocation of resources and hinder needed macroeconomic adjustment. Indeed, the IMF’s “Institutional View” on Liberalization and Management of Capital Flows considers CFMs to be appropriate only under certain circumstances and only if they do not substitute for warranted macroeconomic adjustment (IMF 2012, 2022).<sup>3</sup> In many cases CFMs are long-

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<sup>1</sup> CFMs are measures designed to limit capital flows and comprise residency-based CFMs, which discriminate based on residency, and other CFMs that do not discriminate based on residency but are nonetheless designed to limit capital flows. While this note discusses CFMs, in certain cases restrictions on the current account are also implemented or need to be implemented to complement restrictions on the financial account. Such measures may be exchange restrictions or multiple currency practices subject to Executive Board approval under Article VIII Sections 2 and 3 of the IMF’s Articles of Agreement. Throughout this note, CFMs are meant to mean restrictions on the current account. Note that some transactions that are included in the financial account are considered to be current under the Articles of Agreement.

<sup>2</sup> Targeted CFMs are CFMs on specific types of flows, for instance, into the housing sector.

<sup>3</sup> The Institutional View provides a macroeconomic framework for consistent policy advice to member countries on liberalizing and managing capital flows, with the goal of helping countries harness the benefits of capital flows while managing the risks in a way that preserves macroeconomic and financial stability and does not generate significant negative outward spillovers.

standing measures removed gradually over time, whereas in other cases they are implemented temporarily to deal with sudden capital flow volatility.

Because CBDC holds promises for cross-border transactions, several questions arise: Can a country maintain CFMs effectively together with a CBDC? What might the implementation of CFMs in countries with CBDCs look like? What advantages or disadvantages arise compared with CFMs applied through traditional systems? Is there a way to make CFMs “smarter” through CBDC?

This Fintech note looks at how CFMs could be implemented with CBDC and what benefits, risks, and complexities could arise. The note takes the point of view of a domestic authority—usually the central bank—that would like to implement CFMs through CBDC, either because it plans to issue a domestic CBDC that can be used to buy foreign assets, or because it expects a foreign CBDC to be accessible to domestic entities. Importantly, the note does not opine on whether the CFMs implemented in a country are needed or useful for macrofinancial stability, nor on how the presence of CBDCs may alter such assessments. Instead, it takes it as given that the authorities intend to use CFMs to limit certain capital flows and examines how in the context of a domestic or foreign CBDC the effectiveness of such CFMs can be ensured.

Traditionally, CFMs are implemented by commercial banks and other regulated financial service providers, such as brokers and foreign exchange bureaus. These intermediaries are best placed to collect relevant information on current and capital flows, such as the ultimate beneficiary and transaction purpose. They then use this information to apply CFMs as required by law, under the supervision of the foreign exchange authority, typically the central bank. A CBDC for cross-border payments must be designed such that these checkpoints still exist, although not necessarily by existing financial services providers. This is where technology can help.

The CBDC ecosystem could be thought of as a stack of technical functionalities, from the user interface to the technology architecture that controls the system, and platforms that might connect CBDC with foreign currencies. All these levels have the potential to be used to implement CFMs, each with their respective trade-offs. Characteristics of CFMs can help guide the choice.

The first characteristic is that different types of CFMs require varying amount of information. For instance, prohibiting the purchase of more than 1 million dollars of foreign assets per transaction requires less information than prohibiting the purchase of 1 million dollars of foreign assets by the same person, each year, for a specific purpose. The latter requires keeping track of all transactions conducted within a year and their purposes. The second characteristic is that CFMs must be flexible. On the one hand, they need to be relaxed or removed in the process of liberalization. On the other hand, some type of CFMs might require quick implementation in the face of a crisis or imminent crisis.

This note proposes a taxonomy of CFMs and their corresponding possible implementation at different levels of the CBDC ecosystem, based on the amount of information and the speed required for implementation. CFMs that require a large amount of information, or fast implementation, are preferably implemented at the technology architecture level of the CBDC, the *engine* of the CBDC system, because this is most likely under the direct control of the central bank. Some types of CFMs, those with minor information requirements and less risky if circumvented, could be efficiently and effectively applied at the user interface level, where the front-end users interact with the *dashboard* of the CBDC. In the case of a foreign CBDC circulating domestically, the domestic central bank can either regulate the providers of the foreign CBDC’s user interface or request that the foreign central banks implement CFMs on the foreign



CBDC. However, the latter would entail additional costs for the issuing central banks for the design and implementation of CBDC. Issuing central banks may not be willing to shoulder such a burden. In such cases, the interconnection of CBDCs through a multilateral platform might help (Adrian and Mancini Griffoli 2023).

There are several implications of the analysis. First, CBDC ecosystems generally should be designed such that they can accommodate the introduction of CFMs—when consistent with the IMF’s Institutional View or the country’s other international agreements, if these provide for more stringent conditions than the Institutional View. Given the macroeconomic risks from the cross-border use of CBDC, technical architecture should be designed with the possibility of CFMs from the beginning. Still, this does not imply that issuance of CBDC necessarily requires the implementation of CFMs. If the CBDC cannot be used directly for cross-border transfers, and these need to go through traditional channels (for example, correspondent banking), traditional CFMs could still operate.

Second, thanks to the programmability of the payment infrastructure<sup>4</sup> given by the new digital technologies, certain CFMs could likely be implemented more efficiently and effectively with CBDC compared with the traditional system. These “smart CFMs” could lower costs of monitoring, compliance, disclosure, and leakages. Still, operational risks may rise, mostly because of the automated nature of smart CFMs.

Third, implementing CFMs requires central banks to collaborate on practices and standards. In the case of a foreign CBDC circulating domestically and absent collaboration between the issuing central bank and the domestic central bank, the latter may resort to traditional CFMs exploiting on- and off-ramp access to the foreign CBDC or may need to resort to draconian policies to implement CFMs, such as banning access to foreign CBDC wallets and related applications. Both have limited effectiveness or undue costs and reduce benefits for residents of the domestic central banks’ own country.

Finally, CFMs on CBDC need to operate alongside traditional CFMs. While CBDC represents one way to access or receive foreign assets, the other channels, for example, correspondent banking, will continue to exist. Coordination among these different rails and consistency between digital and traditional CFMs will be important to keep track of transactions across both systems, avoid loopholes, and preserve overall effectiveness of CFMs. This might require the streamlining of some CFMs so that they can be equally implemented in the digital and traditional form. More generally, faster cross-border payments could arise independently of how the CBDC landscape evolves and might require changes in CFM design to keep up with the speed of transfers.

This note is the first that explores the implementation of CFMs through CBDC. Several issues need to be analyzed further. A partial list of issues is presented here, and more are illustrated in the rest of this note.

First, the issues surrounding the legal framework of smart CFMs warrant attention and need to be explored further. This note focuses on the technical aspects of smart CFMs. However, their implementation would require first a careful analysis of the legal and regulatory framework underlying the CFMs. For instance, smart CFMs do not render superfluous the foreign exchange legislation that makes the rules under which CBDC can be used in cross-border transactions. In addition, for CFMs to become

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<sup>4</sup>Please note that programmability of the payment infrastructure is not the same as programmability of money. More on this in Section II.

self-executing, the legal framework will need to assign the relevant powers, rights, and responsibilities of all parties.

Second, privacy concerns could arise and need to be thoroughly addressed. Implementation of CFMs requires extensive information. Information may also need to be stored in data repositories owned by the central bank or financial intermediaries to fully exploit automation. However, if CFM controls are perceived to be overwhelmingly intrusive, users may move toward less regulated alternatives. It is therefore important to strike a balance between privacy protection and risk management. Privacy-preserving technologies, such as zero-knowledge proofs, could provide a good solution, which is an interesting avenue for future research.<sup>5</sup>

Third, operational risks in smart CFMs could add complexity to the risk management of the CBDC and need to be explored further in operational settings. The automation of CFMs reduces the risks linked to human interventions, including slow processes, inability to scale, and human error. However, several challenges need to be properly understood and mitigated in the design and governance of smart CFMs, including the management of software bugs, outages, cyber resilience, and contingency plans. More broadly, CBDC design needs to balance design features that provide added value to payments, such as cross-border use, with effective mitigation of all risks. Experimentation with CBDC will need to find the right balance. Some central banks might prefer to forego the complexities of programmability of smart CFMs. In such cases the implementation of CFMs may need to be ensured through other means.

Finally, the analysis focuses on the implementation of CFMs through CBDC only, the “cash leg” of capital flows. For those CFMs that impose limitations on transactions (such as acquiring or selling securities) as opposed to payments and transfers (payment for the purchase of securities), an alternative option would be to consider the possibility of introducing CFMs on the “securities leg” of the transaction, but this goes beyond the scope of this note.<sup>6</sup> Countries are also analyzing, in parallel, tokenization of assets.<sup>7</sup> The analysis of whether CFMs could be implemented through tokenized assets is not explored here. Novel digital payments solutions and CFMs were also explored in a previous Fintech note, which analyzed the challenges of crypto assets. IMF staff suggested that the use of crypto assets could undermine the effectiveness of CFMs (He and others 2022).

This note is part of the broader work program of the IMF on the implication of digital money for the stability of the international monetary system. The IMF’s Executive Board in July 2021 approved an operational strategy for the IMF to continue to deliver on its mandate amid the rapidly changing developments stemming from the rise of public and private digital money (IMF 2021). This note is a component of the work that develops analytical underpinnings for capacity development in CBDC (IMF 2023).

This Fintech note is organized as follows. Section I introduces the key characteristics of CFMs and the information and speed required for implementation. Section II presents the options for implementing CFMs in the CBDC ecosystem and provides a discussion of trade-offs based on CFM characteristics.

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<sup>5</sup>In cryptography, a zero-knowledge proof or zero-knowledge protocol is a method by which one party can prove to another party that a given statement is true, while avoiding conveying to the verifier any information beyond the mere fact of the statement’s truth.

<sup>6</sup>In a transaction with securities, the payer gives the payee a currency amount (the “cash leg” of the transaction), while receiving from the payee the purchased security (the “securities leg”).

<sup>7</sup>In this note, *tokenization* means writing property rights to a digital ledger that is widely accessible, easily verifiable, immutable, and optimized for cheap, immediate, safe, and final transactions among network participants.

Section III explores why CFMs can be more efficient and effective through CBDC. Section IV presents risks and further complexities.

# I. Key Characteristics of CFMs

**Implementing CFMs requires a varying degree of information, and their design and calibration may need to change over time.** An overview of CFMs can be seen in He and others (2022) and in Annex I. Here, the focus is on two characteristics of CFMs that are important when considering their implementation through CBDCs. The first is that the implementation of CFMs requires information, for example, on the type or identity of the sender or receiver of cross-border financial transfers, on their purpose, or other conditions. CFMs could be ordered in the amount of information they need in order to operate. The second characteristic is that CFMs often change over time, and they sometimes need to be implemented dynamically. Any implementation of CFMs through CBDCs thus needs to collect the necessary information for effective implementation, and its design must be flexible enough to be amenable to change, possibly at a fast speed.

## CFMs and Information

CFMs are typically designed to target three attributes of capital flows.

- *CFMs on flows* aim to curtail the size of any cross-border transfer, regardless of whom the sender or ultimate beneficiary may be or the purpose of the transfer. These are rudimentary CFMs and are not frequently applied outside of crisis periods.
- *CFMs on transaction purpose* are designed to allow transactions only with a certain purpose, for instance, for inward foreign direct investment, often with a limit on the amount or subject to certain conditions.
- *CFMs on stocks* attempt to ensure resilience toward capital flow volatility by limiting the cumulative scale of cross-border transfers in a period (for instance, a yearly \$1 million limit per resident).

Countries usually rely on a combination of these, but the overwhelming majority of CFMs are of the transaction purpose type.

Each type of CFM requires specific, and in some instances increasing, amounts of information. An illustrative, and not exhaustive, characterization is captured in Table 1. CFMs on flows typically rely on information on the transaction size. CFMs on transaction purpose require information about the sender and receiver of foreign funds; they also require invoices or underlying documentation evidencing the purpose of the transaction or proving that the transaction meets the prescribed conditions. Finally, CFMs on stocks require information on the transaction size and on the identity of the buyer of foreign currency—his or her nationality or residence. This last category of CFMs requires that all transactions of an entity, possibly through different intermediaries and rails, are tracked to make sure that the total holdings of foreign currency do not exceed the limit at any time. In some cases, CFMs on flows, transaction purpose, and stocks are also linked to other characteristics of the sender, for instance, on balance sheet characteristics.<sup>8</sup>

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<sup>8</sup>Some CFMs limit firms' foreign borrowing, linking it to specific balance sheet requirements, for instance, on available capital, quantity of foreign debt already issued, and amount of liquid foreign exchange assets.

CFMs can also apply to payments in local currency between residents and nonresidents, or they might apply explicitly to nonresidents' holdings of domestic currency, for instance, allowing the holding of domestic currency only for some transaction purpose (for example, the nonresident is an importer or exporter of goods and services). These types of CFMs always require information on flows, stocks, and transaction purpose; therefore, they can be considered similar to CFMs targeting foreign currency transfers between residents and nonresidents.

**Table 1. Correspondence between CFM Type and Information Requirements**

CFM Type ↓	Information required on...				
	Transaction Size	Identity	Cumulated Flows	Payment Purpose	Balance Sheet Information
Flows	X	X	–	–	–
Transaction Purpose	X	X	–	X	X
Stocks	X	X	X	X	X

Source: Authors' analysis.

Note: CFM: Capital Flow Management Measure.

## CFMs and Change

CFMs tend to change over time, either because countries move toward greater financial openness or because they need to manage capital flows as shocks hit their economies. Over the longer term, better macroeconomic financial and structural policies may allow countries to gradually reduce their need for CFMs. However, even countries with long-standing open financial accounts sometimes need CFMs, and these may need to be changed or implemented fast, for instance, in response to a rapidly deteriorating balance of payments crisis.<sup>9,10</sup> In the face of a crisis or an imminent crisis, CFMs might need to be implemented over a weekend or during a bank holiday. In such situations, some types of CFMs are more important than others. These are usually CFMs that limit outflows, for instance, those that impose restrictions on resident investments or other payments abroad and on the reversal of nonresident inflows, or those that introduce mandatory requirements on currency denomination of payments. For these types of CFMs speed of implementation, or ease of modification, are important characteristics to consider when choosing how to implement them.

## Matrix of CFM Characteristics

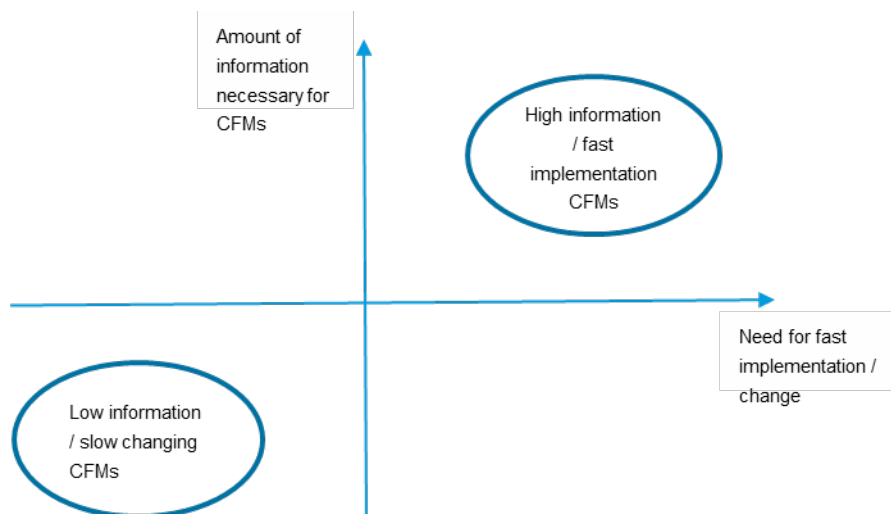
The need for information and speedy implementation defines a matrix of CFM characteristics, as illustrated in Figure 1. For instance, CFMs that require extensive information and that potentially need to be implemented quickly are placed high in the first quadrant of Figure 1. CFMs that do not need quick

<sup>9</sup>See IMF (2022) for a description of when CFMs can appropriately be implemented.

<sup>10</sup>Under the IMF's Articles of Agreement Fund members have broad freedom to regulate international capital movements with a few exceptions (see Article VI Section 3 in the Articles of Agreement). In addition to circumstances in which it may be appropriate under the Institutional View to introduce CFMs, the Fund may also require members to impose CFMs under Article VI Section 1.

implementation and that require less information, are placed low in the third quadrant of Figure 1. The digital environment of CBDC allows for different implementation options for CFMs. Section II analyzes which technological options are preferable for CFMs implementation depending on the two characteristics defined.

**Figure 1. Matrix of CFM Characteristics**



Source: Authors' analysis.

Note: CFM: Capital Flow Management Measure.

## II. How Can CFMs Be Implemented with CBDC?

**Technology allows for the automation of CFMs.** At its core, a CFM is a set of instructions that require information about the users and the nature of the transfer, together with other attributes of capital flows (see previous Section). CFMs determine whether transfers are allowed or disallowed depending on the type of users (for example, residents vs nonresidents) or the purpose for the transfer (for example, investment in permitted sectors) or other conditions. These are rules-based CFMs. CFMs can then be described as a set of well-defined “if ... then ... else” instructions. These instructions can be coded as an algorithm in the design of CBDC, which would make the CFMs automatic. This note refers to such instructions as “smart CFMs.” For instance, consider a CFM that restricts residents’ investment abroad but allows payments for the purchase of goods and services. One algorithm that checks compliance of a transfer with the CFM could be to (1) check if the payer is resident (specific type of resident), (2) check if the counterpart of transfer is foreign, and if so, ask for more supporting documents (for example, customs information, receipt for the provision of services), and (3) check supporting documentation. If it meets the requirements; the transfer can go through; if not, it will be blocked.<sup>11</sup>

Algorithms could also be written to represent discretionary CFMs, that is, those CFMs that require the discretionary decision of an authority to approve the transaction. The algorithm would initially check whether the transfer falls under the description of the discretionary CFMs. Then one option is for the algorithm to stop and ask for the direct intervention of the authority, for instance, through a web interface, before continuing with the transaction. Alternatively, the sender could ask for an authorization from the authority before the transaction is inserted in the payment system and input this authorization as supporting document to the transaction.

Central banks are already using programmability to control domestic flows of CBDC. Several central banks have either launched or piloted CBDCs that have digital wallets with different caps on how much CBDC can be stored in them and how many transactions can be made within a specific period. The purpose is to ensure that use of the CBDC does not reach a level that could disintermediate banks or lead to unmanageable outflow of bank deposits. Such programmability at the interface level, in this case the digital wallet, can also be applied to cross-border transactions, which would essentially be a form of smart CFM. For instance, if a central bank intends to limit access to its CBDC in specific countries, restrictions on the location where the CBDC is used can be implemented by coding geofencing into the user interface (Box 1).<sup>12</sup> Since geofencing would be applied only to nonresidents, the CBDC could still be used for transactions in the home country, even when its residents are travelling abroad.

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<sup>11</sup>The algorithm for other CFMs could be similar but with additional steps. For instance, consider CFMs that prescribe taxes to be paid on foreign transfers. The steps could be (1) check if payer is resident (specific type of resident), (2) check if counterpart of transfer is foreign, if so, (3) ask for purpose of the transfer (for example, transfer of dividends), (4) if the transfer is subject to taxation then either check documentation that the tax applicable has been paid or reduce automatically the foreign transfer by the tax amount and transfer the proceeds to the tax authority.

<sup>12</sup>Technically, the central bank could also implement a more granular access to its CBDC, for instance by allowing access to only selected foreigners (for example, importers) for specific transaction purposes. The access to CBDC by foreign businesses could incentivize the use of local currency for some international transactions.

### Box 1. Geofencing CBDC

Various methods and technologies could be used to control the geographical use of a CBDC by nonresidents. Geographical control can be implemented at the interface level or by the authorized service providers. Existing solutions rely on internet protocol (IP) addresses, global positioning system (GPS) location, or the connectivity provider (telecommunications or internet service provider) to identify the location of a device.

However, these methods can be easily evaded via usage of various applications and commercial services that modify an IP address or a GPS location. Stronger solutions can be adopted to identify the exact location of a device by triangulation. Mobile phone antennas provide such localization, as do decentralized protocols using nearby information or devices.

A trade-off will need to be considered, depending on the CBDC scheme and policy priorities, to determine which measures, alone or combined, might be necessary to control the use within or outside of the jurisdiction's borders by nonresidents.

One important distinction is between programmable payments and programmable money. While the former involves setting conditionalities on payments, the latter implies setting conditionalities on the money itself. This could be the case if a specific digital token is “earmarked” to be used in one or more predetermined ways. Programmable money could create limits in the fungibility property of money, that is, that all money can be equally used for all purchases. The application of smart CFMs requires programmability on payments, not on money.

This section first presents a brief overview of the channels through which a CBDC could be used to acquire foreign assets.<sup>13</sup> It then explores the different technological options in the CBDC ecosystem for CFM implementation and the way the information needed could be collected and stored. Finally, it analyzes which technological options could be more fruitfully used to implement CFMs depending on the characteristics of CFMs. To ground the analysis, two main cases are considered. The first case is one in which a domestic CBDC can be used to acquire foreign assets; this approach would require a domestic authority to design its CBDC ecosystem so that the country's CFMs can be implemented. The second case is one in which a foreign CBDC can be accessed by domestic entities, and the domestic authority needs to implement control on capital flow to and from this foreign CBDC.

### Modalities of Foreign Assets Acquisition through CBDC

Generally, a domestic entity could use a domestic CBDC to acquire foreign assets through at least three channels. The first is through correspondent banking: a domestic entity would transfer its CBDC to a domestic bank, buy foreign exchange from it, and transfer it through correspondent banking to acquire foreign assets. The second channel is directly through a foreign entity, if the domestic CBDC can be accessed and held by foreign entities. In this case the domestic entity would transfer the domestic CBDC

<sup>13</sup>*Foreign assets* in this note mean any sort of assets denominated in a foreign currency, issued by nonresidents, and originated abroad. This also includes foreign exchange, usually deposits denominated in foreign currency with offshore foreign banks.



to a foreign entity in exchange for the foreign asset.<sup>14</sup> The third channel is through multilateral cross-border platforms:<sup>15</sup> the domestic CBDC would be connected to a foreign payment system and intermediaries through a cross-border platform, and via the platform the domestic entity could obtain foreign assets. Implementing CFMs on the domestic CBDC would allow enforcement through all these channels and against all currencies.

Conversely, there are at least three channels to acquire foreign assets using a foreign CBDC. The first channel is through domestic banks and licensed domestic digital wallets if they have access to the foreign CBDC. The domestic entity would need to make a transfer from its domestic bank to the digital wallet that can hold the foreign CBDC. The second channel is through correspondent banking, if the foreign CBDC can be accessed only from the foreign payment system. The domestic entity buying the foreign CBDC would first go through the correspondent banking system before acquiring the foreign CBDC likely for foreign exchange. The third channel is again through multilateral cross-border platforms. Implementing CFMs on the foreign CBDC would enforce CFMs on that currency only and thus can suffer from scalability issues (see more in the discussion that follows).

### Implementation Levels in the CBDC Ecosystem

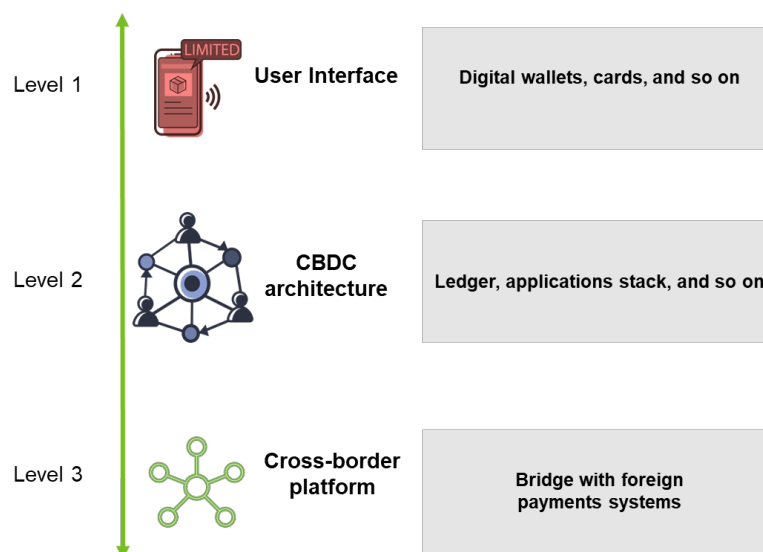
Smart CFMs can be implemented broadly on three levels of the CBDC technology ecosystem (Figure 2). The central bank can mandate providers of the payment interfaces to implement CFMs at level 1, typically the digital wallet interface. The central bank can implement CFMs directly at level 2, which is the CBDC architecture level. Finally, the central bank can coordinate with other central banks to implement CFMs on a cross-border platform that connects the CBDC rails, or payment systems, of different countries at level 3. Each level is explored in turn.

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<sup>14</sup>Foreign exchange regulations may require that foreign assets in the form of foreign exchange are purchased only from intermediaries (banks or exchange bureaus).

<sup>15</sup>See Adrian and Mancini Griffoli (2023), Adrian and others (2022), and the Project mBridge ([Bank for International Settlements Innovation Hub 2022](#)).

Figure 2. The Three Levels for Implementing CFMs in the CBDC Ecosystem



Source: Authors' analysis.

Note: CBDC: Central Bank Digital Currency

The first level is the interface with which end users interact to make CBDC transfers or to check holdings. The most common form of interface is a digital wallet, but other examples include smart cards, traditional web interfaces, or smart wearables such as watches. User interfaces in a two-tiered CBDC system are typically provided and maintained by payment services providers.<sup>16</sup> The interface providers could be responsible for creating and maintaining the code for implementing CFM, following the requirements of the central bank. The central bank should also have the capacity to oversee the smart CFMs and ensure compliance with the country's foreign exchange law.<sup>17</sup> Alternatively, the central bank could build and provide the user interface directly or through a third-party company. In all cases, smart CFMs could be implemented by forcing every transaction to pass through an algorithm that will verify that certain conditions defined by CFMs are met.

The second level is the domestic technological architecture of the CBDC under the control of the central bank. The technological architecture typically includes the ledger and the application stack required for the system to work, including applications providing services to and from the ledger to authorized entities. The central bank should always have complete control over this layer, even when the technology or the code is provided by a third-party company. Smart CFMs could be programmed into this

<sup>16</sup>In a two-tiered CBDC system the central bank issues the CBDC and manages the CBDC architecture, and the private sector builds the user interface and is responsible for onboarding checks. See also Soderberg and others (2023).

<sup>17</sup>Foreign exchange laws may need to be amended to allow for the implementation of CFMs through the various levels of the CBDC ecosystem.

level by the central bank, either directly or through the vendor.<sup>18</sup> Also in this case transactions could be forced to pass through an algorithm that verifies that CFM requirements are met.<sup>19</sup>

Finally, the third level is that of the cross-border platform. In the case of wholesale CBDC built specifically for cross-border purposes, the cross-border platform and the CBDC architecture level might coincide. Smart CFMs could be applied on the platform, provided its governance allows for it. The platform would automatically execute the smart CFMs for any transaction originating from the country issuing the CBDC, ensuring full compliance. The coding of smart CFMs would be done by the platform operator, by the central bank, or by a licensed third party, if allowed by the platform's governance.

### Collection of Information for CFMs

As discussed, CFMs require information on several attributes of capital flows, such as transaction purpose and cumulative amounts over a period of time. How to collect and store such data will depend on the modality of smart CFM implementation and on the type of CFMs.

If the CFMs are applied at the user interface level, required information can be used directly by the code implementing the smart CFMs. Otherwise, such information would need to be passed to other levels enforcing the CFMs, if national data protection and privacy laws allow. The data could also be collected directly by the central bank, for instance via a web interface. In this case, a unique identifier of a cross-border transfer could be associated with a request for the necessary information via the web interface.

Digitalization of supporting documentation could be done through digital scanning and optical character recognition software. This would allow an algorithm implementing the CFMs to cross-check that key information in the supporting documents (for example, amount, destination, and nature of the goods) are the same as those included in the transfer. However, in the long run, standards for creating native digital documents, and also for checking their truthfulness, would be advisable.<sup>20</sup>

Information related to other attributes of capital flows, such as past transfers, might be collected for each single transaction or stored and accessed in a central database. In the latter case, the central database would need to have information on cross-border flows going through different rails so that a comprehensive and up-to-date data set of cumulative flows and other necessary information by entity is available.

Efficiency considerations suggest the required information be collected at the same level at which CFMs are implemented. Indeed, the passage of information between different levels could constitute a loss of efficiency. However, there can be several instances in which deviation from this principle could be beneficial. One instance is when required information is collected and stored domestically, even if CFMs are implemented at the cross-border platform level. This is because collecting and storing such information domestically may be required for compliance with national data protection and privacy laws.

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<sup>18</sup>The central bank can assign to some actors in the CBDC ecosystem specific roles and permissions, including the ability to add their own code. This allows the possibility for the central bank to dictate a participant in the system, such as a payment service provider to program CFMs at this level.

<sup>19</sup>Note that these would be an algorithm on transactions, not on money (tokens) itself. The fungibility property of money would be maintained.

<sup>20</sup>In some countries, digital documents issued by the government are issued with a quick response (QR) code, which can allow the holder to check their authenticity online. Alternatively, if the CBDC is issued on a blockchain, the supporting documentation could be registered directly on the blockchain, which would allow for automatic checking of its truthfulness.

Another instance is when the amount of information needed for the CFMs is minimal. In the case of CFMs on flows, for example, it might be simpler to collect all information at the user interface level, even if the CFMs are enforced at the CBDC architecture level.

In the following discussion all information needed for the implementation of the smart CFMs is assumed to be available at the level at which the CFMs are implemented, irrespective of how it has been collected and stored.

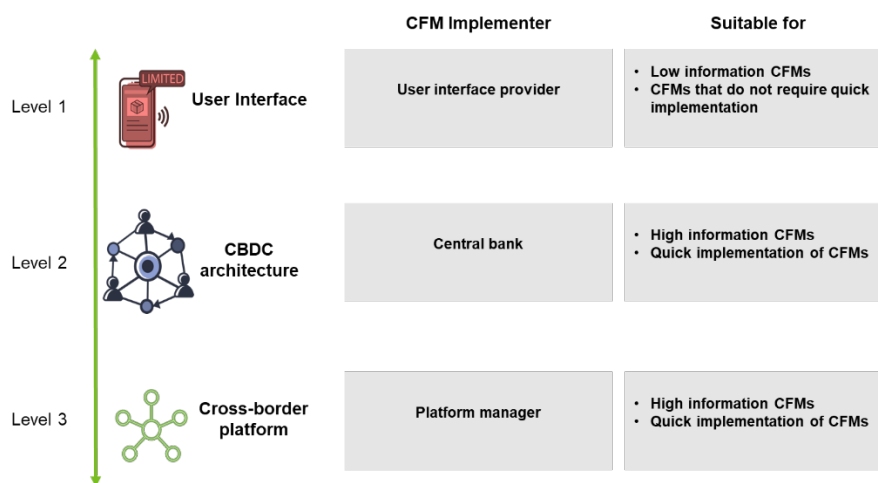
### CFMs and CBDC Implementation

Two main cases are explored: (1) a domestic CBDC used to initiate foreign assets transactions and (2) a foreign CBDC accessible by domestic entities.

### Domestic CBDC to Acquire Foreign Assets

The central bank faces the choice of where to implement CFMs within the CBDC ecosystem, that is, at which of the three levels defined in Figure 2. The framework defined in Section I is used to suggest the effective level of implementation given characteristics of CFMs. The discussion is summarized in Figure 3. The efficiency trade-offs between the three levels are then discussed.

Figure 3. CBDC Technological Levels and CFM Characteristics



Source: Authors' analysis.  
 Note: CBDC: Central Bank Digital Currency

When the central bank implements the CFMs directly at the CBDC architecture level, it takes responsibility for fulfilling the roles of both the designer and enforcer of CFMs. Importantly, this level would be preferable for CFMs that require a large amount of information and need quick implementation. The direct control on this level by the central bank would allow relatively faster implementation of CFMs if needed. At the same time the central bank is also where most of the required information will likely reside.

Typically the central bank is in the best position to host the database about stock information (for example, who has transferred which amounts in the past, meeting a holding period requirement).<sup>21</sup>

Applying CFMs at the user interface could work effectively for CFMs that require only basic information and for which rapid updates and implementation are not critical. Especially when a private company provides the user interface, it might not have the resources to implement CFMs in a very short time.<sup>22</sup> With respect to the amount of information, the user interface level would work well for CFMs on flows and certain transaction purpose CFMs because this information can likely be directly obtained from the user through the interface. Information on stocks needs to be aggregated with other information on flows through other channels, and this will instead likely reside outside of the user interface.

Benefits and drawbacks of implementing CFMs at the cross-border platform level are broadly similar to those at the CBDC architecture level, with some key specificities. Platforms have one key advantage: the CFMs applied on the platform would be implemented with respect to all foreign currencies participating in the platform. This advantage is particularly relevant when the domestic authorities are trying to limit access to foreign CBDC (see the next section). However, the ability of central banks to implement CFMs in multilateral platforms depends on the platforms' governance to establish the roles, procedures, and responsibilities for their implementation. Moreover, compliance with national laws on data use and storage must be ensured. For an application of CFMs on a cross-border platform, see Box 2.

The issue of efficiency should also be considered when choosing the proper level of implementation of CFMs. Implementing CFMs at the architecture level implies additional costs for the central bank because it needs to hire and maintain staff to develop, test, monitor, update, and deploy them in addition to maintaining the capacity and staff to design, implement, and enforce traditional CFMs.<sup>23</sup> The central bank might decide to bear all costs for CFMs or apply a cost-recovery strategy. These costs might be externalized if the CFMs are applied at the user interface level or at the cross-border platform level, although the central bank would still need to supervise the implementation, as it does with traditional CFMs, for which part of the cost of implementation is borne by intermediaries. The costs borne by private providers could then be transferred to the users for the service of cross-border transfers.

Overall, central banks will need to balance considerations of effectiveness and efficiency when determining their most appropriate level of implementation of CFMs with the domestic CBDC. Hybrid solutions are also possible: the central bank might have private providers implement some categories of CFMs, such as those with low information requirements and low macro-criticality, at the user interface level, while retaining direct control for time-critical and information-intensive CFMs at the CBDC architecture level.

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<sup>21</sup> To ensure quick implementation, the central bank might consider preprogramming macro-critical CFMs so that they can be deployed quickly.

<sup>22</sup> Normally, fast implementation of CFMs does not arise often. Keeping a large spare capacity for the private provider might not be economical.

<sup>23</sup> While implementing CFMs at any level requires additional resources for central banks, overall costs of implementing smart CFMs might be lower than with traditional CFMs. These considerations are explored in Sections III and IV.

## CFMs on Foreign CBDC

This section distinguishes between two cases: (1) when foreign CBDC can circulate in a recipient country and (2) when foreign CBDC cannot circulate domestically but can still be accessed by domestic entities.

### *Foreign CBDC Can Circulate in a Recipient Country*

When a foreign CBDC can circulate in a recipient country, the domestic authorities have limited opportunities to implement and enforce the country's CFMs on the foreign CBDC. Still, implementation could be attempted through digital wallet providers operating in the country and through cooperation with the foreign central bank issuing the CBDC.

For the foreign CBDC to circulate domestically, domestic entities need to have access to a digital wallet that can hold the foreign CBDC. In general, the provision of means of payments would be subject to licensing and supervision by the domestic central bank. As such, the issuer of the digital wallet would also be subject to licensing and supervision. The central bank could then require applying the CFMs at the user interface level. If instead the provider of the digital wallet is not regulated and supervised by the domestic authority, then the domestic central bank will need to seek the assistance of the foreign regulator of the digital wallets to request the implementation of CFMs.

CFMs could also be directly implemented on the foreign CBDC architecture level. This channel requires strong trust and cooperation with the foreign authorities. First the foreign CBDC architecture must be designed such that CFMs of other countries can be implemented on cross-border flows. This requires information collection on the identity and purposes or stock information of nonresident users. The collection and sharing of such information can be done only by complying with both countries' data-sharing laws. Second, the foreign central bank must be willing to take the request of the domestic central bank into account and be willing to implement or change CFMs—and potentially to do so swiftly at the request of the domestic central bank. Importantly, the requesting central bank must be able to oversee, or verify ex-post, that the foreign central bank's implementation of CFMs respects the domestic foreign exchange law.

The willingness of the foreign central bank to cooperate depends on many considerations. The willingness to cooperate will likely be stronger if both countries benefit from more stable capital flows between them. Thus, a common understanding of the macrofinancial risks would be helpful. Also, since the foreign central banks will have to bear the costs for the implementation of CFMs, an agreement may be needed to specify how the central banks could share these costs.

In addition to the issues of trust and cooperation between central banks, this approach could lead to scalability issues: setting up CFMs for more than one foreign CBDC could be very costly for the central bank issuing the CBDC and can increase the complexity of the CBDC ecosystem to a level that may not be acceptable for the issuer. Also, the domestic central bank would need to manage the relations with several foreign central banks and check the implementation of its CFMs on several foreign CBDCs.

### *Foreign CBDC Cannot Circulate Domestically but Can Still Be Accessed by Domestic Entities*

If the foreign CBDC cannot circulate domestically but can still be accessed and held by domestic service providers, there are, broadly, three options to implement CFMs. The first is through the foreign CBDC-issuing central bank, as discussed previously. The second option is for the domestic authorities to leverage traditional CFMs. The controls can be imposed on the on-ramp access to the digital wallets or off-ramp when the proceeds from foreign CBDC transactions are collected and converted into local

currency, through domestic financial intermediaries. The challenges and potential solutions in these circumstances are akin to the implementation of CFMs on crypto assets, in which case enforcement of CFMs could be limited (He and others 2022).

The third option is through a multilateral cross-border platform. One key advantage would arise. CFMs on the platform could be applied with respect to all foreign CBDCs (or foreign payment systems) connected through the platform, without the need for bilateral agreements with the foreign central banks. The domestic laws and the governance of the platform, however, must allow for the implementation of CFMs, as discussed previously.

## Box 2. Project Inthanon-LionRock: Implementing CFMs on a Cross-Border Wholesale CBDC\*

Project Inthanon-LionRock is a joint initiative between the Bank of Thailand and the Hong Kong Monetary Authority to explore the use of distributed ledger technology and wholesale CBDC for cross-border transfers (Bank of Thailand and Hong Kong Monetary Authority 2020). Conducted in 2019, the project developed a proof-of-concept “corridor network,” acting as a bridge to connect the domestic wholesale CBDC payment networks of Thailand and Hong Kong, allowing for funds transfers to occur instantaneously on a peer-to-peer basis between participating banks of the two jurisdictions. The corridor also allowed for foreign exchange price discovery, on-demand foreign exchange conversion, atomic payment-versus-payment foreign exchange settlements, and liquidity management. Regulatory monitoring and compliance features were implemented where feasible.

The proof of concept took into consideration a CFM imposed by the Bank of Thailand on the daily outstanding balance limit on Thai baht (THB) accounts held by nonresident entities. At the time Project Inthanon-LionRock was conducted, nonresidents were prohibited from having an aggregated outstanding balance of 200 million THB across all accounts held with banks in Thailand at the end of each day. If this limit is breached, the domestic bank must notify the nonresident to sell their excess THB at an exchange rate specified by the Bank of Thailand, akin to a penalty.

To ensure compliance with this rule, two features were included on the corridor network, at the user interface level and at the cross-border platform level. First, Hong Kong banks’ outstanding THB balance in the corridor, as well as off-corridor THB held with banks in Thailand, were aggregated. Any off-corridor THB would be recorded in the system daily, and the system would automatically aggregate the on-corridor THB and off-corridor THB amounts. If the total exceeds 200 million THB, the amount would be flagged in red on the user interface. This surveillance mechanism allowed nonresident banks to monitor and manage their THB balances efficiently.

Additionally, an automated reduction mechanism was programmed into the architecture level. At the end of each day, the system was designed to automatically reduce the THB balance Hong Kong banks held on the corridor if their aggregated THB holdings exceeded 200 million by selling the excess THB amount to the operator node at a specified exchange rate.

The achievements of Project Inthanon-LionRock demonstrated the ability to embed CFMs into a cross-border CBDC platform, albeit with some limitations. An exemption to Thailand’s CFM exists where nonresidents are permitted to have an outstanding balance exceeding 200 million THB if funds are to be used for trade or investment in Thailand on the next business day. The proof of concept did not take into consideration nuanced exemptions such as this and several others. The project team noted in its report that it may be necessary to modify the design of the corridor model to fully comply with existing regulations, which could result in a trade-off between efficiency and regulatory compliance. Alternatively, if the goal is to fully harness the capabilities of distributed ledger technology for cross-border transactions, monitoring approaches would need to be revised or CFMs would need to be amended to better accommodate the dynamic nature of transactions within the corridor.

\* Prepared by Tayo Koonprasert.



### III. Can CBDC Improve CFM Implementation?

**CBDC can leverage technology to lower costs associated with conducting CFMs.** Traditional CFMs are usually handled manually by staff at financial intermediaries involved in cross-border transfers. New technology, incorporated from the outset in CBDC design, holds the promise of automating and increasing the efficiency of the information processing involved in CFMs. Smart CFMs can be more efficient than traditional CFMs for several reasons.

A key enabling factor involves the availability of digitalized information to be used by smart CFMs. Such digital information relevant for cross-border transfers includes goods type, purpose of transaction, and balance sheet information. The information will need to be stored and protected in central repositories, either at the central bank or through private operators, and accessed when needed, for example, for the implementation of CFMs but also for overseeing and checking compliance by the foreign exchange authority. Digitalization will lead to more comprehensive and efficient information collection, as well as more effective storage and use of information for CFM needs. Incidentally, the collection of digital information and its central storage could, when not already present, also help the efficiency of traditional CFMs.<sup>24</sup>

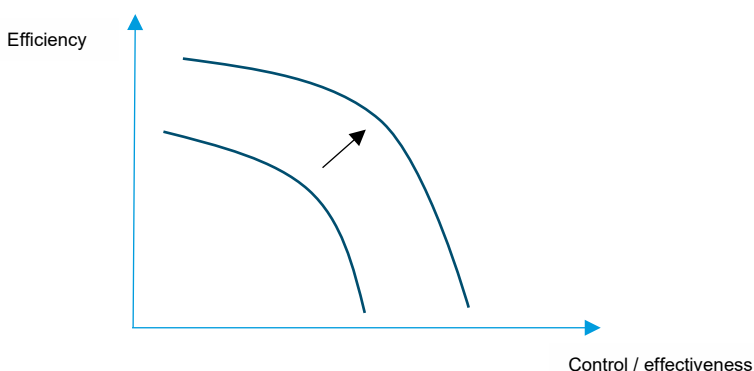
Second, in contrast to traditional CFMs, the central bank can build the controls directly within the CBDC system. While fixed costs of implementing CFMs might be higher due to needed software development and maintenance, total costs of enforcement for central banks could decrease, as there would be reduced costs for ex-post supervision. Also, by having direct control over the system the central bank can better monitor capital flows in real time, which can lead to the triggering of CFMs only if aggregate flows reach a certain threshold.

Finally, automation of processes could reduce the scope of interpretation by financial intermediaries, as well as manual and human errors. This would decrease the regulatory burden, risks, and costs on financial intermediaries, leading to increased compliance.

These elements could, in theory, lower costs (increased efficiency) and increase effectiveness (better control) of smart CFMs as compared to traditional CFMs, which face important implementation challenges (Box 3). This can be stylistically displayed as an outward shift of the possibility frontier over the trade-off between efficiency and control (Figure 4). However, smart CFMs cannot be expected to overcome institutional weaknesses that fundamentally undermine the effectiveness of CFM implementation.

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<sup>24</sup>Additionally, private financial intermediaries could also start performing digital checks on CFMs. While this would improve efficiency of traditional CFMs, it would probably be less efficient than a centralized approach implemented by the central bank. The central bank would still need significant resources for ex-post supervision, and the differentiated approach might lead to inconsistencies.

**Figure 4. Technological Frontier for Smart CFMs**

Source: Authors' analysis.

Note: The bold lines represent the technological frontier between efficiency and control. The arrow represents the potential shifting of the frontier with Smart CFMs.

It must be added that, even if smart CFMs will enable higher efficiency and better control, costs for the central bank might increase in the short term because smart and traditional CFMs will co-exist for a time. In the long run, one possibility is that domestic entities would increasingly use the CBDC system for international transfers if the costs of doing so are lower than in the traditional system. This situation could arise if the costs of implementing CFMs are lower because the CBDC system has already been designed with smart CFMs. In that case, while the two rails would likely continue to exist in parallel, larger volumes would go through the CBDC-based system, mostly because of cost efficiency. Eventually, the costs for keeping traditional CFMs in place could decrease, leading to lower overall costs of implementation of CFMs.

### Box 3. Imperfect Implementation of Traditional CFMs

Enforcement challenges are common in the use of traditional CFMs. This problem may reflect a host of issues including lack of experience with enforcing such measures; limitations regarding legal powers, data collection, and verification processes; and monitoring and supervision of capital flows. Corruption, limited credibility, and poor communication may also play an important role. Smart CFMs may assist with easing some of these enforcement challenges.

Countries with limited experience with using CFMs generally face greater challenges and may need more time to prepare for their introduction. This can be particularly challenging if comprehensive outflow CFMs need to be introduced swiftly in the context of a (imminent) crisis. On the other hand, countries with long-standing CFMs tend to have much of the needed infrastructure in place and can more easily introduce and enforce new CFMs. That being said, countries with long-standing CFMs may also face chronic challenges in implementation.

Legal powers to use CFMs need to be accompanied by powers to collect information, ensure enforcement, and sanction noncompliance. This is not always the case; in particular, powers to collect information from other than authorized dealers or to sanction their noncompliance may be weak. For enforcement of traditional CFMs to work, adequate verification processes need to be in place, typically with authorized dealers playing a key role in checking whether each transaction should be authorized based on the existing CFMs. The foreign exchange authority, typically the central bank, also needs to have the capacity to monitor such verification processes, collect information from them in an efficient manner, and thereby monitor and analyze capital flows in a timely manner and identify and close loopholes that may arise. Enforcement challenges can therefore arise at the verification stage if authorized dealers are not effective or at the supervision and monitoring stage where capacity at the central bank is weak or interagency cooperation challenges are present (for example, between central banks and custom authorities). Corruption can facilitate circumvention of CFMs and undermine their effectiveness. Similarly, poorly communicated CFMs may leave room for interpretation and cause uneven enforcement across the economy, and lack of credibility of central banks may fuel circumvention.

Smart CFMs may help countries overcome some of these challenges with transactions that go through CBDCs rather than traditional routes. Smart CFMs are an integral part of the CBDC design, and many aspects of their enforcement can be built into the process. As a result, transactions can be more efficiently verified and monitored and their associated information can be collected more efficiently, which could foster more effective supervision and use of CFMs. Also, smart CFMs provide greater scope for composability, where several actions are brought together into one executable package, and actions can be made contingent on fulfilling certain conditions (that is, the CFMs). That being said, some countries have efficient processes in place for traditional CFMs, including a high degree of automatization and sophisticated information collection systems, whereas in other countries transactions are delayed to complete the verification process, a step which increases the cost of using traditional CFMs.

## IV. Risks and Complexities

**CFMs through CBDC could pose several risks, and complexities may also arise.** Some have been mentioned throughout the text, and this section provides a more systematic treatment.

### Coexistence with Other Rails for Cross-Border Payments

A cross-border system based on CBDC would constitute a new rail for international transfers, complementing the traditional correspondent banking system. Importantly, traditional CFMs will continue to exist as long as traditional payment channels exist. The implementations of CFMs on these two channels need to be working seamlessly to avoid loopholes. For instance, for CFMs on stocks, information on the amount of foreign exchange acquired through the different rails needs to be accessible to all agents involved in the implementation of CFMs, including the private intermediaries enforcing traditional CFMs. This information will need to be shared with those implementing CFMs on crypto assets as well, if CFMs are imposed on crypto transactions.

CFMs should be applied consistently in their digital and traditional forms. Some change in the design of CFMs might be needed. In fact, the implementation of smart CFMs might require some streamlining of CFMs, if these are not particularly suitable for an algorithmic representation. In particular, a switch from discretionary CFMs to rules-based CFMs as much as is feasible might be necessary to reap the full benefits of digital implementation and automation.<sup>25</sup> In any case, faster cross-border payments might require changes in CFM design independently of how the CBDC landscape evolves. For instance, CFMs that are based on overnight restrictions (see Box 2) might not be well suited for a payment system that is intended to work 24/7. The change in the design of CFMs might imply a loss of control for some type of transfers; however, the loss might be offset by more efficient control of flows in the aggregate through both traditional and digital CFMs. Policymakers will need to carefully evaluate this trade-off.

### Issues Related to Cooperation between Jurisdictions

Appropriate management of capital flows with CBDC would be greatly facilitated by cooperation between jurisdictions, as explored in Section II. However, jurisdictions issuing a CBDC might be unwilling or unable to cooperate in ensuring that CFMs of a foreign country are enabled. A jurisdiction might desire its CBDC to circulate outside of its jurisdiction, for instance, to strengthen its balance of payment or to support its exchange rate. It might also have little interest in devoting resources to implementing CFMs of other individual jurisdictions. Hence, countries might find themselves in a position in which a foreign CBDC is made accessible by the issuer to its residents, without the possibility to implement CFMs on the foreign CBDC or its user interface providers. The country would then need to consider its policy options to implement CFMs. One option would be to exploit the on-ramp and off-ramp access through financial intermediaries relying on traditional CFMs. These would apply whenever there is a conversion between the local currency and the foreign CBDC. Another option would be to consider how it can block or

<sup>25</sup> A shift to more rule based-CFMs would increase transparency and predictability but, on the other hand, it might result in more rudimentary CFMs restrictions and thus be more distortionary than needed.

severely restrict its residents from accessing the foreign CBDC. These challenges are similar to those with a crypto asset (He and others 2022), even though risks from the domestic circulation of crypto assets might not be the same as risks from the domestic circulation of foreign CBDC.

While options are available for recipient countries to unilaterally limit the use of foreign CBDCs within their jurisdiction, none is completely effective. Countries can regulate payment service providers and financial institutions within their jurisdiction, impose restrictions, or even ban these institutions from providing access to specific CBDCs. But restricting access to digital interfaces might be more challenging, given that such applications may be available across borders.<sup>26</sup>

Policymakers also need to balance the macroeconomic trade-offs of allowing a foreign currency to circulate domestically. While outright bans may be suboptimal, if residents could derive benefits from the use of the foreign CBDC in a controlled manner,<sup>27</sup> the unrestricted domestic circulation of foreign CBDC could lead to currency substitution (IMF 2020).

### Managing Risks and Trade-offs Arising from CBDC and CFMs

The implementation of CFMs with CBDC raises trade-offs. Adoption of CBDC, either for domestic or for cross-border payments, cannot be taken for granted. Potential users will have to find its design features attractive and useful. If CFMs introduce limits and constraints, it could reduce the overall attractiveness to use CBDC. In addition, some central banks might not want to introduce programmable functionalities into the CBDC architecture, worrying that such functionalities may impede the universality of currency. Alternatives without such constraints, for instance, potentially unregulated crypto assets, could be seen as more attractive to some users. This could undermine the implementation of CFMs in the first place, by pushing users toward alternative means of cross-border payments.

Some trade-offs are similar to those implied by traditional CFMs. As traditional CFMs increase the burden on financial intermediaries, smart CFMs increase the burden on private firms in the CBDC ecosystem. If smart CFMs are implemented at the user-interface level, the regulatory burden for some private firms will increase, especially if they need to continue to implement, and bear the cost of, traditional CFMs. Moreover, if the private entities themselves—for instance the digital wallet providers—are responsible for programming extensive CFMs, the demand on resources might not be negligible. The costs will be relatively higher for smaller financial intermediaries, like small banks or payment service providers. Such increased costs could raise barriers of entry for new potential interface providers, which could hamper competition on the CBDC payment market. There could thus be a policy trade-off between the goals of reducing risks from capital flow volatility and improving competition in the domestic payments system.

Privacy concerns of citizens could also lead to a policy trade-off. Privacy in the digital age can be a policy goal that a central bank wants to promote in the context of issuing CBDC. Using CBDC for domestic transactions requires information on the payer and the payee as part of standard checks for anti-money laundering/combating the financing of terrorism. However, the implementation of CFMs in

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<sup>26</sup> The central bank can work with local authorities to require the smartphone system providers to remove the software from the domestic official app store. However, such apps might also be available through unofficial channels.

<sup>27</sup> For example, in many countries with CFMs, residents or certain groups of residents are allowed to keep foreign exchange in accounts with local banks.

cross-border transactions may require information beyond what is required for purposes of anti-money laundering/combating the financing of terrorism. Information stored in data repositories owned by the central bank or financial intermediaries could become easier to access and cross-reference, potentially impinging on privacy in the absence of proper privacy protection rules. If CFM controls are perceived to be overly intrusive on privacy, users may opt out of using the CBDC for cross-border transfers. This could push usage toward less regulated alternatives. Privacy-preserving technologies, such as zero-knowledge proofs, could potentially improve the trade-off, provided they allow transparency to regulators under certain conditions specified by law.

### Capacity Requirements for Central Banks

Smart CFMs would in general require an expansion of capacity for central banks. Central banks would need to build the necessary know-how and capacity to deploy, or oversee, smart CFMs as they do with traditional CFMs. They will also need the capacity to monitor the real-time data generated by the CBDC, especially if there is a plan to link the implementation of CFMs to real-time data on flows. Capacity must be commensurate to the need for quick implementation of CFMs, if needed. Capacity requirements might be more challenging for central banks in emerging markets and developing economies because knowledge of the new technologies needed for smart CFMs might not be widespread yet and these countries' CFMs may not be adaptable enough to benefit from the automated implementation of smart CFMs.

### Operational Risks

Many challenges can arise from embedding CFMs in CBDC design. Operational risks with smart CFMs could add complexity to the risk management of the CBDC. Smart CFMs reduce the risks linked to human interventions, including slow processes, inability to scale, and human mistakes. However, several challenges need to be mitigated in the design and the governance of smart CFMs, including the management of outages, cyber resilience, technology obsolescence, and increasing the complexity of the design of CBDC systems themselves. Since smart CFMs are self-executing, particular care should be devoted to managing programming or logic errors. If CFMs are not well suited to algorithmic representation, loopholes in capital flows can emerge and unintentional blocking of transactions can occur. The digitalization of supporting documentation might also create operational risks, if documents are not recognized by the system.<sup>28</sup> A central database with the information needed for CFMs might be exposed to cyberattacks. If any of the technologies is provided by third-party providers, the roles and responsibilities of each party need to be clearly defined. These risks, which are common to any digital solution, could lead to the network's complete inability to process some or all payments until the problem is resolved. Contingency plans for pitfalls in the implementation and execution of smart CFMs need to be prepared, reviewed, and tested regularly.

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<sup>28</sup>At least two possibilities could arise: (1) valid documents may not be recognized by the system, for instance, because they were provided by the issuing entity in a format that is not accepted by the system; and (2) some special cases that could not be predicted at the algorithm design stage prevent users from producing the complete required documentation, effectively excluding users from service.

## Conclusion

Many IMF member countries rely on CFMs to limit risks arising from sudden and volatile capital flows. The IMF's Institutional View considers the introduction of CFMs to be appropriate only under certain circumstances and only if they do not substitute for warranted macroeconomic adjustment. It also acknowledges that the liberalization of the financial account is not an appropriate goal for all countries at all times and the removal of especially long-standing CFMs should be carefully planned and sequenced with the macroeconomic and financial preconditions. While remaining neutral on the need or usefulness of CFMs, this Fintech note analyzed the possibility of implementing CFMs on a CBDC. The analysis shows that, by exploiting automation and digitalization of information, CFMs can be implemented within a CBDC ecosystem at different levels. Depending on the design, such smart CFMs could also potentially improve the efficiency and effectiveness of CFM implementation.

This work is the first one to tackle the possibility of embedding CFMs in CBDC design. Future work will need to explore different aspects of smart CFMs, including an understanding of the trade-offs between making CFMs more programmable and their ability to restrict the targeted flows efficiently without resulting in more distortion than traditional CFMs. There are important legal questions, too: Will the legal framework need to be changed if the central bank is in charge of programming smart CFMs? What happens if smart CFMs written by the user interface providers are incorrect? What roles and responsibilities should each party have? Additionally, the mechanics of the implementation needs to be further studied. How exactly does an algorithm implementing CFMs need to be written? Could smart CFMs be preprogrammed to ensure quick implementation when needed? How can central banks cooperate to ensure the implementation of CFMs on a foreign CBDC? These are some of the questions that will need to be resolved for CBDC projects in those central banks interested in implementing CFMs.

The development of CFMs in the digital age could also go beyond CBDC and be considered together with tokenized assets. In a tokenized financial system, information can be attached to the token itself. Such information could pertain to the attributes of capital flows needed for CFMs. How would CFMs be implemented with tokenized assets? The question raises interesting possibilities, as the focus shifts from the "cash" leg of cross-border transfers to the "asset" leg. As a first possibility, it could widen the scope of applications of CFMs so that they could be enforced more efficiently and at faster speed. These topics are left for future research.

## Annex I: Overview of CFMs

### Definition of CFMs

CFMs are measures that are designed to limit capital flows. They may encompass a wide range of diverse measures (including taxes and regulations) that often have country-specific characteristics reflecting countries' institutional arrangements, level of economic development, and exposure to capital flow volatility. CFMs comprise (1) residency-based measures (often referred to as capital controls), which affect cross-border financial activity and discriminate based on the residency of transacting parties (that is, between residents and nonresidents) and (2) other CFMs, which do not discriminate by residency but are nonetheless designed to limit capital flows based on an evaluation of the context in which they were introduced and the totality of the country-specific circumstances. This definition of CFMs is set out in the IMF's Institutional View on the Liberalization and Management of Capital Flows (IMF 2012, 2022).<sup>29</sup> Under the IMF's Articles of Agreement, countries have broad freedom to regulate international capital movements, with a few exceptions.<sup>30</sup> Additionally, the IMF may request a country to impose CFMs pursuant to Article VI of the Articles of Agreement.

### The Role of CFMs

There has been a broad-based gradual tendency for countries to become more financially open in recent decades. As a result, CFMs have in many instances been relaxed or removed (referred to as capital flow liberalization in the Institutional View). The Institutional View provides guidance on the removal of CFMs, that is, capital flow liberalization, and stresses that it needs to be well planned, timed, and sequenced, especially to ensure that its benefits outweigh the costs. It notes that the degree of liberalization that is appropriate for a country at a given time depends on its specific circumstances, notably its financial and institutional development; the Institutional View also stresses that there is no presumption that full liberalization of capital flows is an appropriate goal for all countries at all times (IMF 2012, 2022).

The Institutional View recognizes that CFMs are part of the policy toolkit, and that they may be useful in certain circumstances, but emphasizes that they should not substitute for warranted macroeconomic adjustment. CFMs may be useful during excessive capital flow episodes (that is, capital inflow surges or crisis-related disruptive outflows) in which macroeconomic or financial stability is threatened and the space to address the risks with conventional policies is constrained. CFM may also be useful outside of such excessive capital flow episodes if stock vulnerabilities (for example, currency mismatches) have built up as a result of capital inflows and they cannot effectively be addressed with conventional policies.

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<sup>29</sup>CFMs are sometimes categorized based on whether they take the form of "administrative" (or direct controls) or "market-based" (or indirect measures). Administrative or direct controls usually involve either outright prohibitions on, or an (often discretionary or somewhat rule-based) approval procedure for certain cross-border capital transactions. Indirect or market-based controls typically discourage capital movements and the associated transactions by making them more costly and may take the form of taxation of cross-border financial flows (for example, a Tobin tax or unremunerated reserve requirements), but these controls may also take other forms.

<sup>30</sup>See Article VI, Section 3 of the IMF's Articles of Agreement; also see discussion of the IMF's legal framework in IMF (2012).



## Implementation of CFMs

The IMF maintains a [taxonomy of CFMs](#) of macro-critical policy measures assessed as CFMs and referred to in published IMF staff reports as they have been introduced or adjusted since the adoption of the Institutional View.

CFMs are often applied at the aggregate or sectoral level. This reflects that the challenges stemming from large and volatile capital flows can either be broad based or sectoral, but in both instances the capacity of macroeconomic or financial sector policies to address the associated risk may be constrained, and CFMs can play a useful role.

CFMs can also be deployed on a structural basis or only temporarily (that is, wall versus gates) and can be applied separately to inflows and outflows. For instance, CFMs have been applied to inflows to minimize speculative bubbles in sectors or applied to outflows in (imminent) crisis circumstances to preserve reserves and attenuate exchange rate pressures and spillovers to the financial system, while appropriate macroeconomic adjustments are undertaken.

Compliance with stipulated CFMs typically requires that regulated financial intermediaries verify transactions and identities of the parties to the transaction. The process typically starts with the issuance of regulations that specify the controlled transactions. Regulated financial agents—such as commercial banks that facilitate the payments and transfers, exchange bureaus selling foreign exchange for travel purposes, brokers, and security dealers—then ensure that only transactions permitted by regulations take place. The central bank can verify compliance by the regulated entities with applicable laws and regulations through off-site monitoring and on-site inspections.

The verification process varies with the nature of the CFM being enforced. The process could include checking or registering counterparties and the purpose of the foreign exchange purchase or sale; proving that the foreign exchange was purchased for the stated purposes; enforcing limits set by the foreign exchange regulations; and verifying that authorization from the authorities was obtained. The process may stipulate documentation needed to prove that the foreign exchange purchased or transferred is for the stated purpose and in the stated amount.

## Current Trends and Practices

CFMs remain prevalent among IMF member countries, albeit on a reduced scale and scope. Based on the Financial Account Restrictiveness Index<sup>31</sup> more than 90 percent of IMF member countries had some CFMs in place at the end of October 2021, although almost half had only a very limited number of CFMs, and only 21 countries had exchange control regimes that restricted the financial account transactions fully or partially. The intensity of restrictions is higher in low-income and developing economies followed by emerging market economies, while advanced economies have largely liberalized their capital accounts (Annex Figure 1).

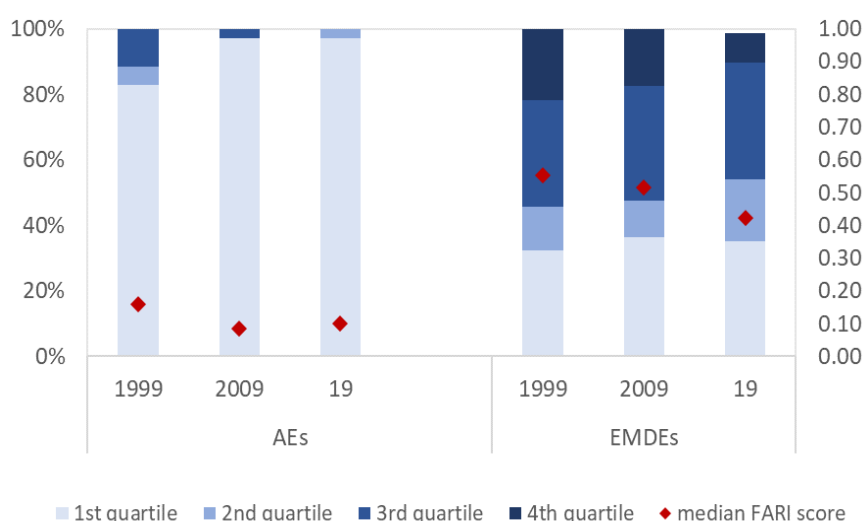
A review of the CFMs that have been applied by countries over the last decade indicates that countries continued to avail themselves of a broad spectrum of CFMs (Annex Table 1). The restrictions have typically included exchange controls that prevent or limit the buying and selling of a national

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<sup>31</sup> The Financial Account Restrictiveness Index is constructed using data of the Annual Report on Exchange Arrangements and Exchange Restrictions (Baba and others, forthcoming) and focuses on capital controls, that is, residency-based CFMs.

currency, caps on the allowed volume for the international sale or purchase of various financial assets, transaction taxes on currency exchanges, minimum stay requirements, requirements for mandatory approval, or even limits on the amount of money private citizens are permitted to remove from the country.

**Annex Figure 1. Financial Restrictiveness Index by Income Group and Year**  
Percent of countries in each quartile (left axis) and median score (right axis).



Sources: Baba and others (forthcoming); and authors' calculations.  
Note: Higher values represent more restrictions. AEs = advanced economies, EMDEs = emerging market and developing economies, FARI = Financial restrictiveness index.

**Annex Table 1. Country Practices Relating to CFMs, 2010–21**

	Type of Measures	Transaction Affected
CFM on Inflows	Tax	Inbound fund transfer
		Inflows into financial markets
		A stamp duty that is higher for nonresidents on property transactions than for residents
	Reserve requirement	Capital inflows or foreign exchange deposit accounts
		Liabilities to nonresidents
	Ban	Borrowing from nonresidents
	Limits or restrictions	Limit on external borrowing
Limit on foreign exchange open positions (net/gross)		

		Limit on foreign exchange transfers between local and foreign bank accounts
		Limit on residential property sales to foreigners
	Approval and requirements	Approval to issue local currency denominated corporate bond in offshore
		Approval for resident land purchase
CFMs on Outflows	Tax	Remittance of funds by nonresidents from domestic financial assets transactions
	Reserve requirement	Foreign exchange purchase through foreign exchange derivative transactions
		Offshore local currency deposits
		Holding period for capital inflows, for example, foreign direct investment
	Surrender and repatriation	Export surrender
		Repatriation of foreign exchange debts and external assets abroad
	Bans	Transfer abroad of proceed from local currency assets including profit transfers
		Lending to nonresidents
		Holding investments abroad
		Foreign exchange purchase from onshore foreign exchange market for selected use cases
		Participation in offshore local currency derivative trading
	Limits/restrictions	Limit on external borrowing
		Limit on investment abroad
		Limit on transaction abroad including local currency and foreign exchange derivative contracts
	Approval requirements	Approval for the overseas capital account transfer
		Approval for the purchase of external assets

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