Motivation to Regulate Central Bank Digital Currency: A Conceptual Model

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Abstract

The nonexistence of well-structured information about the design and implementation of the Central Bank Digital Currency (CBDC) is affecting the cooperation of teams in CBDC research projects. CBDC research teams need to structure their country's motivation to regulate CBDC within a shared vision to solve the problem of the financial and technological regulation of the digital currency, which will have a significant impact, especially on the digital innovation of the digital economy ecosystem, the digital transformation of the companies, and the digital inclusion of unbanked people. This research aims to survey the key constructs of the CBDC design through the literature review, map these constructs in ArchiMate elements and propose a conceptual model that uses the key constructs to combine the motivation, the business, the application, and the technology layers of ArchiMate, providing the legal, financial, and technological viewpoints of CBDC design scope. The proposed model simplifies the collaboration between researchers and practitioners, namely central banks, policymakers, and technology providers, as a communication tool between financial, legal, and technological professionals in a CBDC research project.

Keywords

Distributed Ledger Technology, Decentralized Application, Central Bank Digital Currency, Motivation, CBDC, Conceptual Model.

1. Introduction

Distributed ledger technology (DLT) has established itself as an umbrella term to designate multi-party systems that operate in an environment with no central operator or authority [1]. This technology is changing payment, clearing, and settlement processes, including how funds are transferred and how securities, commodities, and derivatives are cleared and settled [2]. It combines several technologies and computing concepts to create modern cryptocurrencies: electronic cash protected through cryptographic mechanisms instead of a central repository or authority [3].

Bitcoin is the first DLT-based application and first blockchain-based cryptocurrency, which is defined by its creator Satoshi Nakamoto [4] as a peer-to-peer version of electronic cash that would allow online payments to be sent directly from one party to another without going through a financial institution (bank) with the use of digital signatures as part of the solution without trusted to prevent double-spending.

CBDC is described as centrally banked cryptocurrencies by [5] and defined by [6] as central bank-issued digital money denominated in the national unit of account, represented in a digital form, unlike

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physical coins and banknotes, different from existing forms of cashless payment instruments for consumers such as credit transfers, direct debits, card payments and e-money [6].

The CBDC research is progressing quickly; according to the Bank for International Settlements (BIS) report, central banks have communicated that they are researching CBDC, resulting in 29 pilots relating to the BIS survey applied to 80% of central banks in the world. Another report published in 2020 assumed that the purpose of central bank digital currency (CBDC) research are financial stability, monetary policy implementation, financial inclusion, domestic and cross-border payment efficiency, and safety/robustness of payment system. In this report, some central banks reported other motivations, such as reducing costs and improving know-your-customer, countering-the-financing-of-terrorism ("KYC/CFT"), and public access to the central bank money (Boar, Holden, and Wadsworth 2020).

The main issues addressed by CBDC research are solutions for managing cryptocurrency through distributed networks; the design features such as value-based, account-based, wholesale, retail, interest-bearing, and non-interest bearing; risks of unregulated cryptocurrencies in the monetary policy [7]. These authors emphasize that the CBDC research challenges, such as the legal and societal aspects of central bank digital currency, international cooperation, the harmonization of regulation, the standards for card-based payments and micropayments with CBDC, the security standards in the financial sector applied to blockchain-based financial transactions in 5G networks, and standards for CBDC accounting.

The challenge for central banks and governments will be to advance innovative governance approaches that enable an influx of substitute currency without losing tax revenues or losing currency sovereignty [8]. These authors highlight the inexistence of no single model for global collaboration between central banks, governments, and regulators, emphasizing that best practices could be derived from existing economic unions.

The research on CBDC crosses the legal, financial, social, and technological dimensions: The financial dimension integrates the technological dimension to regulate drivers such as the crypto-economy, disruptive innovation, crypto market, data economy, financial technology (fintech), cryptocurrency transactions, and use of crypto-wallets. The legal integrates the financial dimension to regulate drivers such as the cybercrime economy, money laundering, tax and accounting, and cryptocurrency data protection. The social dimension analyses the adoption and business ethics drivers [9].

The absence of well-structured information is a problem of the CBDC research project collaboration, especially the cooperation between economists, legal experts and information technology professionals because they need to structure their country's motivation to develop and experiment CBDCs, within a shared vision that finds results of the financial regulation of CBDC. This research gap needs to be solved by systematizing the concepts used in the context of CBDC design and implementation with a concept model to support the communication between the financial, legal, and technological professionals in a CBDC experiment project.

This research study aims to survey the key construct by which CBDC design operates and propose a conceptual model to support the motivations to design and regulate CBDC. The methodology used to conduct this research was a combined methodological approach. We structured the research in three steps: i) To find the key constructs of CBDC design using the Multivocal Literature Review; ii) To Map the constructs found in the literature to ArchiMate Motivations; and iii) To propose the conceptual model.

The paper is organized into six sections: Here, in section 1, we have introduced this research paper with the context, objective, methodology, and structure. Section 2 explains the research method, including the research design and implementation. The results of the research questions are presented in section 3. The conceptual model with the constructs of CBDC design mapped in ArchiMate is proposed in section 4. The results are discussed in section 5, and finally, the concluding remarks are made in section 5.

2. Research Method

In this section, we present the research motivation and method.

Despite the effort to research the CBDC, we observed a gap between researchers and practitioners in its conceptualization and the absence of a well-structured common language to design and implement CBDC. This problem could impact the cooperation between economists, legal experts and information technology professionals because they need to structure their country's motivation to develop and experiment CBDCs within a shared vision to solve the problem of economic and technological regulation of the digital currency with CBDC implementation, which is a significant impact, especially to promote digital innovation and digital inclusion of unbanked people. To solve this gap, we propose to research the key constructs of the CBDC domain and present a conceptual model that can be used to design CBDC.

Research Goal: To survey the key construct by which CBDC design operates and propose a conceptual model to support the motivations to design and regulate CBDC.

With this focus, we defined the following **research question**s:

- **RQ1:** What are the key constructs of the CBDC design?
- **RQ2**: How the key constructs of the CBDC design relate to ArchiMate

The design of artefacts is a rigorous process to solve observed problems, make research contributions, evaluate the designs, and communicate the results to appropriate audiences [10]. Artefacts named IT artefacts can be any designed object in which a research contribution is embedded in the design [11]. They can be constructs, models, methods, frameworks, architectures, design principles, instantiations, and design theories [12].

In this context, **constructs** are defined as the conceptual vocabulary of a domain that defines the basic concepts and language in which problems and solutions are defined and communicated. The **Model** uses constructs to represent the real-world contexts of the design problem and solution spaces or sets of propositions or statements expressing relationships between constructs [12].

We adopted the combined methodological approach to conduct our research. First, we use the Multivocal Literature Review (MLR) [13] to find the key constructs (or key concepts) of the CBDC. Then, we use concept mapping (CP) [14] to map the key construct found in the literature to ArchiMate and finally propose the conceptual model (see
Figure **1**).

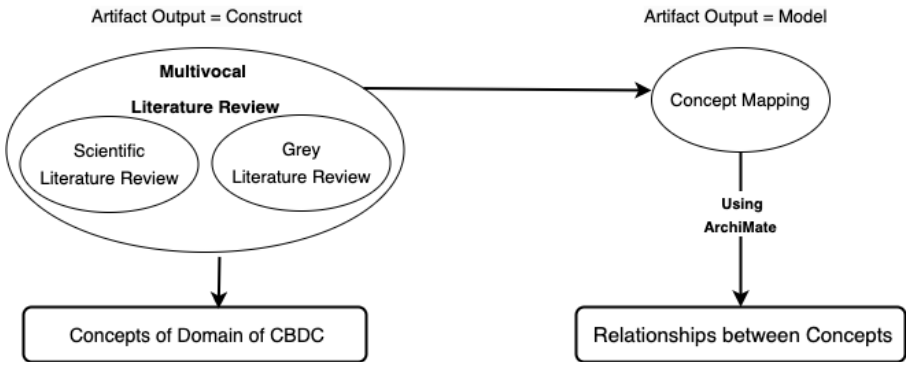

Figure 1: A combined methodological approach

Multivocal Literature Review (MLR) is defined by [13] as a form of SLR that includes the grey literature (e.g., reports, white papers, discussion papers, blog posts, social network posts, videos, and others) in addition to the published formal literature (e.g., journal and conference papers). These authors

argued that MLRs are helpful for researchers and practitioners since they provide summaries of the state-of-the-art and state-of-the-practice in a given area.

Considering the gap in the CBDC conceptualization between academics and practitioners, we conducted the MLR to find the key and common concepts in the CBDC domain (constructs) used by both, which will serve as a high level of the CBDC design. This research method is composed of three steps: **i) Planning** the review protocol with review need or motivations, research goal and questions, search strategy, selection criteria, and quality evaluation; **ii) Conducting** the review to make data syntheses with studies identification of studies, selection, quality assessment, and data extraction and **iii) Reporting** the review results with data analysis, synthesis and RQs answer.

Then, we used the concept mapping method [14] to represent the CBDC constructs, using ArchiMate as an enterprise architecture modelling language [15] to organize topics. This method comprises six steps: Planning, generating the ideas, statement structuring, concept mapping analyses, interpreting the maps, and composing and articulating a utilization plan. We choose this method because it provides the orchestration of the constructs identified in the literature review in a new artefact, especially a model to design, implement and regulate CBDC.

For MLR, we used a search string to find all relevant scientific literature reviews:

Search string: `("central bank") AND ("central bank digital currency") AND ("decentralized application").`

With this search string, we searched all of the most essential electronic digital libraries in software engineering: Google Scholar, Semantic Scholar, ACM, IEEE, Web of Science, Science@Direct, Scopus, and Springer to find scientific and conference papers. We adjust our search query for each database with an advanced search string.

To conduct the grey literature review, we searched reports of central banks and other practitioners using the Google search engine and websites of Arxiv, google, and the website of the policymakers' institutions that are conducting research in CBDC, such as the International Monetary Fund (IMF), European Union, Bank for International Settlement (BIS), World Economic Forum (WEF), International Telecommunication Union (ITU), and Central Banks. We also researched on websites of technology providers like Hyperledger, consensus R3/Corda, and others to find reports and white papers on CBDC research practice.

We used the selection criteria proposed by [16] to identify studies that provide direct evidence for the research questions. We defined inclusion and exclusion selection criteria as follows:

- **Inclusion criteria**: The selected studies must be in English, with author and date information, accessible, not duplicated, the content should be focused on CBDC design or implementation, and the document's quality needs to be available. The paper could be included through the snowballing process (Heuristics).
- **Exclusion Criteria:** Studies not written in English, without date, author unidentified, title and abstract not related to the CBDC, document type like site news, social network post, PowerPoint file, video, poster, and newspaper, duplicated, content not related to the research questions, quality of the document not available.

The selection process was made using the PRISMA guideline [17] to do the selection process through the identification, screening, eligibility, and inclusion of studies that were focused on CBDC design or implementation (see Figure 2).

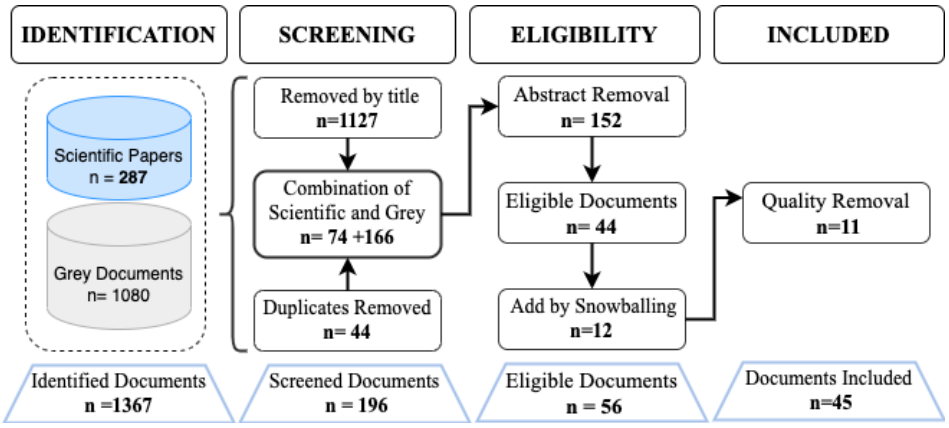

Figure 2: Selection process based on the PRISMA guideline [17]

After the inclusion of 45 research papers and reports, we made the full reading extracting the key constructs of the CBDC design. In this research step, we found 14 key constructs of the CBDC domain. In concept mapping process [14], we made the planning step by selecting a data collection using the results of MLR (CBDC constructs). Then, we use the results of MLR, specifically the constructs found in the literature, to generate concepts using the ArchiMate modelling language [15] to create mapping analyses, interpret, compose and articulate a utilization plan.

ArchiMate is an enterprise architecture modelling language [15] that supports the description, analysis, and visualization of an architecture within and across business domains. It is composed of layers, passive structure, behavior, active structure, and motivation. In this research paper, we used the **motivation layer,** which communicates with all other ArchiMate layers (see Figure 3), to guide our data systematization and mapping. ArchiMate motivation elements are used to model the motivations or reasons that guide the design or change of an enterprise architecture. In this context, our mapping intent is to pilot the motivations of central bank money transformation and its architecture ecosystem change using ArchiMate.

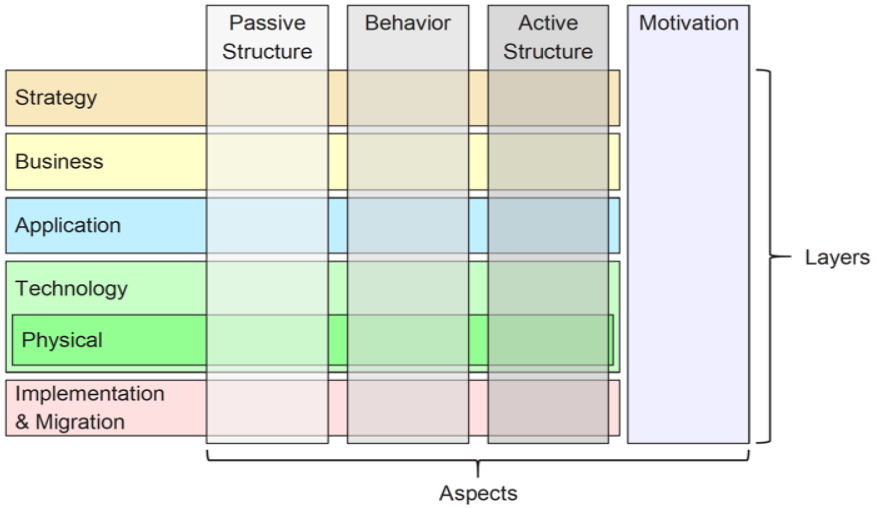

Figure 3: ArchiMate 3.1 Full Framework, source [15]

The ArchiMate layers are: 1) The **strategy layer** has a set of elements to model strategic direction and choices; 2) The **business layer** has business services offered to customers, which are realized in the organization by business processes performed by business actors; 3) The **application layer** that has application services that support the business, and the applications that realize them; 4) The **technology layer** that has technology services such as processing, storage, and communication services needed to run the applications, the computer and communication hardware, and system software that realize those services. 5) The **physical layer** elements are included in the technology layer for modeling physical

facilities and equipment, distribution networks, and materials; 6) **Implementation and Migration** layer support the implementation and migration of architectures and includes a model of the implementation to support portfolio, program, and project management [18], [19].

The ArchiMate motivation elements metamodel is used to model the motivations or reasons that guide the design or change of an enterprise architecture, the passive structure has elements that can be accessed by behavior elements to represent the dynamic aspects of the enterprise, and the active structure elements are the subjects that can perform behavior [15][18][19].

In the next section, we present the results.

3. Results

In this section, we present the results of the research, detailing the key constructs of the CBDC design found in the literature review and their mapping to ArchiMate layers and elements.

3.1. Key Constructs of The CBDC Design

The key constructs of the CBDC design found in the literature review are function, digital asset, proposal, participants, layer, life cycle, types, use case, transaction, architecture, infrastructure, and model (see Table 1).

Table 1
Constructs of CBDC Design and Characteristics

Constructs	Characteristics	References
Function	Medium of Exchange, Store of Value, Unit of Account	[20][21][22][5][23]
Proposal	Monetary Policy, Financial Stability, Safe Payment System, Digital Innovation, Digital Inclusion, Digital Transformation	[24][25][26][27][28][29]
Participant	Central bank, government regulatory agencies, accounting office, audit bodies, commercial banks, clearing institutions, non-banked financial institution, Payment Service Provider, business, household, and citizen.	[30][20][31][32][33]
Layer	Regulatory layer, Regulated Layer, User layer	[22][33][30][34]
Life cycle	Issuance, management, distribution, circulation, withdraw, and redeem	[22][35][36][33][31][37]
Model	Direct, hybrid, indirect	[38][39][35][40][38][36]
Digital Asset	Digital form, issued by a central bank, algorithm-based, tokenized, encrypted, and decentralized	[41][21][22][42][20][43] [29][41][5][28][44]
Types	Wholesale and Retail	[45][20][5][46][24]
Use Case	Wholesale Payments, Retail Payments, Cross- border Payment, Cross-Currency Payment, Machine-to-Machine Payment, and transactions.	[45][5][40][46][24][31] [47][48][49]
Architecture	Application Layer, Service Layer (API Layer), Smart contract Layer, Protocol Layer, and Network Layer.	[50][22][32][36] [31] [49]
Infrastructure	DLT-Based, Non-DLT-based.	[38][51]
Access	Account-based (valued-Based), Token Based (wallet-based), IoT Based-access	[38]
Principle	Finality, Convertible, Interest Rate, Transferable, Convenient, Available, Secure, Resilient, Scalable, Extensible, Flexible, Interoperable, Private, Compliant, Auditable, Robust.	[26][22][32][52][45][20] [23][27][53][54][55] [56][24][42]

Constructs	Characteristics	References
Governance	National laws, supervisory policy, Digital Identity Integration, Technology neutral regulation, GDPR, AML/CFT, Tax regimes, regulation-by-design.	[27][23][24][22][26][25] [44][57][56][40][45][55]

The currency **functions** of CBDC are equal to cash: **medium of exchange,** meaning that it can be exchanged for cash, e-cash, goods, and services in a decentralized [20], [21], [22], [5], [23], support interest rate serving as a secure **store of value**, and **unit of account** [20]. The **proposal** of CBDC includes the leading Central Banks' missions which are monetary policy, financial stability, safe payment system [24] [25] [26] and needs of the digital society digital innovation, [27][28] [29], digital inclusion and digital transformation [27].

The **Participant** of CBDC are central bank and other regulatory agencies [30], accounting office, audit bodies, commercial banks, clearing institutions [20] [31], non-banked financial institution [30], Payment Service Provider [32], Household (citizens) and business [30] [33] [20]. The **Layer** or tier includes: The regulatory **layer** [22] [33], the **Regulated layer** [30], and the **User layer** [22] [34].

The CBDC **life cycle** includes a set of steps, [22] [35] [36]: **Issuance**; **Management, distribution** [33], **circulation, withdraw**, and **Redeem** [31][37]. The **digital asset** refers to an asset issued or transferred using distributed ledger technology [44] in digital form [41] [21] [22] [42], issued by a central bank [20] [21], algorithm-based [43], tokenized [29] [41], decentralized [5], encrypted [28][22]. [44].

The CBDC **Model** is the option to distribute CBDC for circulation [38] [39]. It can be **Direct CBDC model** (One Tier), [35] [40] [38]; **Indirect CBDC model** (two-tier CBDC"), [35] [36] [40] [38]; **Hybrid CBDC** model (One Tier), [38] [39]. The Committee on Payments proposes two types of CBDC and Market Infrastructures (CPMI) [45]: ***i)*** **Wholesale CBDC** that is a digital currency limited to regulated institutions [20], and non-banked financial institution (FinTech) [30] for more efficient interbank payments [5] [45] [46]; ***i)*** **Retail CBDC** that is used for general purposes in small businesses, and even individuals [20] [46] [5] [24] [45].

The **use case** comprises different types of payment: The **wholesale payment** between financial institutions [45] [5] for security settlements as delivery versus payment (DvP), delivery versus delivery (DvD), payment versus payment (PvP), token vs token (TvT), and token(s) versus token(s) (T*vT*) [40]. **Retail payment** is used for peer-to-peer payments from consumers to merchants [46], [5], [24], for example, UnionPay in China [58], pay taxes, cashless transactions, fund transfers, withdraw [31]. **Cross-border payments** are those where the payer and payee reside in different jurisdictions (different countries), and **cross-currency** is cross-border payment, but when the payer and payee aren't within the monetary unions [47]. The **Machine-to-Machine Payment** named Internet of the Things (IoT)-Base payment is being proposed to integrate of retail CBDC models in uses cases related to Consumer IoT (CIoT) [48] via another type of regulation known as regulation-by-design and compliance-by/through-design [49].

The CDBC **Architecture** is composed of five layers: i) **Application Layer** [50] that comprises currency issuance (money creation), CBDC lifecycle application, use cases and integration with digital entity, [22] [32]; ii) **Service Layer** (or Application Programming Interface – API Layer); iii) **Smart contract Layer** contains codes and rules for execution (programable money) [36] [31] [49]; **iv) Protocol layer** (or consensus algorithms) [31] [37] and **Network Layer** [22] [32].

The technology to **Access** CBDC is related to the design model and infrastructure adopted. Four types of access technology are proposed by [38]: **Centralized CBDC Accounts** which transactions are initiated via an account based on a centralized system that operates with access conditioned by identification; **Centralized Token CBDC** which transactions are initiated via token (or wallet) based on a centralized system that operate without access conditioned by identification; **DLT-based CBDC**

Account which transactions are initiated via an account at the central bank, maintained by validators with identification required; **DLT-based Token Account** which transactions are initiated via decentralized operated CBDC open to anyone with central bank guarantees values.

The **infrastructure** is the technology used to build CBDC. It could be a DLT-based (Blockchain technology) [40] or a conventional (Current bank System) [38]. The conventional-base system is a centralized application based on a web 2.0 infrastructure [51] the resilience is achieved by data stored over multiple physical nodes which are controlled by the central Bank [38]. The DLT-based system is a decentralized application based on a web 3.0 infrastructure [51] witch the resilience is achieved by a stored ledger managed by different entities in a decentralized manner [38].

The CBDC design **principles** identified are **Finality** [26] [22] [32], **Convertible** [52], **Interest Rate** [45] [20], **Transferable** [23] [22] [27], **Convenient** [52] [45] [53], **Available** [52], **Secure** [52] [26] [22], **Resilient** [52] [26] [32], **Scalable** [52] [26] [53], **Extensible** [53], **Interoperable** [52] [54] [26] [55] [56], **Private** [45] [23] [24] [26] [55] [56] [27] [32].

Several terms are used to mention the CBDC design **principles**. The CPMI mentioned **core properties** and **design feature** [45] of CBDC, highlighting a set of features that will determine how a CBDC may serve as a means of payment and a store of value: Availability, anonymity, transfer mechanism, interest-bearing, and limits or caps. The technical paper of Digital Asset Holdings [23] mentioned **key desirable properties** for a CBDC: Transferable, Ownership, Data access is controlled and Portable across any ledger. The Bank of Thailand [26] emphasizes a set of **non-functional requirements** for CBDC: Finality, interoperability, privacy, resilience, scalability, and security, and [52] presented three types of **features**: *i)* Instrument features (convertible, convenient, accepted and available); *ii)* system features (secure, instant, available, throughput, scalable, interoperable, flexible and adaptable) and *iii)* institutional features (robust legal framework and standards).

We observed that several design **principles** have a different designations for the same objective, for example, security is related to unforgeability that requires anti-counterfeiting technology to ensure currency security that none can falsify, just like physical currency [22]. The security extends to auditability, which must prevent transactions that do not comply with regulations while maintaining the privacy of transactions [42] and verifiability, which requires that all transaction records involved in the CBDC system can be validated effectively [22]. Interoperability is another principle associated with security that ensures interchangeability with other systems of the same or heterogeneous type [56], implying a common payment technology or strong standardization [55]. The scalability of the CBDC should be able to manage a large number of transactions and be extensible to the innovation of third parties or the central bank adding services in the future [53]. Convenient is related to user-friendly and inclusive which ensures CBDC services are easy to use and accessible even for unbanked populations and other vulnerable demographics [53] [45].

Governance is mentioned by these authors [27] [23] [24] [22] [26] [25] as the compliance via design principles such as supervisory law and policy, digital Identity Integration, technology-neutral regulation [44], General Data Protection Regulation (GDPR), AML/CFT, Tax regimes and Regulation-by-design. It is argued by [57] as techno-legal methods to balance privacy and transparency compliance within a regulation-by-design scheme [57]. Governance is also mentioned inter-CBDC exchange system based on ISO/IEC 11179 [56], FIX, FpML, ISO 20022, token taxonomy framework (ERC-20) [40], and the interest rate policy (smart monetary policy) to encourage or discourage demand for CBDC [45]. The CBDC use in circulation and payment for ongoing value movements in economic activities need to be conform with Know Your Customer (KYC), Anti-Money Laundering (AML), Countering the Financing of Terrorism (CFT), and other compliance requirements [22]. This feature is also mentioned as anonymity of CBDC which includes anonymity of identity and anonymity of transaction [22], where full anonymous transactions cannot comply with AML and CFT regulation [55].

In the next section, we will describe the mapping process of the above-described concepts to ArchiMate elements.

3.2. CBDC Key Constructs Mapped in ArchiMate Motivation Layer

In this section, we answer the research question "*How the key constructs of the CBDC design relates to ArchiMate?"*. First, we present the mapping results of the key constructs (or concepts) of the CBDC design to ArchiMate motivation elements and then the construct's characteristics mapped to ArchiMate passive structure, behavior elements and active structure elements of the business, application and technology (include physical) layers.

The results of the CBDC key construct mapped to ArchiMate motivation layer is presented in the table below. In the mapping process, we align each construct definition with the definition of motivation layer elements and their relationships resulting in one more construct that we found in ArchiMate which several constructs were associated (the requirement motivation element) remaining 15 key constructs of the CBDC (see Table 2).

Table 2
CBDC Key Constructs Mapped to ArchiMate

CBDC Key Construct	Mapped ArchiMate Motivation Element	Construct(s) Relationship(s)				
		Association	Realization	Specialization	Inclusion	Constructs
Function	Driver	x				Participant, Proposal, Model
Proposal	Goal	x				Function, Model
Participant	Stakeholder	x				Type, Digital Asset, Function
Layer	Requirement	x				Requirement
Life cycle	Requirement	x				Requirement
Model	Assessment	x				Function, Proposal
Digital Asset	Value	x				Participant, Use Case
Types	Meaning	x				Participant
Use Case	Outcome	x				Digital Asset
			x			proposal
Architecture	Requirement	x				Requirement
Infrastructure	Requirement	x				Requirement
Access	Requirement	x				Requirement
Principle	Principle		x			Use Case
Requirement	Requirement		x			Principle
					x	Access, Life Cycle, Layer, Architecture Infrastructure
Governance	Constraint			x		Particular king of Requirement

Then, we mapped the key constructs (or concepts) of the CBDC and their characteristics to business, application and technology layers of the ArchiMate and their elements (see Table 3).

For **business layer**, we mapped the constructs related to legal and financial dimension of the CBDC design, implementation and regulation, assuming that: **i)** The legal dimension, relates to the CBDC goal, law, supervisory policy, standards, guidelines to develop CBDC, day-to-day usage by citizens and businesses to buy goods and services; **ii)** The financial dimension of CBDC is related to business goal like as mission of central bank and proposals to implement CBDC and central bank business process related to CBDC creation and distribution.

We presumed that the **application layer** relates to constructs of the CBDC as an application which have services that support the business process of central banks related to CBDC, and the applications that realize these business process. Finally, we consider that the **technology layer** relates to constructs which their characteristics are related to the technology services used to develop and distribute CBDC in the network.

Table 3
CBDC Key Constructs and Characteristics Mapped to ArchiMate Layers

CBDC Design Key Construct	Motivation Layer Element	Constructs Characteristics	Business	Application	Technology	ArchiMate Elements	
Proposal	Goal	Monetary Policy, Financial stability, Safe Payment System, Digital Innovation, Digital Inclusion, Digital Transformation,	x			Business Process	
Function	Driver	Medium of Exchange, Store of Value, Unit of Account	x			Business Interaction	
Participants	Stakeholder	Central bank, Medium Regulatory agencies, Accounting office, Audit bodies, Commercial banks, Clearing institutions, Non-banked financial institution, Payment Service Provider, Business, Household, Citizens	x			Business Actor	
Layer	Requirement	Regulatory layer	x			Business Function	Business Role
		Regulated Layer, User layer	x				Contract
Life cycle	Requirement	Issuance, Management, Distribution, Circulation, Withdraw, Redeem		x		Application Collaboration	Application Process
Model	Assessment	Direct	x			Business Service	Business Interface
		Hybrid, Indirect	x				Business Collaboration
Digital Asset	Value	Digital form	x			Representation	
		Issued by a central bank	x			Business role	
		Algorithm-based, Tokenized, Encrypted			x	Technology artifact	
		Decentralized			x	Path	
Types	Meaning	Wholesale, Retail	x			Product	
Use Cases	Outcome	Wholesale Payments, Retail Payments, Cross-border Payment, Cross-currency Payment, Machine-to-Machine Payment, Transactions		x		Application Service	
Architecture	Requirement	Application Layer		x		Application Function	Application Component
		Service Layer (API Layer)		x			Application Interface
		Smart contract Layer		x			Application Collaboration
		Protocol			x		Technology Collaboration
		Network Layer			x		Technology interaction
Infrastructure	Requirement	DLT-Based, Non-DLT-based			x	Technology Function	Communication Network
Access	Requirement	Account-based (valued-Based), Token Based (wallet-based), IoT Based-access		x		Application Interaction	Application Interface
Principle	Principle	Interest Rate, Transferable, Convenient, Available, Secure, Resilient, Scalable, Extensible, Flexible, Interoperable, Private, Compliant, Auditable, Robust		x		Application Function	
Governance	Constraint	National Laws, Supervisory policy, Digital Identity Law, Technology neutral regulation, GDPR, AML/CFT, Tax regimes, Regulation-by-design	x			Contract	

In this section we mapped the concepts of CBDC to ArchiMate motivations and the constructs characteristics to other layers of the ArchiMate.

4. Proposed Conceptual Model

In this section, we present the details of the proposed conceptual model to design CBDC which is composed by 15 constructs and 4 viewpoints, namely:

1. Motivation viewpoint
2. Business motivation viewpoint
3. Application motivation viewpoint
4. Technology motivation viewpoint

The **motivation viewpoint** highlights the general information about reasons that motivates a central bank to design, to implement and to regulate the CBDC. This viewpoint includes all key constructs of the CBDC domain found in the literature and mapping process to ArchiMate, namely the function, the governance, the proposal, the participant, the layer, the life cycle, the principle, the model, the access, the digital asset, the architecture, the infrastructure, the type, and the use case (see Figure 4).

The function (currency function) characterizes an external and internal condition that motivates central bank and their stakeholders to define its goals in CBDC as well to implement the change necessary to achieve those goals. The proposal represents the high-level statement of intent, direction or desired end state for central bank and its stakeholders in CBDC design, implementation and regulation.

The participant characterizes the role of citizens or organizations that represents their interests in the effects of currency digitalization through CBDC design, implementation and regulation. The type represents the knowledge or expertise presents in CBDC or the interpretation given in the context of the CBDC design, implementation and design, while the digital asset represents the relative worth utility or importance of the CBDC concept.

The use case symbolizes an end result of the CBDC which can be used by participants, while the model characterizes the results of any analysis of state of affairs of the central bank with respect of same drive. The principle represents a statement of intent defining a general property that applies to any context of CBDC system in certain context in the CBDC implementation. The requirement includes the Layer, the access, the life cycle, the architecture, and the infrastructure to represent a statement of need, defining a property that applies to a specific CBDC system. It has a governance as its particular king.

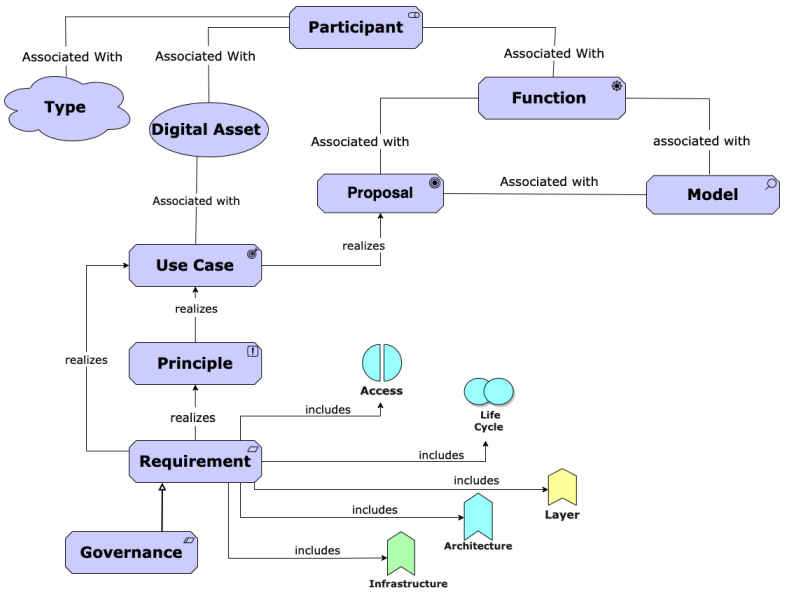

Figure 4: Motivation viewpoint

The participant is associated to type, digital asset, and function that is associated to function and model. The use case realizes function and is associated do digital assets while the principle and the requirement realize the use case. The requirement realizes principle and use case, includes access, life cycle, layer, architecture and infrastructure, and have governance as its particular king.

The **Business motivation viewpoint** comprises constructs related to legal and financial scope of CBDC namely the proposal, the function, the model, the participant, the type, the digital asset, the layer, and governance. This viewpoint details the legal information related to CBDC, namely the business process, interaction, actor, role, interface, collaboration, and business representation (see Figure 5).

The business process, namely the monetary policy, the financial stability, the safe payment system, the digital innovation, the digital inclusion, and the digital transformation are related to central bank mission and they represent a sequence of business behavior to achieve a specific result with CBDC.

The medium of exchange, store of value and, unit of account are business interaction because they represent a unit of collective business behavior performed by the collaboration of business actors that are business entities capable of performing the behavior, such as central bank and other regulatory agencies, accounting offices, audit bodies, commercial banks, clearing institutions, non-banked financial institutions, payment service providers, households, citizens, and businesses.

The digital form of the CBDC represents a perceptible form of money. The issued by a central bank is a business role because it means the responsibility of the central bank. The wholesale and retail as type of the CBDC are business product because they represent a collection of services, accompanied by a contract or set of agreements offered to central banks' customers. The model represents the business service because it explicitly defines behavior that a business role or collaboration exposed to its environment. The direct model is the business interface because it represents a point of access where a business service is made available to the environment. The hybrid and indirect model are the business collaboration because it represents an aggregation of two or more business internal active structure elements that work together to perform collective behavior.

The Layer's characteristic, especially the regulatory layer, is the business role because it represents the responsibility of central banks and other regulatory agencies in defining the roles of CBDC usage, which influence the behavior of all business actors. The regulated layer and user layer are contracts because they represent formal specifications, rights and obligations associated with CBDC usage implemented via a smart contract between the central bank and regulated agencies and final users of CBDC.

The Governance includes required national laws, supervisory policy, digital identity law, technology neutral regulation, GDPR, AML/CFT, tax regimes, regulation-by-design are mapped to contract because they represent a formal obligation that need to be observed in the CBDC application, development and usage.

The **Application motivation viewpoint** contains constructs related to CBDC as information system namely the use case, access, life cycle, architecture, and principle, emphasizing the information of CBDC as centralized application or decentralized application, such as application function, process, component, interface, collaboration, and services (see Figure 5).

The Life Cycle's characteristics, namely the issuance, management, distribution, circulation, withdraw and redeem are application process because they represent a sequence of business behavior that achieve a specific result in the context of CBDC usage. The Architecture characteristics are represented as follows: The application layer is the application component because it represents an encapsulation of components (or modules) of the CBDC as a decentralized application. The service layer are application interface because it represents a point of access where the application services are made available to a end user, another application component, or a node (p.e M2M payment).

The wholesale payment, retail payment, cross-border, cross-currency, and machine-to-machine payment are application services because they represent an application behavior. The interest rate, the transferable, the convenient, the available, the secure, the resilient, the scalable, the extensible, the flexible, the interoperable, the private, the compliant, the auditable, and the robust are application functions because they represent automated behavior that can be performed by an application component. The Access characteristics particularly the account-based and token-based, are application interface because they represent the point of access in which the CBDC application services are made available to users.

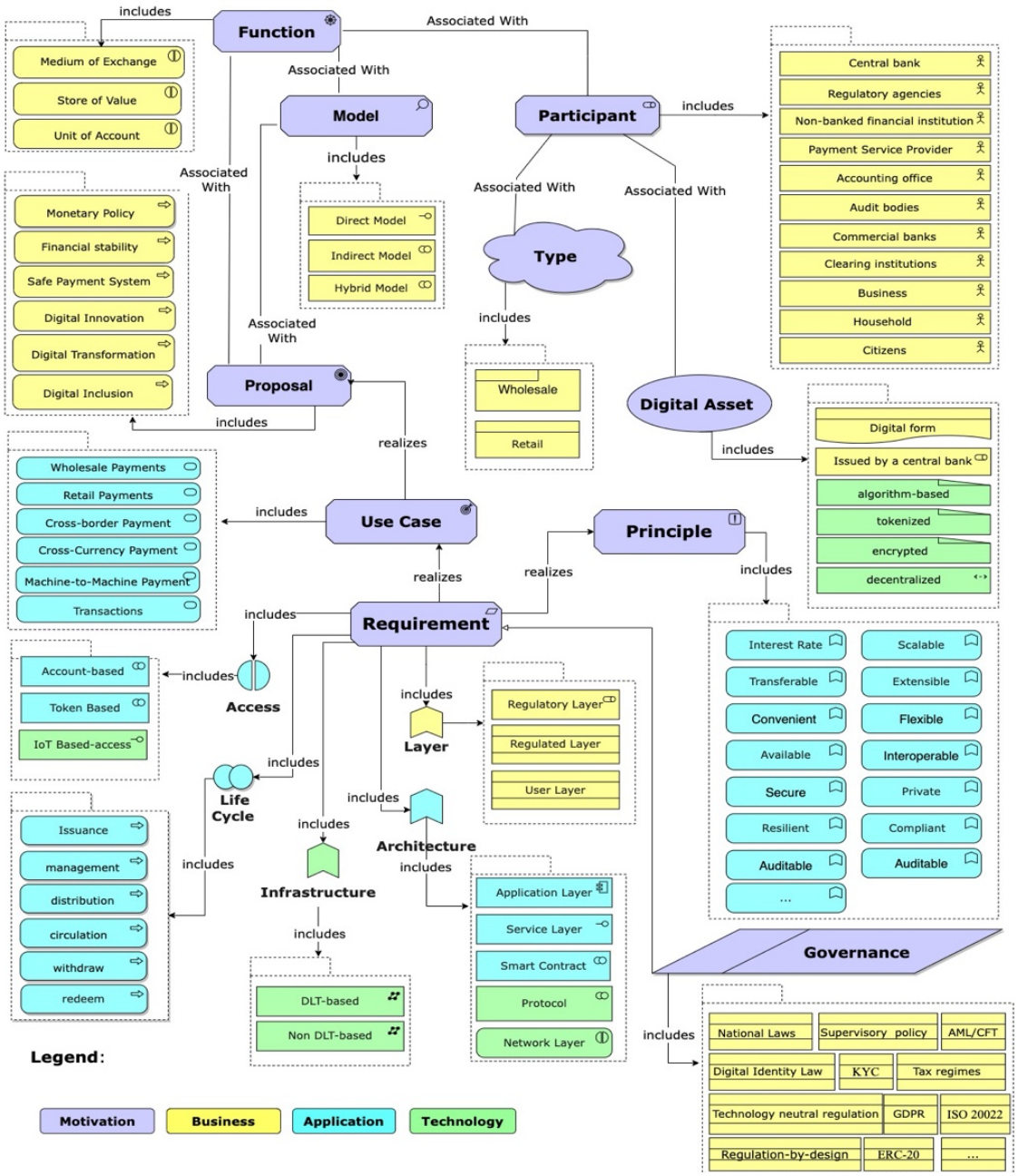

Figure 5: Proposed Conceptual Model

The **technology motivation viewpoint** covers digital asset, access, infrastructure, and architecture. This layer accentuates in technology artifact, path, technology function specifically the communication network showing the networks, protocol, IOT equipment, algorithm, and other information technology artifacts (see Figure 5).

The algorithm-based, tokenized, and encrypted are technology artifacts because they represent a piece of data produced by the software. The decentralized is a path because it means, the connection between two or more nodes through which the exchange of data is done. The Access characteristics particularly the IoT-based access is the technology interface because it represents a point where the technology services offered by a node can be accessed.

The Architecture characteristics are represented as follows: The smart contract is an application collaboration, because it aggregates two or more application internal structure elements that work together to perform collective application behavior. The protocol layer is the technology collaboration,

because it aggregates two or more technology internal active structure elements that work together to perform collective technology behavior. The network layer is the technology interaction, because it represents a unit of collective technology behavior performed by a collaboration of two or more nodes. **The infrastructure characteristics** namely DLT-based and the non DLT-based (centralized ledger technology) are communication network because it represents a set of structures that connects nodes for transmission, routing and reception of data.

In this section, we propose a conceptual model that combines the key constructs of CBDC and motivations, business, application, and technology ArchiMate viewpoints.

5. Discussion

In this section, we will discuss the results.

The conceptual model to design CBDC is composed by 15 constructs namely function, digital asset, proposal, participants, layer, life cycle, types, use case, transaction, architecture, infrastructure, model, and requirement.

The model covers 4 ArchiMate layers: i) motivation: ii) business; iii) application and iv) technology. For each layers the model presents a specific viewpoint comprising the several constructs and their relationships. The proposal, function, participant, layer, model, digital asset, type, principle and governance constructs and their characteristics are related to business layer, the life cycle, use cases, architecture, access, and principle are related to application layer, and the architecture and infrastructure characteristics are related to technology layer. The Access, architecture, and digital asset are related to more than one layer.

The participant of the CBDC represents people and organization interested in the CBDC design and regulation, representing business entities that are capable of performing dynamics activities in decentralized financial market infrastructure. The CBDC function represent an internal and external condition that motivates a central bank to change physical currency to digital currency to ensure central bank mission and business process functionality through the combination of the dynamic aspects of CBDC performed by the participants, the business rules defined in the regulatory layer, and the collaboration between participants through direct, indirect, and hybrid CBDC model.

The proposal represents the central bank objective and the other participants' desires in the CBDC regulation to achieve the main bank mission, which is realized by the business processes to move a country to digital economy with CBDC usage. The CBDC types are retail and wholesale, which represent the interpretation given to the CBDC by the different types of participants and a collection of services accompanied by a contract or set of agreements offered to central banks' customers. The CBDC digital asset represents the utility of the CBDC, the central bank's responsibility, a piece of data produced by the software, and the connection between two or more nodes through which the data exchange is done.

The CBDC use case represents an explicitly defined application activity and the final result of various participants' goals or requirements to solve problems related to unregulated cryptocurrency or CBDC operationalization. The CBDC principles are a set of properties that are applied to CBDC implementation and regulation in the context of financial system stability or financial market infrastructure, which represent automated behaviors that an application component can perform.

The CBDC governance represents a factor that limits the realization of goals, for example, legal requirements such as the national and international laws related to a payment system, digital identity, GDPR, AML/CFT, and tax regimes influence CBDC deployment and usage. The CBDC requirement includes the layer, access, life cycle, architecture, and infrastructure representing the financial, legal, and technological needs to design and implement CBDC.

The constructs of CBDC design are related to legal, social, financial, and technological dimensions of the CBDC regulation: **i)** The legal dimension involves law, supervisory policy, standards, and guidelines to develop a digital currency, which needs to be compliant with national and international laws and best practices; **ii)** The social dimension relates to the participant, principle, use case, access of the digital currency by citizens and business; **iii)** The financial dimension is responsible to digital currency creation, distribution, and circulation which is ensured by the system implementation, **iv**) The technological dimension of CBDC is associated to the technical procedure to create a digital currency, the used technology to operationalize the application and to give the participants the access to CBDC for usage.

6. Conclusion

To find the response to the financial and technological regulation of CBDC that operates in a decentralized market infrastructure, it needs to involve the cooperation between economists, lowers, and information technology professionals in a CBDC project of experimentation.

In this paper, we propose two artifacts: The constructs of the CBDC domain and a conceptual model that show the relationships of the identified constructs and serve as support do CBDC design. First, we identified the key constructs of CBDC design using the literature review, and then we mapped the identified ideas in an enterprise architecture language named ArchiMate. Then, we propose a conceptual model that combines the identified concepts of CBDC design, combining the motivations, the business, the application, and the technology elements, providing the legal, financial, and technological viewpoints of CBDC design scope.

The proposed model simplifies the collaboration between researchers and practitioners, namely central banks, policymakers, and technology providers. It can be used as of communication tool between the financial, legal, and technological professionals in a CBDC experiment project.

For future work, we plan to use retail and wholesale CBDC projects to evaluate the proposed model.

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Conflicts of interest/Competing interests

The authors declare that they have no competing interests.

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