Adoption of Retail Central Bank Digital Currencies with a Focus on User-Centricity

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Abstract

This research aims at obtaining insights into user perspectives to generate tangible contributions to a user-centric approach of retail Central Bank Digital Currency (rCBDC) adoption. Commonly identified factors of rCBDC adoption are revisited in a literature review. Subsequently an empirical analysis of user sentiments towards these factors utilizing Confirmatory Factor Analysis (CFA) is conducted. Findings validate the importance of user-centricity in CBDC design, such as through user needs (e.g., efficiency, integrity, safety, and privacy). In contrast, findings also indicate a limited degree of public awareness towards CBDC.

Keywords: Central Bank Digital Currencies; retail CBDC, CBDC adoption; financial inclusion

1. Introduction

1.1 Research Background

Is the concept of money considered significant in society? Considering the substantial quantity of banknotes and coins in circulation among the member nations of the Committee on Payments and Market Infrastructures (CPMI), it is plausible to assert that the response is affirmative. Based on the most recent data from the Bank for International Settlements (BIS) Statistics Explorer, the aggregate worth of banknotes and coins in circulation exceeds 2.23 billion USD for the United States, surpasses 1.51 billion USD for China, and approximately amounts to 1.10 billion USD for Japan. In addition, it is worth noting that the Euro area now has a monetary supply exceeding 1.78 billion USD (Bank for International Settlements, 2021).

Based on the presented data, it could be inferred that money and cash have significant influence among diverse global economies. However, it is important to note that the discourse pertaining to currency and money is subject to variability and change. When examining the historical development of currency, it is notable that the first instances of monetization can be traced back to ancient China, namely to the year 770 BCE (Hao, et al., 2021). Whilst gold coins saw fluctuations in popularity throughout the subsequent centuries, the significance of gold eventually diminished. During the 20th century, central banks (CBs) adhered to the gold standard, which required them to back their issue of money with gold reserves. However, the Bretton Woods agreement, established after World War 2, significantly reduced the significance of gold in the global monetary system, although it did not completely eliminate its function (Monnet & Puy, 2019). In the years prior to the Bretton Woods agreement, Frank D. Graham (1940) at Princeton University described the functions of money as one of (p. 1) “an accounting unit, a measure of value, a standard of value, or *numéraire*”, whilst also commenting on the role of money as a “medium of exchange”.

Nevertheless, the current discourse around currency and physical money has deviated significantly from what Graham would have envisioned as a medium of exchange.

1.1.1 Rise of Centralized Finance

The advent of new technology has brought about significant changes in the nature of money throughout the early years of the 21st century. In September 2022, the International Monetary Fund (IMF) issued a guide titled "Digital Money 101" in the Finance & Development magazine. Although the guide only consists of two pages, it effectively covers twelve distinct concepts and definitions pertaining to money and emerging financial technologies (fintech). These include terms like "stablecoin," "blockchain," "distributed ledger technology (DLT)," and "decentralized finance (DeFi)" (pp. 36-37).

Whilst there may be differing amounts of attention given to these emerging concepts and technologies, it is important to acknowledge the significant popularity of DeFi. The IMF guide defines DeFi as a collection of alternative financial markets, products, and systems. Global news outlets display a notable level of enthusiasm whilst observing the DeFi market, often making optimistic projections based on various measures. For instance, according to a report by GlobeNewswire (2023), the Compound Annual Growth Rate (CAGR) for the DeFi market is anticipated to reach 46% throughout the period of 2023-2032. However, other scholarly sources, including papers from esteemed institutions like the BIS, European Central Bank (ECB), Massachusetts Institute of Technology (MIT), and London School of Economics (LSE), extensively discuss a multitude of issues and risks associated with

the DeFi space. The ideological and architectural democratization of finance established through decentralized aspects of DeFi, tends to be a reoccurring problematic, entailing issues like risk to financial stability and disruptive changes through removal of intermediaries in the financial system (e.g., Makarov & Schoar, 2022; Born, Gschossmann, Hodbod, Lambert, & Pellicani, 2023; Bank of International Settlements, 2023).

1.1.2 Central Bank Responses

Returning to Graham's remark about money as a medium of exchange, DeFi is famous for its various innovative fintech solutions, enabling alternative products of monetary value, including cryptocurrencies, such as Bitcoin and Ethereum. In stark contrast to traditional currencies such as the Euro and the US Dollar, however, these currencies exist largely outside the centralized financial systems of CBs.

It is with these drastic developments in the financial world in mind that CBs around the world have started exploring their own options to address the apparent paradigm shift. One important avenue being explored is the implementation of central bank digital currencies (CBDCs). A publication of the IMF refers to the Bank of England and HM Treasury as one instance of a CB driven to participate in research on CBDC with the aim of upholding monetary sovereignty and ensuring financial stability (Soderberg, et al., 2023). Meanwhile, India sees increasingly negative sentiments towards cryptocurrencies, whilst launching its own CBDC pilot program (Kharpal, 2022).

On one of their webpages (Board of Governors of the Federal Reserve System, 2023), the Federal Reserve System of the United States simply refers to CBDC as a digital "liability of the central bank" (para. 1). Similar notions can be found on a dedicated webpage of the ECB (European Central Bank, 2023), where a hypothetical CBDC within its jurisdiction dubbed as Digital Euro is defined as an "electronic equivalent to cash" (para. 1). Both webpages are educative in nature, since their primary purpose is to provide information to the general public in a manner that is easily comprehensible and straightforward. Definitions of CBDCs provided in scholarly articles tend to be more in-depth, however ultimately converge on the same understanding of their functionality (e.g., Meaninga, Dysonb, Barkera, & Clayton, 2021; Wenker, 2022). Additional characteristics of CBDCs exist, nonetheless. Complexity increases through further differentiation, for example, between different types of CBDCs. Overall, CBs around the world are in different stages of exploring CBDCs. As of 2023, a total of 130 countries are researching or developing CBDCs. Eleven countries have progressed to advanced phases and already implemented CBDCs (CBDC Tracker, 2023; Atlantic Council, 2023). This significant milestone signifies the beginning of a transformative era in the realm of monetary systems.

1.1.3 User-Centric Adoption of Central Bank Digital Currencies

The present research landscape in the field of CBDCs is currently occupied with a wide range of studies and topics. CBDCs are often examined from either a technical or a policymaking standpoint, within and across the various jurisdictions of CBs around the world. Nonetheless, all CBDC research is ultimately and inevitably confronted with the issue of adoption.

A BIS publication (Bank for International Settlements, 2021) covering the topic of adoption, for example, notes that (p. 1) "CBDC adoption would likely be driven by its future usefulness to users". We can find similar notions in a publication of the ECB about the design of a Digital Euro (European Central Bank, 2022). Like for all rCBDCs, the emphasis of the Digital Euro lies in its retail purposes. Consequently, this entails additional considerations and challenges for the general public and users. Nonetheless, scholarly reception of rCBDC adoption with emphasis on user-needs tends to be underwhelming, with a few scholars pointing out the risks of mismatching visions of policymakers and actual users (Abramova, Böhme, Elsinger, & Summer, 2022).

1.2 Research Purpose and Objective

This paper addresses the research gap found in the area of user-centered rCBDC research. Generally, CBDC adoption has been covered by numerous scholars, nonetheless the outcomes of these studies may in some cases be somewhat intangible, e.g., the approach of Hofstede's cultural dimensions (Luu, Do, Pham, Ho, & Dinh, 2022). The primary objective of this study is to gather insights from the user perspective to generate tangible contributions to a user-centric approach of rCBDC adoption. Accordingly, this research will revisit commonly identified factors of rCBDC adoption through a literature review in form of secondary data and obtain user sentiments towards these factors from survey participants in form of primary data. An empirical analysis of the primary data is conducted, yielding an elevated understanding of user-centric sentiments towards CBDC adoption factors in the form of hypotheses that are either supported or unsupported.

2. Literature Review

2.1 Consumer Factor

Amongst the three main independent variables in this research, the consumer factor is exclusively concerned with intrinsic aspects of the users (user and consumer are used synonymously in this research), meaning, factors contributing to this variable solely steer from the users themselves.

The most important findings pertaining user-centric factors are listed in the following sections, namely, the economic factors (i.e., personal income; household income; savings; and other assets), the personal factors (i.e., education; occupation; and age), as well as the awareness/knowledge level of users regarding rCBDCs. The consumer factor is included as an independent variable with an emphasis on the research gap in user-centric rCBDC research introduced in chapter, underscoring the significance of user needs as identified in prior literature (e.g., Abramova, Böhme, Elsinger, & Summer, 2022; Bank for International Settlements, 2021; Zamora-Pérez, Coschignano, & Barreiro, 2022). Altogether, user-centered factors determine the degree to which the consumer factor as an independent variable positively affects rCBDC adoption, thus we assume:

Hypothesis 1 (H_1): The consumer factor positively affects rCBDC adoption.

2.1.1 Economic Factors

Scholarly research has previously identified income as a likely economic factor in early CBDC adoption. Whilst some research pinpoints individuals with high income as possible early-adopters of CBDCs (Bijlsmaa, van der Cruijsen, Jonker, & Reijerink, 2021), other papers point out the reliance on cash amongst groups of lower income, e.g., homeless, migrants, or specific user groups (Bank for International Settlements, 2021).Research papers, which previously have identified income as an economic factor in early CBDC adoption, differentiate between personal income and household income (Bijlsmaa, van der Cruijsen, Jonker, & Reijerink, 2021). Whilst personal income may only serve as an economic indicator of one single individual, household income can serve as an economic indicator of multiple users, e.g., individuals living with their partners or younger adults living with their parents.

Amongst the most common formal financial services offered today, savings are very prominent amongst consumers. Amongst CBDC proponents, CBDCs may increase financial inclusion in some parts of the world as an alternative to savings accounts of commercial banks. Various research papers, which cover this topic, have been published in recent time (Tan, Central Bank Digital Currency and Financial Inclusion, 2023; Bijlsmaa, van der Cruijsen, Jonker, & Reijerink, 2021). Although some findings may indicate that consumers perceive rCBDCs distinctively from given commercial options (Zamora-Pérez, Coschignano, & Barreiro, 2022), we nonetheless include savings as a general economic factor.

In summary, economic factors relate to the following economic measurements in this research: personal income; household income; and savings; and other assets. Personal income and household income are commonly employed economic measurements in CBDC research (e.g., Bijlsmaa, van der Cruijsen, Jonker, & Reijerink, 2021; Bank for International Settlements, 2021). Furthermore, previous literature has identified the crucial role of savings accounts in the current economy, dominated by commercial banks, thus leading to the proposal of rCBDC savings accounts (e.g., Tan, 2023; Zamora-Pérez, Coschignano, & Barreiro, 2022). Based on these observations, we adopt the second hypothesis:

Hypothesis 2 (H_2): Economic factors significantly contribute to the consumer factor in CBDC adoption.

2.1.2 Personal Factors and Awareness/Knowledge Level

To further investigate user-centric factors in this research, personal factors explore demographic measurements, firstly: education; occupation; and age. Secondly, awareness/knowledge level regarding CBDCs are added – departing from formal education alone and explicitly pinpointing CBDC thematically. As research indicates, large portions of prospective users may lack awareness regarding CBDCs, due to their exotic nature (Abramova, Böhme, Elsinger, & Summer, 2022). Demographic measurements are commonly employed in CB and scholarly CBDC research (e.g., Bijlsmaa, van der Cruijsen, Jonker, & Reijerink, 2021). We adopt the following hypotheses as follows:

Hypothesis 3 (H_3): Personal factors significantly contribute to the consumer factor in CBDC adoption.
Hypothesis 4 (H_4): Awareness/knowledge level regarding CBDCs significantly contributes to the consumer factor in CBDC adoption.

2.2 Design Factor

Besides the consumer factor, the design factor is one other main independent variable in this research, however, the design factor is not concerned with intrinsic issues of the users – instead, the design factor solely steers from rCBDC design choices. Findings of interest concerning the design of the rCBDCs are summarized in the following sections, namely, efficiency (i.e., ease of use; fulfilment of payment needs; lower cost than commercial options; higher interest rate than commercial options; and offline payment needs), integrity (i.e., security from theft and fraud; and consumer protection), as well as safety (i.e., robustness and resilience; and equivalent to deposit insurance).The design factor is included as an independent variable with an emphasis on the bulk of previous literature, which largely focuses on CBDC design choices (e.g., Abramova, Böhme, Elsinger, & Summer, 2022; Bank for International Settlements, 2021; Zamora-Pérez, Coschignano, & Barreiro, 2022). Altogether, design-centered factors determine the degree to which the design factor as an independent variable positively affects rCBDC adoption, thus we assume:

Hypothesis 5 (H_5): The design factor positively affects rCBDC adoption.

2.2.1 Efficiency

Frequently CBDC research thematizes efficiency in CBDC design. Efficiency in this research relates to the following factors: ease of use; fulfillment of payment needs; lower cost than commercial options; higher interest rate than commercial options; and offline payment needs. In the context of CBDC research, the ease of use describes the level of efforts users are facing when handling novel CBDC technology. Various publications have explored ease of use, some of which identify it as a core element in CBDC design and an element of financial inclusion (e.g., Bank for International Settlements, 2021; Zamora-Pérez, Coschignano, & Barreiro, 2022). Both publications also cite payment needs as important factors in CBDC adoption and efficiency. Whilst an ECB publication further investigates the role of costs associated with CBDCs (Zamora-Pérez, Coschignano, & Barreiro, 2022), a publication of the Dutch CB identifies interest rate as a determinant in CBDC usage (Bijlsmaa, van der Cruijsen, Jonker, & Reijerink, 2021).

Lastly, as the CBDC economy largely operates digitally, CBDC research also covers offline functionalities and offline payment needs, which are of crucial importance, for example, in areas of lacking connectivity. Accordingly, we adopt the following hypothesis:

Hypothesis 6 (H_6): Efficiency significantly contributes to the design factor in CBDC adoption.

2.2.2 Integrity

Amongst the many topics in CBDC research, we also find various elaborations about integrity in the form of security, and consumer protection. Security in CBDC research is defined as a form of protection against loss or theft of money (Zamora-Pérez, Coschignano, & Barreiro, 2022). As CBDCs occupy the digital space, various publications, for example, explicitly propose cybersecurity techniques (Minwalla, 2020). Whilst CBDC security is often approached from a technical perspective, CBDC consumer protection tends to fall into the area of law and policymaking. Early publications identify consumer protection as a motivating factor in researching CBDCs – after all CBDCs may offer an alternative to volatile products of monetary value in the DeFi marketspace (Alonso, Fernández, Bas, & Kaczmarek, 2020). In recent publications from a legal perspective, CBDCs remain controversial – such is especially the case in countries and regimes with a high floor of data protection (Santaolalla, 2023). Accordingly, we adopt the following hypothesis:

Hypothesis 7 (H_7): Integrity significantly contributes to the design factor in CBDC adoption.

2.2.3 Safety

In midst of the various dynamics, ranging from the impact of volatile DeFi products of monetary value to the Covid-19 pandemic, the global financial market and banking sector frequently experience higher levels of scrutiny. Rather common indicators of interest are hereby a bank's ability to operationally withstand disruptions and shocks(robustness), and its capability to return to a stable operational equilibrium after passing disruptions or shocks (resilience) (Mens, Klijn, de Bruijn, & van Beek, 2011; Bond, Morrison-Saunders, Gunn, Pope, & Retief, 2015; Cao & Chou, 2022; de Vijlder, 2023). Another topic associated with disruptions and shocks in the banking sector is banking panic. From the perspective of policymaking, deposit insurance tends to be a common tool to address the issue of banking panic within a national banking system. Deposit insurances are thought to provide stability and mitigation against a systemic crisis (Nikolaj, Draženović, & Buterin, 2022; Williamson, 2022). Whilst the possible impacts of CBDC introduction have only been insufficiently covered by academia (Van Roosebeke, Van Roosebeke, & Van Roosebeke, 2023), major contributions to CBDC research reportedly discuss the feasibility of CBDC stability through technical design choices, such as distributed ledger technology (DLT) (Marketsmedia, 2023). Based on the observations above, we adopt the following hypothesis:

Hypothesis 8 (H_8): Safety significantly contributes to the design factor in CBDC adoption.

2.3 Privacy

Alternative products of monetary value in the space of DeFi space, such as cryptocurrencies, offer high levels of anonymity for users. Apparently, these levels of privacy are also highly demanded by users, if it comes to CBDC design choices, for example, in form of transaction privacy or data privacy (Zamora-Pérez, Coschignano, & Barreiro, 2022). More recent research refers hereby to cash-like privacy, exploring CBDC privacy through zero-knowledge proofs (ZKPs) (Gross, Sedlmeir, Babel, Bechtel, & Schellinger, 2022). Accordingly, we adopt the following hypothesis:

Hypothesis 9 (H_9): Privacy significantly contributes as a design factor in CBDC adoption.

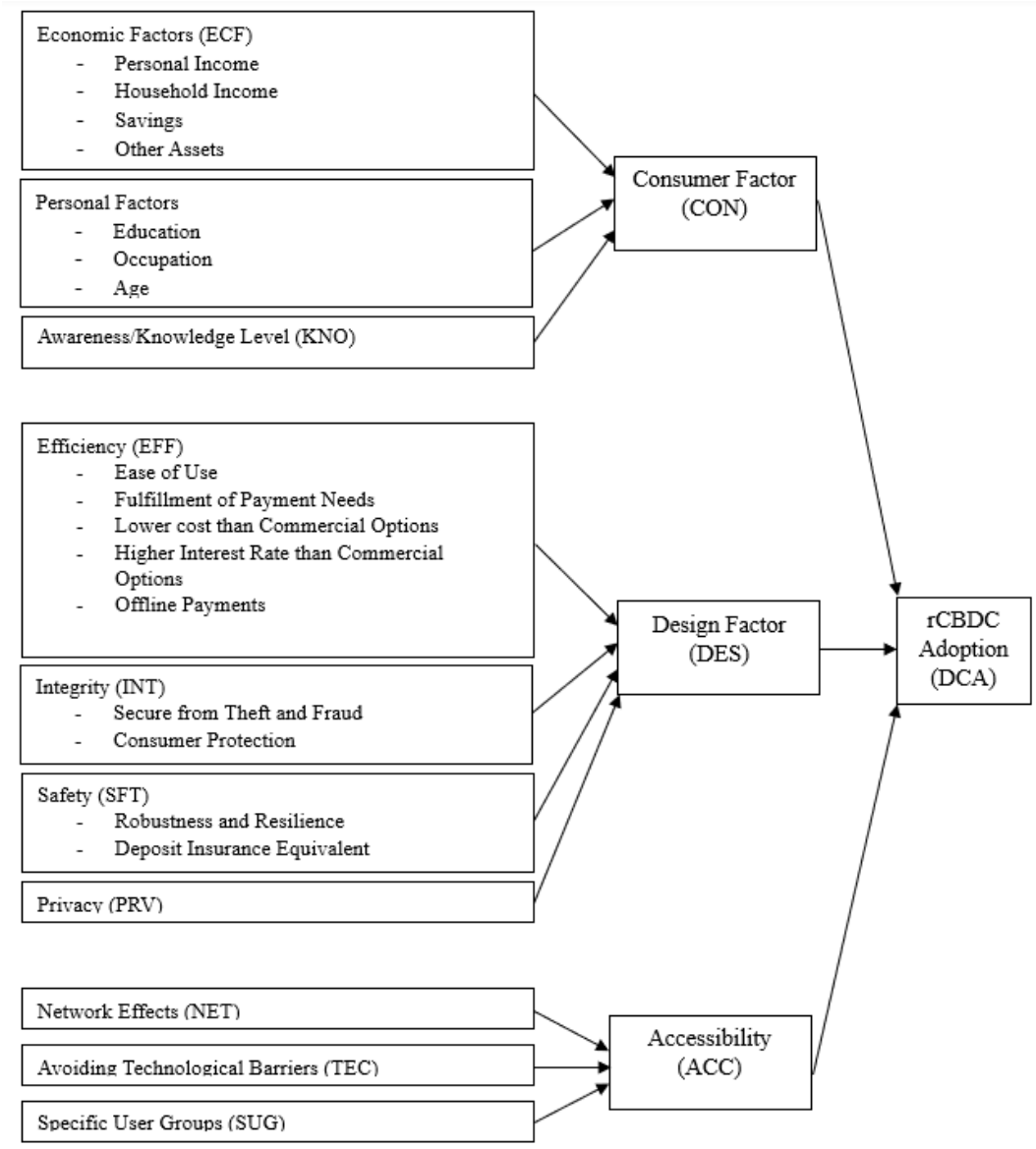
2.4 Accessibility

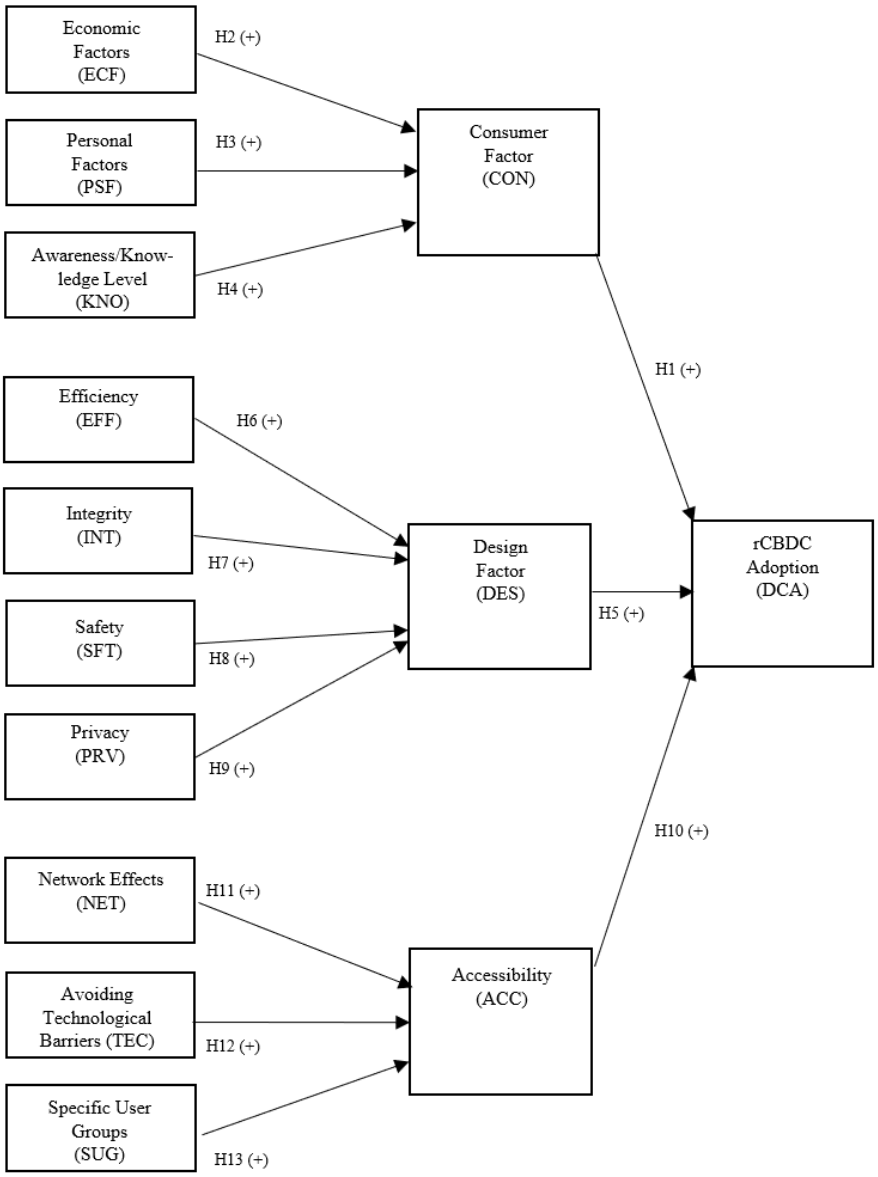
Following the consumer factor and design factor as the first two main independent variables in this research, accessibility is identified as the last main independent variable. The majority of CBDC research assumes accessibility as a core functionality of CBDCs with reference to enhanced financial inclusion through, for instance,

digitalization (Zamora-Pérez, Coschignano, & Barreiro, 2022; Lannquist & Tan, 2023). The most important findings concerning the topic of accessibility and financial inclusion in rCBDC research are as follows: network effects; technological barriers; and specific user groups. Current CBDC literature identifies network effects as one of many core functionalities CBDCs should have. Network effects hereby refer to enhanced functional capabilities of the digital currency to create synergies with existing financial, commercial, or public services (Abramova, Böhme, Elsinger, & Summer, 2022; Tan, Central Bank Digital Currency and Financial Inclusion, 2023). A similar perspective is considered when evaluating the technological synergies as well as dependencies CBDCs can create, for instance, with reference to digital infrastructures and technologies. Furthermore, it being argued, that CBDCs may have the capability to satisfy the needs of specific user groups through enhanced customization options – this would bring benefits to social minorities (Lannquist & Tan, 2023). We adopt these ideas in the following hypotheses:

Hypothesis 10 (H_{10}): Accessibility positively affects rCBDC adoption.
Hypothesis 11 (H_{11}): Network effects/fulfillment of specific user group needs significantly contribute as factors of accessibility in CBDC adoption.
Hypothesis 12 (H_{12}): Avoiding technological barriers significantly contributes as a factor of accessibility in CBDC adoption.
Hypothesis 13 (H_{13}): Compatibility significantly contributes as a factor of accessibility in CBDC adoption.

Figure 1: Conceptual Model





3. Research Methodology

To enable an empirical analysis of primary data with insights into user-sentiments towards rCBDC adoption factors, survey research has been identified as a suitable quantitative research method. The sections below discuss how data was collected and analyzed for this research.

3.1 Data Collection

3.1.1 Research Questionnaire

Before designing and distributing the survey, relevant secondary data touching the topic of rCBDCs and rCBDC adoption was collected. As an outcome of this first step, possible factors of rCBDC adoption have been identified, which consequently are discussed in the literature review of this paper. The design of the questionnaire largely follows the logical structure of the factors previously identified in the literature review and the conceptual model (figure 1). The purpose of the questionnaire is to gather insights into the user sentiments towards these factors.

The questionnaire consists of 14 sections. The first section briefly elaborates on CBDCs by referring to them as 'digital money'. The intention behind this simplification is to allow research participants from all kinds of educational backgrounds to understand CBDCs despite their rather exotic nature. Accordingly, the remainder of the questionnaire throughout all sections exclusively refers to digital money instead of CBDCs. Furthermore, the questionnaire does not thematize one specific CBDC, such as the Digital Euro or the Digital Renminbi. This simplification allows research participants across all CB jurisdictions to contribute to the survey. The following 11 sections consist of closed-ended questions. Participants are requested to assess each question on a 5-point Likert scale. Section 13 of the research questionnaire deviates from the Likert scale, as it is collecting demographic data, including gender, age, education, occupation, or the use of different types of other assets, amongst others.

As this research was conducted at National Formosa University in Taiwan, the questionnaire was first distributed in Mandarin Chinese, followed by a second distribution in English outside Taiwan. Each distribution occurred at one point in a time, making this a cross-sectional survey. The distribution of the survey was conducted online.

3.1.2 Selection of Research Participants

As previously mentioned, this research enables an empirical analysis of primary data with insights into user-sentiments towards rCBDC adoption factors. Logically, the primary agents identified in this research are the prospective rCBDC users themselves. The demographic range of the sample is not limited by age, gender, or other demographic factors. Furthermore, this research is not limiting itself to any specific CB jurisdiction. Consequently, research participants across all CB jurisdictions were invited to participate in the survey. Similar research has been conducted earlier, referring to user-needs in CBDC adoption, however, under the limitation of specific CB jurisdictions (e.g., Abramova, Böhme, Elsinger, & Summer, 2022). As implied above the sample of research participants is broad, nevertheless, due to technical limitations, the survey was distributed in two languages – Mandarin Chinese and English – as well as in two different locations – Taiwan and Germany. The resulting demographic data is discussed at the beginning of chapter four.

3.2 Data Analysis

Primary data retrieved through the distribution of surveys featuring a 5-point Likert scale are processed with LISREL in accordance with the assumption model. Hereby, we observe the following dependent variable followed by the independent variables: rCBDC Adoption = DCA; Consumer Factor = CON; Design Factor = DES; Accessibility = ACC; Economic Factors = ECF; Personal Factors = PSF; Awareness/Knowledge Level = KNO; Efficiency = EFF; Integrity = INT; Safety = SFT; Privacy = PRV; Network Effects, Specific User Groups = NSU; Avoiding Technological Barriers = TEC; Compatibility = COM.

3.2.1 Confirmatory Factor Analysis

To verify the quantitative structure within the complete array of manifest and latent variables used in this research, the model parameters are closely inspected through Confirmatory Factor Analysis (CFA) (Abrahim, Mir, Suhara, Mohamed, & Sato, 2019). Following the concept of an inferential model, CFA allows us to mitigate bias using means and variance–covariance matrices. The analysis follows the proposed equation model explaining rCBDC Adoption (DCA), primarily through the main independent variables, namely Consumer Factor (CON), Design Factor (DES), and Accessibility (ACC). We have employed the widely known LISREL software package to operate the CFA verification through adequate measurements, first and foremost, through goodness of fit.

3.2.2 Descriptive Statistics

Due to the demographic complexity of quantitative data in the sample, the characteristics of the sample data are more explicitly analyzed. That being the case, this paper makes use of descriptive statistics to provide a compact overview of scattered data in an organized manner. Various measurements of descriptive statistics are offered, including variability, spread of distribution, and proportions.

4. Results

4.1 Demographic Data

The distribution of the cross-sectional survey through freely accessible online platforms took place throughout the second and third quarter of 2023. As previously noted, the surveys were distributed in Mandarin Chinese and in English and in two different locations, namely Taiwan and Germany. More than 200 responses from Taiwanese participants did not qualify for this research, mostly due to missing data, leading to a total sample size of n=185. Of the 185 participants, 164 participants and 21 participants are of Taiwanese and German nationality respectively (88.6% and 11.3%). Many participants are in their early twenties, whilst the number of male participants (65.4%) in the sample is double the size that of female participants (32.9%). The most common educational level found is the Bachelor with 74.0%. Interesting findings are made regarding the use of marketable securities, such as stocks or bonds. Most users (56.2%) claim to use marketable securities. This contrasts the use of cryptocurrencies, which are found to be used amongst 6.4% of all participants. Ownership over tangible assets, such as gold, automobiles, and real estate, is the most common observation, making up to 65.9%. The findings are summarized on the next page (see table 1).

Characteristics	Categories	Frequency	Percentage
Nationality	Taiwanese	164	(88.6%)
	German	21	(11.3%)
Age	Under 20	27	(14.5%)
	20 – 25	101	(54.5%)
	26 – 30	30	(16.2%)
	Over 30	27	(14.5%)
Gender	Female	61	(32.9%)
	Male	121	(65.4%)
	Other	3	(1.6%)
Level of Education	Secondary educational degree	19	(10.2%)
	Bachelor	137	(74.0%)
	Master	26	(14.0%)
	Doctoral	3	(1.6%)
Marketable Securities	User	104	(56.2%)
(e.g., Stocks, Bonds)	Not a user	81	(43.7%)
Cryptocurrencies	User	12	(6.4%)
(e.g., Bitcoin, Ethereum)	Not a user	173	(93.5%)
Tangible Assets	Owner	122	(65.9%)
(e.g., gold, real estate)	Not an owner	63	(34.0%)

Table 1: Description of responses (n=185)

4.2 Covariance Analysis

	CON	DCA	ECF	PSF	EFF	INT	SFT	DES	ACC	PRV	COM	NSU	TEC	KNO
CON	.549													
DCA	.497	.949												
ECF	-.010	-.011	1.764											
PSF	-.069	-.526	1.335	20.609										
EFF	.131	.191	.003	.045	.189									
INT	.078	.103	-.037	-.277	.092	.316								
SFT	.016	.081	.022	-.376	.083	.181	.341							
DES	.066	.114	-.008	-.219	.111	.193	.194	.171						
ACC	.105	.165	-.047	-.262	.110	.172	.153	.149	.304					#
PRV	.039	.082	-.022	-.268	.083	.186	.174	.180	.161	.281				
COM	.034	.063	-.009	-.128	.078	.146	.107	.110	.167	.109.	.194			
NSU	.086	.170	-.114	-.448	.115	.173	.187	.163	.317	.177	.176	.387		
TEC	.124	.159	.021	-.076	.106	.172	.119	.135	.285	.144	.157	.251	.0323	
KNO	.575	.560	.016	-.047	.156	.072	.029	.075	.122	.043	.040	.101	.143	.649

Table 2: Covariance Matrix of Measure Variables (DCA = rCBDC Adoption; CON = Consumer Factor; DES = Design Factor; ACC =Accessibility; ECF = Economic Factors; PSF = Personal Factors; KNO = Awareness/Knowledge Level; EFF = Efficiency; INT = Integrity; SFT = Safety; PRV = Privacy; NSU = Network Effects, Specific User Groups; TEC = Avoiding Technological Barriers; COM = Compatibility)

Covariance values based on the multivariate data available, and variables set for this research are summarized in the covariance matrix of table 2. Diagonal values are hereby of interest, as they display the variance of each respective dataset. At a first glance, the matrix is exclusively composed of non-zero elements – the majority of which indicate positive linear relationships. Nonetheless, negative values were computed, too, leading to the observation of negative relations.

The Consumer Factor (CON) displays the lowest variance CON. The highest variance is observed for the Personal Factors (PSF).

4.3 Goodness-of-Fit Testing

To determine a fit, statistical testing based on the indices listed in table 3 was performed. First and foremost, the chi-square goodness-of-fit test results in a value of χ^2 = 813.865. This is a rather significant value, given the small sample size. Nonetheless, the ratio computed between chi-square statistic and degrees of freedom (χ^2/df) remains acceptable at a value of ≤4 (see figure 3).

Validity was also assessed based on the Goodness-of-Fit Index (GFI), Normed Fit Index (NFI), Comparative Fit Index (CFI), Incremental Fit Index (IFI), Root Mean Square Residual (RMR), and the Root Mean Square Error of Approximation (RMSEA). Whether the obtained figures represent a good fit or not is determined through commonly recommended values.

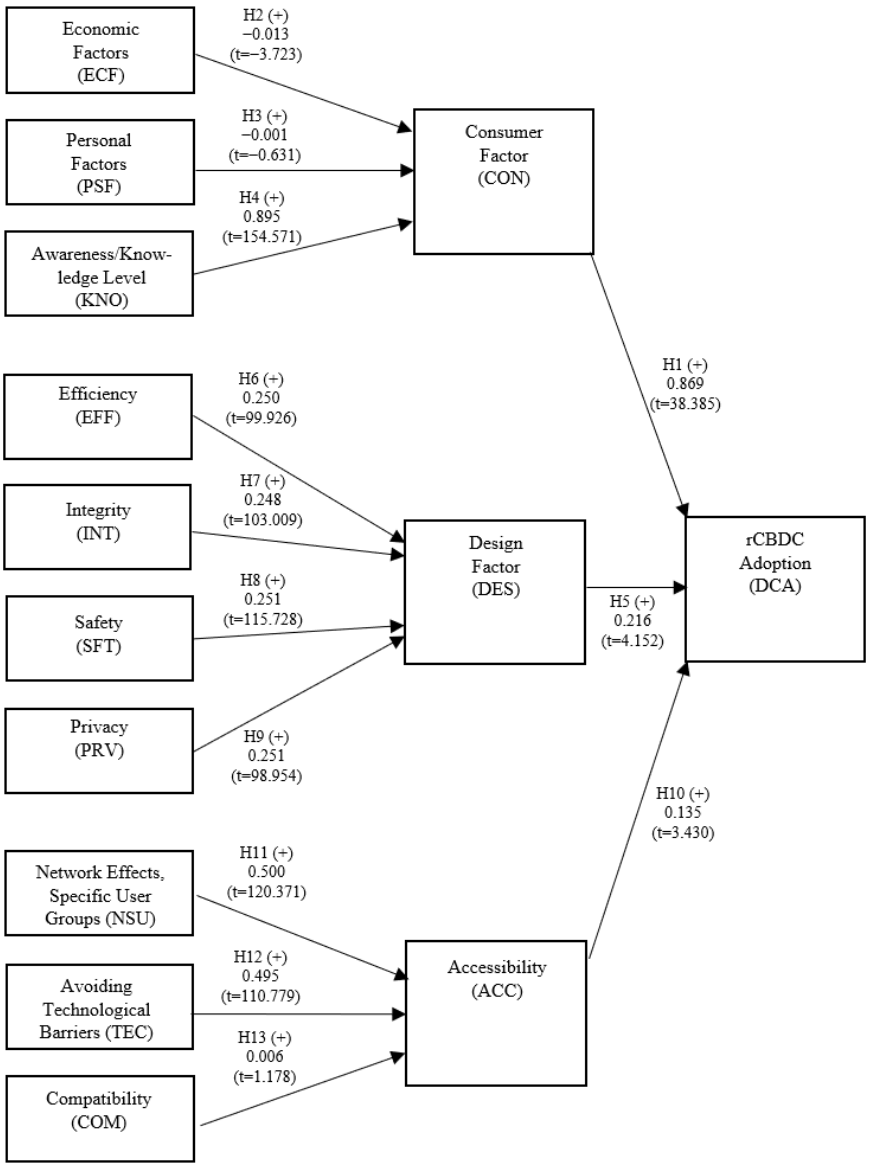
Besidesχ^2, the other absolute fit indices provided in this research are the GFI, the RMR, and the RMSEA. The GFI and RMR recorded are 0.973 and 0.0389 respectively. The index value for the GFI is acceptable at >0.90, whilst the RMR-value is small at 0.0389. Furthermore, the RMSEA obtained through LISREL represents good fitness at a value of 0.0402 – below the widely accepted benchmark of 0.07 and relatively close to 0.03 deemed as an excellent fit indicator.

The NFI, CFI, and NFI are the incremental fit indices provided in this research. The obtained values of 0.989 for the NFI and 0.992 for the CFI are acceptable. The normed value of 0.992 for the IFI is good at > 0.95.

Normed χ^2	**RMSEA**	**GFI**	**NFI**	**CFI**	**IFI**	**RMR**
813.865	0.0402	0.973	0.989	0.992	0.992	0.0389

Table 3: Goodness of Fit Indices

Figure 3: Result of Structural Hypothesis Model including Total Measurement Items (P < 0.01); Chi-square = 813.87, df = 204, p-value = 0.00, RMSEA = 0.040



4.4 Analysis of Estimates and t-Values

The construction of parameter values (hereafter also referred to as coefficients of the regression model) as well as the employment of test statistics and probability values (p-values) of test statistics are common and popular ways to approach hypothesis testing. After formulating the null hypothesis (H_0), the calculation of p-values provides a reliable insight into the probability givenH_0 is true. Corresponding to p-values, test statistics (t-statistics) allow a deeper assessment of sample data compared to what is to be expected under the null hypothesis.

Both p-values and t-statistics are primary indicators in validating H_0, which if rejected can be contrasted by the alternative hypothesis (H_A). An overview of p-values and t-statistics is added to the original structural hypothesis model (figure 3). T-statistics obtained exceeding a critical value of 1.96 indicate high significance at a probability level of 0.01. The p-value is within the expected value range of [0,1] at 0.00. Overall, this finding supports the parameter estimate of interest in this research as meaningful.

4.5Hypothesis Testing

The hypothesis testing throughout the following sections of this paper is based on the pooled sample data obtained from both surveys explained in the previous chapter. A total of thirteen hypotheses (H_1-H_{13}) have previously been formulated. Each hypothesis directly corresponds to a variable. The computed statistical outcomes are displayed in table 4 below.

Based on the sample data a positive coefficient of 0.869 is obtained for the consumer factor, indicating its positive effect on rCBDC adoption (H_1). The t-statistic is significant (t-statistic =38.385, p<0.01). Findings corresponding to the economic factors (H_2) and personal factors (H_3) deviate from this observation, due to the coefficient values and t-statistics obtained for both variables. For the economic factors thought to contribute to the consumer factor in CBDC adoption, negative coefficient values are obtained (coefficient = 0.869, t-statistic = −3.723, $p < 0.01$). Moreover, a negative coefficient value is obtained for the personal factors (coefficient = − 0.001), however, at a low statistical significance (t-statistic = − 0.631, $p < 0.01$). Unlike the economic factors and personal factors, the level of awareness/knowledge of CBDCs amongst users (H_4) does positive contribute to the consumer factor (coefficient = 0. 895, t-statistic = 154.571, $p < 0.01$). A positive coefficient of 0.216 (t-statistic = 4.152, $p < 0.01$) is obtained for the design factor, indicating its positive effect on rCBDC adoption (H_5). According to the original hypotheses formulated, efficiency (H_6), integrity (H_7), safety (H_8), and privacy (H_9) are expected to contribute to the design factor in CBDC adoption. In fact, coefficient values and t-statistics support this assumption (respectively: coefficient = 0.250, t-statistic = 99.926, $p < 0.01$; coefficient = 0.248, t-statistic = 103.009, $p < 0.01$; coefficient = 0.251, t-statistic = 115.728, $p < 0.01$; coefficient = 0.251, t-statistic = 98.954, $p < 0.01$). A positive coefficient of 0.135 (t-statistic = 3.430, $p < 0.01$) is obtained for accessibility, indicating its positive effect on rCBDC adoption (H_{10}). With regards to accessibility, hypotheses have been formulated pinpointing network effects/fulfillment of specific user group needs (H_{11}), avoidance technological barriers (H_{12}), and compatibility (H_{13}) as contributing factors to accessibility. Statistical findings support said assumption for network effects/fulfillment of specific user group needs (coefficient = 0.500, t-statistic = 120.371, $p < 0.01$) and the avoidance of technological barriers (coefficient = 0.495, t-statistic = 110.779, $p < 0.01$), both for which positive coefficients and high t-statistics are recorded. A low coefficient value of 0.006 and insignificant t-statistics of 1.178 ($p < 0.01$) for compatibility lead to the rejection of hypothesis 13.

Independent Variables	Hypotheses	Coefficient	t-statistics	Supported (Yes/No)
CON	H_1	.869	**38.385**	**Yes**
ECF	H_2	−.013	**−3.723**	No
PSF	H_3	−.001	−.631	No
KNO	H_4	.895	**154.571**	**Yes**
DES	H_5	.216	**4.152**	**Yes**
EFF	H_6	.250	**99.926**	**Yes**
INT	H_7	.248	**103.009**	**Yes**
SFT	H_8	.251	**115.728**	**Yes**
PRV	H_9	.251	**98.954**	**Yes**
ACC	H_{10}	.135	**3.430**	**Yes**
NSU	H_{11}	.500	**120.371**	**Yes**
TEC	H_{12}	.495	**110.779**	**Yes**
COM	H_{13}	.006	1.178	No

Table 4: Hypothesis testing; t-statistics> 1.96 or <−1.96 are held in bold.

5. Conclusion and Discussion

5.1 Discussion

5.1.1 Summary of Results

As stated introductorily, this paper addresses the research gap found in user-centered rCBDC research. It is hoped that through this research more tangible outcomes are attained, which shed light on critical factors in rCBDC adoption. Accordingly, we have identified factors commonly covered in existing rCBDC-related literature. These findings are compared with survey data through an empirical analysis. The resulting hypothesis testing yields potential for an elevated understanding of user-centric sentiments towards CBDC adoption factors.

First and foremost, user-centricity appears to play a crucial role in rCBDC adoption – that is, however, rather in form of addressing user needs through design choices than intrinsic attributes associated with the users. The importance of user needs and user protection through efficiency, integrity, safety, and privacy as design factors cannot be understated. Nonetheless, it should be noted that awareness of CBDCs and its conceptual underpinnings amongst users are imperative to ensure widespread rCBDC adoption. As a considerable number of survey participants stated to have never heard about CBDCs before, it may be argued that stakeholders on the governmental level and academic level, amongst others, may be required to further their efforts in educating and informing potential users about CBDCs. This observation also confirms the risk of mismatching visions of policymakers and actual users (Abramova, Böhme, Elsinger, & Summer, 2022), due to the absence of healthy discourses with future users.

Secondly, empirical analysis validates accessibility as a factor in rCBDC adoption. This is due to the positive user sentiments towards financial inclusion in the form of network effects, the satisfaction of needs amongst specific user groups, and the avoidance of technological barriers.

5.1.2 Consumer Factor, Economic Factor, Personal Factor, and Awareness/Knowledge Level

The consumer factor is exclusively concerned with intrinsic aspects of the user, meaning, factors contributing to this variable solely steer from the users themselves. In line with previous literature (e.g., Abramova, Böhme, Elsinger, & Summer, 2022; Bank for International Settlements, 2021; Zamora-Pérez, Coschignano, & Barreiro, 2022), the consumer factor and all factors contributing to it are of special interest due to the user-centricity of this research.

Hypothesis 1 (H_1), which assumes that the consumer factor positively affects rCBDC adoption, is accepted. Nonetheless, this observation must be scrutinized, as a closer inspection of the economic factor, including indicators such as income and savings (Tan, Central Bank Digital Currency and Financial Inclusion, 2023; Bijlsmaa, van der Cruijsen, Jonker, & Reijerink, 2021)as well as the personal factor, including mostly demographic assessments thought to contribute to the consumer factor reveals. Hypotheses 2 (H_2) and 3 (H_3) are rejected, diminishing the assumed correlation between economic factors and personal factors with the consumer factor. In contrast, hypothesis 4 (H_4), which poses the importance of awareness/knowledge level of potential rCBDC users, is accepted. Large portions of prospective users may lack awareness regarding CBDCs, due to their exotic nature (Abramova, Böhme, Elsinger, & Summer, 2022). This underscores the importance for potential users to be aware of rCBDCs and their conceptual functionality, independently of the education level of said users included in the personal factor of hypothesis 3.

5.1.3 Design Factor, Efficiency, Integrity, Safety, and Privacy

The design factor is not concerned with intrinsic issues of the users, meaning that its attributes solely steer from rCBDC design choices. The design factor is investigated due to the widely available scholarly literature available with focus on CBDC design choices (e.g., Abramova, Böhme, Elsinger, & Summer, 2022; Bank for International Settlements, 2021; Zamora-Pérez, Coschignano, & Barreiro, 2022). Hypothesis 5 (H_5) poses that the design factor positively affects rCBDC adoption and empirical analysis confirms this assumption. Furthermore, hypotheses 6-9 ($H_6 - H_9$) are accepted, thus efficiency, integrity, safety, and privacy contribute to the design factor in rCBDC adoption. These findings are in line with preceding publications (e.g., Bank for International Settlements, 2021; Zamora-Pérez, Coschignano, & Barreiro, 2022; Bijlsmaa, van der Cruijsen, Jonker, & Reijerink, 2021; Gross, Sedlmeir, Babel, Bechtel, & Schellinger, 2022). It is noteworthy that empirical evidence suggests that efficiency, integrity, safety, and privacy are equally correlated to the design factor due to their similar statistical significance. Whilst this implies that rCBDC design choices should align with existing functionalities and mechanisms ensuring enhanced protection of users, this rather advocates for rCBDCs to operate well beyond the current scope of protection offered through commercial options to be competitive.

5.1.4 Accessibility, Network effects/Specific User Groups, Technological Barriers, Compatibility

Current CBDC-related literature research advances accessibility to one of the core functionalities of CBDCs. Previous works have thematically linked CBDCs to financial inclusion (Zamora-Pérez, Coschignano, & Barreiro, 2022; Lannquist & Tan, 2023).

Empirical findings of this research suggest that accessibility does in fact positively affect rCBDC adoption, thus hypothesis 10 (H_{10}) is accepted.

A closer look at the concept of network effects, the inclusion of specific user groups, the avoidance of technological barriers as well as compatibility sheds light on this. Network effects, and the needs of specific user groups substantially touch the topic of financial inclusion. Hereby, functional capabilities of rCBDCs are hoped to create synergies with existing financial, commercial, or public services (Abramova, Böhme, Elsinger, & Summer, 2022; Tan, Central Bank Digital Currency and Financial Inclusion, 2023), whilst satisfying the needs of specific user groups through enhanced customization options (Lannquist & Tan, 2023).Survey data suggests that participants agree with these sentiments, therefore hypothesis 11 (H_{11}) and hypothesis 12 (H_{12}) are accepted. Surprisingly, hypothesis 13 (H_{13}) is rejected, thus user sentiments towards rCBDC compatibility with existing gadgets and technologies appear to be limited.

5.2 Research Limitation and Suggestions for Future Research

The demographic assessment of the sample data reveals that most survey participants in this research are of younger age. Their sentiments may not necessarily reflect the population across all age groups (table1). Although the survey was distributed in Taiwan and Germany, the research design and design of the survey are not geographically defined, thus this research reflects a broad sample. Future research should focus on one specific CB jurisdiction to allow conclusive results with regard to specific CBDCs. Current user-centric CBDC research covers a wide spectrum of topics. This research has attempted to narrow this spectrum down to three specific variables, namely the consumer factor, which intrinsically derives from the users themselves; the design factor, which steers from CBDC design choices; and accessibility thematically covering factors associated with financial inclusion. The systematic analysis of CBDC adoption is complex – it appears impossible to set priorities. Future research should expand the exploration of this issue by comparing variables through correlation coefficients.

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