FACTORS OF CHANGES IN THE PAYMENT SYSTEM. PRESENTATION AND TRANSITION TO (NEW) CURRENCY - CENTRAL BANKING DIGITAL CURRENCY (CBDC)

by

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Abstract

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Central Banking Digital Currency (CBDC) is the digital form of physical money [ex: Sand dollar in the Bahamas]. CBDCs were introduced in response to the interest of the public in digital payments, like non-fiat payment systems such as cryptocurrencies. These cryptocurrencies are often developed by individuals or large corporations. Thus, CBDCs are seen as a government-supported financial technology which is an alternative to cryptocurrencies. This research will be helpful to introduce CBDCs to future countries based on successful launches from other countries.

The goal of the project is to study the possibility of introducing digital currency of central banks into everyday life, which is a generalization of the research question about identifying factors influencing the adoption of digital currency within the state (what factors contribute to the expression of interest in CBDC in forms of adoption process stages by country).

This project intends to explore and apply machine-learning techniques to identify specific characteristics needed to reach particular stages and implement CBDC as a valid country currency. To study the implementation of CBDC in a particular country, data will be collected using open-source databases, and a dataset will be created directly on which the study will be performed.

Using machine-learning techniques, this project will answer questions about how quickly it is possible to implement CBDC, whether it will be successful, and predict the transition from a state of disinterest to the active use of this type of currency (payment system).

Identification of factors that can help in the implementation of the project, as well as the introduction and acceptance of CBDC, will be carried out.

Such identification will help in the introduction of a new payment system and provide the steps necessary to reach stability within the growth of non-governmental-supported cryptocurrencies in the financial sector.

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LIST OF ABBREVIATIONS

CBDC Central Banking Digital Currency

DLT Distributed Ledger Technology

GDP Gross Domestic Product

MNL Multinomial Logit

MLE Maximum Likelihood Estimation

ATM Automated Teller Machine

ICT Information and Communication Technology

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CHAPTER 1. INTRODUCTION

The modern world is a world of shocks, changes, and crises; traditions are collapsing; norms and conventions are being destroyed; all spheres of life are affected. In this regard, the ability to adapt to changes in the external environment can be considered as a tool for finding support points for action in situations of uncertainty. This project focuses on the financial and banking sectors.

Financial stability is a concern, and there are crucial differences between current conditions and those that have emerged since the global financial crisis. Since the onset of the COVID -19 crisis in early 2020, it is also clear that fiscal policy can be a significant driver of inflation [1-4]. Most countries experience excessive inflation.

The nature and frequency of shocks has changed. Monetary policy requires a modified approach that is resilient to sudden and unexpected changes in the macroeconomic scenario.

The central bank acts as the director of the modern economy. A central bank has de jure independence if it has the ultimate authority to establish a central bank digital currency.

Currently, more than 100 countries are exploring the possibilities of CBDC [6]. The emergence of a central bank digital currency (CBDC) as part of the ongoing digital currency revolution will allow central banks to explicitly set the interest rate paid on a CBDC, allowing them to enforce monetary policy impacts on the country. Banks do not fully pass on the impact of rate changes (especially rate increases) to households. Therefore, an increase in the discount rate set by central banks does not lead to an equivalent increase in deposit rates.

The introduction of CBDC will also play a crucial role in shaping the central bank's role in the economy. If central banks issue digital currencies, they will have to expand their balance sheets (roughly estimation of European Central bank is 34% of quarterly GDP). The central bank may decide to invest its increased portfolio in government bonds, providing strong fiscal policy support, or lend to the private sector, encouraging investment in specific sectors. Central banks will have to be careful about their reputation for independence because any investment decisions could have political consequences.

This thesis explores methods that can contribute to the expansion and dissemination of this type of payment. To do this, the criteria necessary for analysis will be selected and subsequently a set of data, followed by their analysis.

The dissertation consists of six parts, which reveal the project step by step:

The first part is an introduction, giving a general idea of the project.

The second part presents existing materials and research on and compatible with this topic.

The third part shows and describes a technique that makes it possible to familiarize oneself with the structure of the analyzing elements in an accessible form.

The fourth describes the data used, how to find it, and the process of collecting it.

The fifth part presents the results of the project obtained in the process of analyzing previously obtained data.

The sixth part is the final one, summarizing the study results and providing recommendations for applying the results obtained.

CHAPTER 2. LITERATURE REVIEW

Before determining what factors influence a person's choice of a payment system, it is important to clarify the true meaning of the payment, namely, to find out what money is. According to the definition made by Gregory Mankiw in his publications on *Macroeconomics*, money is the property of a person with the help of which they can make a certain transaction that is beneficial or necessary to them. Here one sees the functions performed by money [14]:

- preservation of value that does not disappear over a certain period;
- a means of making an exchange, using money to purchase an item or service a person needs;
- a quantitative function that determines the value of an object and unifies the method of ensuring this value.

Given the functionality of money, the next step is to define its change in representation. Starting from the changes and formation of nations, their evolution in terms of society and social values was described in Adam Smith's first publication, The Wealth of Nations, in 1776 [15]. The term "barter" (exchange by possession of goods) started to fade away, and the idea of a free-market system appeared. Further exploring this idea that the economy needs to be beneficial (progressed), but in the same way, regulated, French historian Fernand Braudel studied changes in monetary systems in Civilization and Capitalism, 15th to 18th Centuries, 1992. From his publication, one can trace how money was formed and changed its form depending on the development of civilization and its needs [5].

That hints at a conclusion that the payment system and the economy itself depend on society, its interactions, and its progress. That leads to changes that support the innovative growth and evolution of nations. And one of the drivers of those

changes is the aim of humanity to simplify the process. For example, the transition from physically heavy objects or precious metals to more transportable ones (gold into paper, etc.) was driven by the need for a more efficient medium of exchange. This evolution continues into the digital age, with the rise of cashless payments and digital currencies, further exemplifying this ongoing evolution.

Currency changes can occur for distinct reasons, including economic, political, and social factors. Some of the main reasons for currency changes include inflation, interest rates, government debt, political stability, and economic health.

Countries may introduce new currencies to achieve monetary independence, improve financial stability, and facilitate trade.

Another aim of the country or state can be to posses the dominant currency – the national currency of an economically highly developed state, which at the international level performs all the functions of money on a much larger scale than other key currencies. Before World War II, the British pound sterling dominated, and after the war to the present day, the US dollar dominated. The formation of the exchange rate of most currencies in the world is significantly influenced by the supply of foreign currency on the market, while the dominant one is based on the demand for it. As it is required not only for payment of domestic foreign trade contracts, but also for settlements on trade and non-trade transactions of third-party counterparties, for the formation of government reserves of other countries and private savings of non-residents, as well as for replacing the national currency in the domestic monetary circulation of other countries.

Introduction of a new currency itself can be beneficial and negative as well, the outcome depends on the government regulations and action made. Benefits of the introduction of the new currency:

1. Monetary Independence: The introduction of a new currency allows a country to control its monetary policy, which can be used to regulate the economy and stimulate economic growth.
2. Financial Stability: A new currency can help a country achieve financial stability if sound fiscal policies are followed at the time of its introduction or soon after its introduction.
3. Trade Facilitation: The introduction of a new currency can facilitate trade by reducing currency conversion costs and eliminating currency risk in international trade.
4. Economic growth: A new currency can help improve a country's balance of trade by making its exports more competitive in foreign markets and its imports more expensive, thereby stimulating domestic production and consumption.
5. Political stability: A stable currency can attract foreign investment, leading to faster economic growth and political stability.
6. Controlling Inflation: A new currency can help a country control inflation by allowing the central bank to implement appropriate monetary policy.

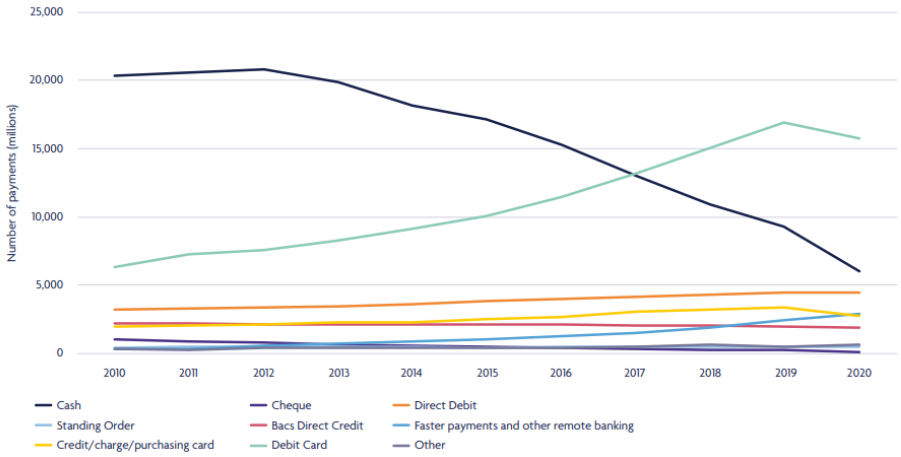
The resulting changes identify whether an item can be a monetary asset, as well as the definition of the authority that can determine and declare the item's value. Mankiw defines valuable money as paper money, that is, those funds that the authorities have defined as money. This type of money is convincing to the subjects of a particular state, which, under the influence of an authoritative object, gives money significance - the faith of those who use it. It is this characteristic that will appear in subsequent studies along with other components.

Over the past few years, the Taiwan Academy of Banking and Finance and Hank K.S. Huang, in the book *Fundamental Knowledge of Financial Technology,* 2020, highlighted the following payment methods: cash, checks, debit cards, credit cards, mobile payments and electronic bank transfers [13]. To simplify things, let us conditionally divide the options into three categories:

- physical (Cash, Checks);
- semi-physical (Debit cards, Credit cards);
- electronic (Mobile payments, Electronic bank transfers).

UK payments market research [16] provides information on the frequency of use of a particular payment type.

Figure 2.1. Payment volumes (in millions) from 2010 to 2020 in the UK [Source: 16 UK Finance].



As the figure above illustrates, the physical payment method is inferior to card methods and electronic ones. An electronic means of payment allows a client of a money transfer operator to draw up, certify and transmit orders to transfer funds using special technologies and storage media.

Cash transactions have decreased due to global political events, wars, pandemics such as COVID-19, which had a significant impact on the development of electronic payment methods and the creation of non-physical money - cryptocurrency.

Charles Kahn, Manmohan Singh, and Jihad Alwazir, in *Digital Money and Central Banking*, in their research describe the cryptocurrencies as a non-government-verified form of payment has strong citizen support—faith [12]. This factor (faith) among others was overseen by the financial authorities which led to the cryptocurrency strengthening in financial markets.

Based on information provided by the Bank for International Settlements, the interest and implementation of their cryptocurrency (mentioning of the banking interest toward the government cryptocurrency, 2015 [7]) by large companies (Facebook with its Libra cryptocurrency and so on) led to the active position of the government for government-supported cryptocurrency investigation. And the idea was born to create a state cryptocurrency called Central Banking Digital Currency (CBDC).

The main difference between CBDC and cryptocurrency is their support from the state. But both types of payment are an alternative to the physical type (cash, checks), as defined by the Atlantic Council.

As stated earlier, the main difference between regular cryptocurrency and central bank cryptocurrency, and what government aims to achieve, is government support and public trust; depending on the technology used (government can familiarise the citizens with the term of CBDC, and creating policies for its support), the last element can be achieved without much difficulty.

Technologies that are considered for the CBDCs are Distributed Ledger Technology (DLT), for peer-to-peer transactions, as well as non-DLT in another cases.

Architecture of CBDC based system:

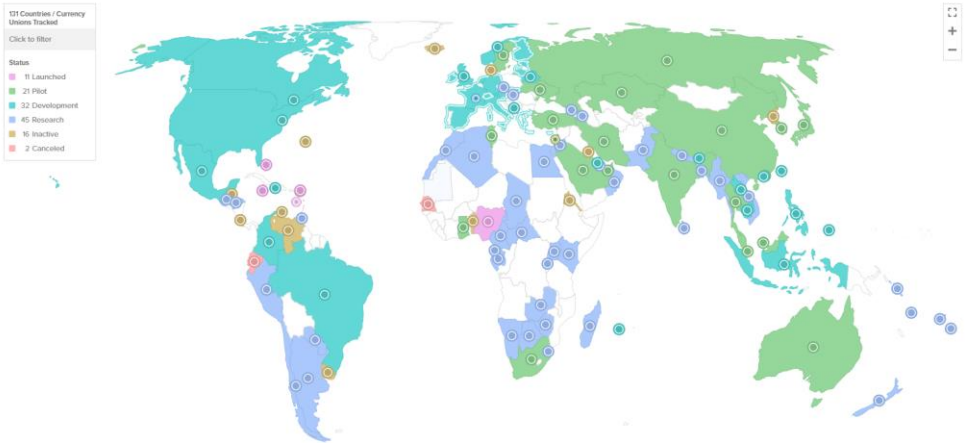
1. Account-based. Transactions approved between sides on the verification of user's identities.
2. Token-based. Transactions approved between sides based on public-private key pairs and digital signatures.

There are currently two types of CBDC models:

1. Retail CBDC (which is like existing technologies such as cards and online payments) – to summarize, this model can be thought of as country–level technology, a "micro-economic" level technology. There are indirect retail CBDC, direct retail CBDC and hybrid retail CBDC models defined per authority distribution.
2. Wholesale trade CBDC (analogue of cross-border transaction technology) - this model is focused on the interaction of financial institutions, and this technology can be attributed to the "macroeconomic" level. Based on existing research on CBDC wholesale trading, it is predicted that this technology will surpass the Swift system in speed and other characteristics. There is consideration on Domestic payments and Cross-border transactions.

Figure 2.2 shows the countries that are participating in the CBDC study, 131 countries are studying the possibility of implementing a CBDC, including Ukraine [6, 7]. Of greatest interest for the study are those countries that have introduced currency into the system, as well as those that are developing pilot versions and are directly involved in its testing.

Figure 2.2. Country participation in exploring a new type of currency [Source: 7 Atlantic Council].



Information provided by the Bank for International Settlements on the pilots of the countries selected above will appear in the study. A model will be built with the criteria used to establish payment methods on the market and similar ones.

CHAPTER 3. METHODOLOGY

The objective of this project is to determine the adaptability of the new payment system, which is CBDC. Additionally, another objective is to observe the stage of investigation of payment acceptance by country. This can be achieved by creating the dataset. The dataset consists of demographic factors, socio-economic factors, development factors, and geographical factors. These variables and their connectivity will be identified and explained in the data-and-results chapters.

Methodology explanations:

By analysing feature importance (identifying what criteria to choose in relation to the dependent variable) and multicollinearity identification (identification of the interpretability of the defined criteria) and comparison according to factors chosen, it becomes possible to understand the dynamics of research into a new type of payment.

Those techniques enable to predict the use of the selected type of payment by creating an equation.

The data set is compiled from several sources based on reports from the central banks of the countries featured in the government cryptocurrency study. To do this, a data set was collected for each country with different criteria. The formula mentioned below for analyzing the connection and type of operation according to pre-selected criteria is as follows:

$$\mathbf{status} = \beta \cdot \mathbf{criterias} \quad (1)$$

status – what status of adoption of CBDC is in the country;
criterias - criteria selected (as those may influence the choice towards adopting a new payment type).

The next stage is collecting information on the types of payments used, namely, the identified criteria that affect the desired dependent variable. The data in the range was formed and systematized, the data set was sorted and filtered according to new criteria.

The data sets from the first and second steps will be combined into one. The resulting data source was analyzed using a multinomial (MNL) logit model, as it supplies the opportunity to assess the multicategory nature of the dependent variable, which is the CBDC implementation status. The obtained result will let us analyze the model's behavior and view its predicted behavior according to specified criteria.

The process also uses other methods of analysis and assumptions, for example, random forest provides the opportunity to evaluate the importance of the collected criteria in relation to the desired variable (in the project it is used as classifier in support to the feature selection). Evaluating the results of the model allows one to determine the dataset and select the most successful model in terms of assessing the influence of the model for further determination of the feature which influence state of CBDC adoption in country.

The findings also contribute to further data construction over time, which in turn allow one to predict data for a coming period. For this purpose, the random forest method, lasso, and others are used. During the analysis, the most optimal result is selected. This method is designed for future expansion of this study.

The first phase data set will be supplemented by countries included in the Atlantic Council study, considered as countries that have implemented a central bank cryptocurrency system, as well as countries that are analyzing and testing pilot versions (pilot stages will be treated as an adoption criterion, as a criterion for user familiarity

with this type of payment) and, on a par with them, those that exist, but have no interest in implementing CBDC.

Countries occupying leading positions will be ranked according to the sampling frame (the period for which the analysis is performed by year).

Based on the results obtained, an analysis is made of the economic and technical development of countries around the world with the determination of criteria suitable for the countries under study, which will make it possible to determine and formulate a plan for their improvement for the introduction and promotion of CBDC in the market. The resulting criteria make it possible to introduce CBDC in countries where its research has not been started.

Since the data is of a panel type, methodologies for working with time periods will be applied to it.

In addition, in subsequent studies, if it is possible to obtain data from a country that has not implemented a CBDC, its entry into the market in that country can subsequently be predicted, as well as the output of the strongest and weakest qualities that can be considered when introducing a CBDC.

Based on the results, a conclusion and recommendations will be formed.

CHAPTER 4. DATA

This study has no analogue; the compilation and collection of data for analysis is carried out from scratch.

4.1 Sources of data collected

4.1.1 First source

First source is *CBDC Tracker* project [6], which, along with news sources from Coinbase, provides information on changes and interest in implementing CBDC by country.

This source that provided data on the implementation of Central banking digital currency – Status. The 5 types of changes are:

1. Canceled – countries that have canceled or decommissioned CBDC.
2. Research – countries that have conducted the first explanatory research on CBDC.
3. Proof of Concept – countries that are at an advanced stage of research and have published proof of concept for CBDC.
4. Pilot - Countries that have developed a CBDC that is being tested in a live environment either with a limited number of parties or on a large scale.
5. Launched - Countries that have officially fully launched a CBDC.

Years of this event (dating from 1993 to 2023).

Type of CBDC - Retail_or_Wholesal:

- Retail.
- Wholesale.
- Retail-Wholesale.
- Other.

Digital_currency – name of currency.

Central_Bank – name of the central bank.

Structure:

- Account.
- Token.
- Account/Token.

Technology_Provider – name of the supplier.

Technology – name of technology.

DLT_or_non-DLT – whether CBDC uses distributed ledger technology (DLT) or not).

Country – name of countries that are researching CBDC - 131 countries.

Subsequently, the information was adjusted and compared according to the news announcement for each country.

4.1.2 Second source

The second source [19] is *World Bank Statistics***,** which provides socio-economic and demographic information for 266 countries. For convenience, the years are selected from the beginning of active participation in the CBDC study (2017-2021).

Then formation which is currently available includes:

income groups. Distributed by income level:

- High-income.
- Lower-middle-income.
- Upper-middle-income.
- Low-income countries.

Development Regions. Distributed by development:

- the least developed.
- less developed.

- more developed.
- unclassified, of which the unclassified ones were removed after data cleaning).

Region (abbreviations: EAP, ECA, LAC, MENA, NA, NC, SA, SSA).

Region name (East Asia & Pacific, Europe & Central Asia, Latin America & Caribbean, Middle East & North Africa, North America, Not Classified, South Asia, Sub - Saharan Africa),

Other factors collected: Population, male, female, rural, urban, GDP (constant from 2010).

4.1.3 Third source

Third source [9] *Human Development Reports*, which includes data by country, which is available for 191 countries:

HDICode. Can be low, high, medium, or very high

HDI – Human Development Index, which can provide information on quality of life.

4.1.4 Fourth source

Fourth source [11], *The International Monetary Fund (IMF)*, contains values economic factors for 191 countries:

FD (Financial Development index) – a metric that ranks nations based on the breadth, accessibility, and efficiency of their financial institutions and markets.

FI (Financial Institutions index) - aggregation of three financial institutions indices.

FM (Financial Markets index) - aggregation of three financial markets indices.

FID (Financial Institutions Depth index) – measure size of financial institutions in relation to GDP.

FIA (Financial Institutions Access index) – measure that determines access to bank branches and ATMs per 100,000 adults.

FIE (Financial Institutions Efficiency index) – measure that evaluates efficiency through the use of numerous banking industry criteria.

4.1.5 Fifth source

Fifth source provides data about electronic control [17], *The United Nations E-Government Development Database (UNeGovDD)*, information provided for 193 countries:

E-Government Index – assesses e-government by looking at online services, telecommunication connections, and human capital.

E-Participation Index – measures citizen participation in government decisions as well as the efficacy of online services.

Online Service Index – assesses the use of information communication technologies by the government, concentrating on service availability, quality, and connection.

Human Capital Index – measures the effect of health and education on future production.

Telecommunication Infrastructure Index – measures a country's digital infrastructure's resilience and capacity to deal with technological difficulties.

For each average will be calculated so that the years are consistent and available from 2017 to 2021(as information for 2016, 2018, 2020 and 2022 is available).

4.1.6 Sixth source

Sixth source [19], *Our World in Data***,** including information about political modes by countries, selection was done from 2017–2022.

Regime – distinguishes between:

- closed autocracies - score 0.
- electoral autocracies - score 1.
- electoral democracies - score 2.
- liberal democracies - score 3.

By analyzing these features from various data sources, we can gain a comprehensive understanding of the factors influencing CBDC adoption in different countries and regions.

This information can help policymakers, central bankers, and other stakeholders make informed decisions about the development and implementation of digital currencies.

4.2 Type of collected data and its primary processing

Collected data from sources have next view, Table 4.2.

Table 4.2 – Data collected.

Feature	**Year: 2017-2023, Outliers (single data for 1993, 2014, 2016)**
country	Country name per year
Country Code	Country code per year
income_groups	Category of the income group of country per year
Development Regions	Category of the Development Regions of country per year
hdicode	Category of the hdicode of country per year
region	Category of the region of country
region_name	Category of the region name of country
population	Population counted per country per year
pop_mill	Population counted in millions per country per year
male	Male population counted per country per year
male_mill	Male population counted in millions per country per year
female	Female population counted per country per year
female_mill	Female population counted in millions per country per year
rural	Rural population counted per country per year
urban	Urban population counted per country per year
GDP	Gross domestic product constant from 2010
HDI	Human Development index
regime	Category of the regime of country per country

Table 4.3 – Data collected (continues).

Feature	**Year: 2017-2023, Outliers (single data for 1993, 2014, 2016)**
E-Government Index	E-Government Index counted per country per year
E-Participation Index	E-Participation Index counted per country per year
Online Service Index	Online Service Index counted per country per year
Human Capital Index	Human Capital Index counted per country per year
Telecommunication Infrastructure Index	Telecommunication Infrastructure Index counted per country per year
digital_currency	Currency name per country (per year of introduction)
Central_Bank	Name of the Central Bank or finance state per country
Status	Category of status of CBDC per country per year
Retail_or_Wholesale	Category of CBDC being Retail or Wholesale or both.
Structure	Type of the structure: account or token based per country
Technology_Provider	Technology provider of CBDC
FD	Financial Development index counted per country per year
FI	Financial Institutions index counted per country per year
FM	Financial Markets index counted per country per year
FID	Financial Institutions Depth index counted per country
FIA	Financial Institutions Access index counted per country
FIE	Financial Institutions Efficiency index counted per country
Technology	Name of technology used (defined per its provider)

Since not all countries have publicly available information, those that have the most complete information on the selected ranges of independent variables will be selected from the generated dataset.

Thus, for the primary analysis, categories on financial development and information on power were excluded and years from 2017-2020 were selected (where the data dominates).

Since the analysis is carried out by country and not by region, for the European area (where the countries of interaction in the CBDC study are not indicated) it is assumed that countries using the euro as the main/national currency are the players in the study.

The countries excluded because of the lack data are (30 countries, 9 of which accept participation in interaction with CBDC): American Samoa, Anguilla (digital currency research – DCash, from 2017 and pilot status from 2019), Aruba, Bermuda, British Virgin Islands, Cayman Islands, Channel Islands, Curacao (digital currency research – Curacao CBDC, from 2018), Democratic People's Republic of Korea (North Korea) (news article about CBDC research, from 2019), Faroe Islands, French Polynesia, Gibraltar, Greenland, Guam, Isle of Man, Kosovo (as part of Euro area – research of 2020 on Digital Euro), Macau (digital currency research – Macau CBDC, from 2021), Monaco (as part of Euro area – research of 2020 on Digital Euro), Morocco (digital currency research – Morocco CBDC, from 2021), Nauru, New Caledonia, Northern Mariana Islands, Palestine (digital currency research – Palestine CBDC, from 2017), Puerto Rico, Sint Maarten (Dutch part), St. Martin (French part), Taiwan (digital currency research – Taiwan CBDC, from 2020 and status proof of concept from 2022), Turks and Caicos Islands, Virgin Islands (US), West Bank and Gaza.

Also, some countries participate in cross-border projects (Wholesale projects) alongside to retail one, so the unique values (meaning the one country name per one year entity) with the highest indicator for each year (whether highest Retail CBDC status or highest Wholesale CBDC) will be chosen.

After data preparation (cleaning in terms of the null and outliers processing or deletion), the dataset consists of 183 countries, data for which are selected over 4 years (2017-2020), which provides 732 observations. The dataset employs a panel data type, which will lead to specific model to be chosen for its analysis.

This data provides us with information about changes in status (what state of status is identified per country per year) as a dependent variable and other criteria selected for analysis for each country within a filtered period. The next step is to analyze the obtained data using the Python programming language to perform statistical analysis of the data and answer the questions/hypotheses (according to how the data will be analyzed) about whether and how much the selected criteria influence the dependent variables.

CHAPTER 5. RESULTS

The fifth chapter is devoted to the results of our analysis by categories, starting from the models and ending with forecasting methods.

The initial phase of this study involved collecting data for the study, and then examining the collected data to identify structure and patterns across it. In the process, those data were selected that most correspond to the stated purpose of this study.

5.1 Inspection of received data

5.1.1 Correlation matrix

By examining the correlation matrix, we can understand what leads to a change in status (meaning change between the category identified in Status variable).

Figure 5.1. Correlation Heat Map

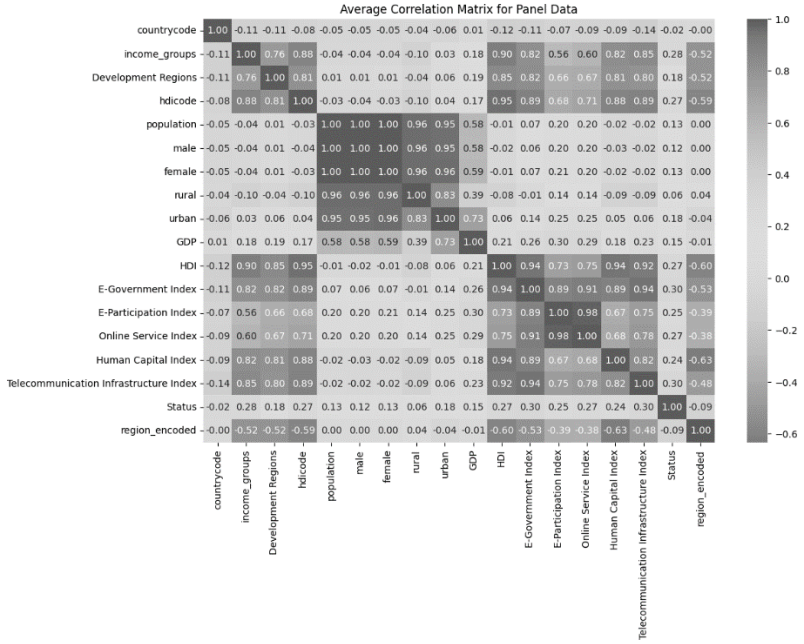


Figure 5.1: Correlation heat map (see figure description below) shows the strength and direction of the correlations.

Additional correlation matrices for each year are available for review in the Appendix.

The status is positively influenced by Telecommunication Infrastructure Index, E-Government Index, E- Participation Index, Online Service Index, HDI, income_groups, Development Regions, GDP, Human Capital Index, which indicates that with higher values the status in the country is higher.

5.1.2 Testing for multicollinearity

To check the values for multicollinearity, the Variance Inflation Factor (VIF).

Table 5.1. Multicollinearity

ID	Variable	VIF
0	const	2.451568e+02
1	hdicode	1.179285e+01
2	population	inf
3	male	9.007199e+15
4	female	9.007199e+15
5	rural	7.531794e+08
6	urban	6.847660e+08
7	egovi	7.412525e+07
8	epi	3.338395e+01
9	osi	1.481681e+07
10	hci	8.559064e+06

Table 5.2. Multicollinearity (continues)

ID	Variable	VIF
11	telii	1.295966e+07
12	income_groups	7.110033e+00
13	devr	3.939721e+00
14	HDI	3.481783e+01
15	GDP	3.600478e+00
16	region_encoded	1.923319e+00

This type of testing is carried out to understand whether there is a possibility of problems with the interpretation of the dependent variable since the values of the variables can be calculated from other variables, which subsequently affects the interpretation of the results obtained. In table 5.1 we can see the results of this testing.

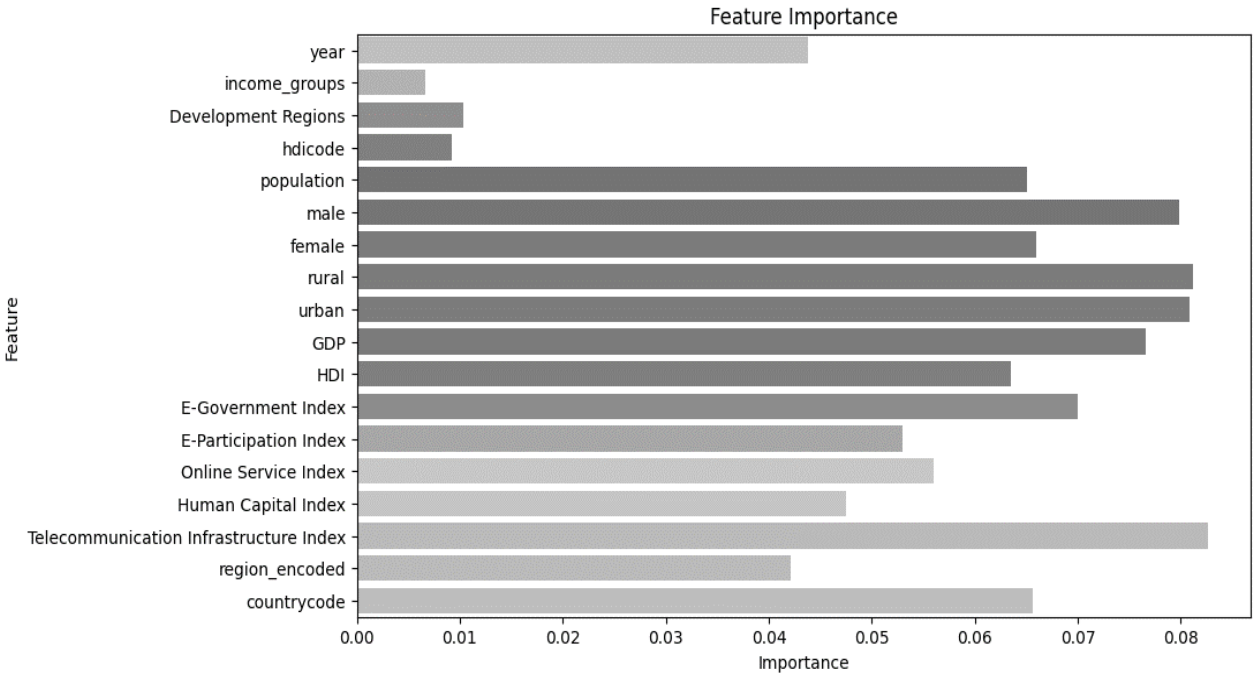
The highest indicators of multicolinearity are found in variables responsible for the population and its distribution, giving us the opportunity for analysis to avoid multicolinearity by excluding variables with the highest correlation (one of the 'population', 'male', 'female', 'rural', and 'urban').

5.1.3 Feature importance

To view which variables most, influence the dependent (search) variable.

Figure 5.2 illustrates the importance of the influence of each independent variable on the dependent variable in its prediction.

Figure 5.2 Feature importance plot (average)



On this basis, we can compile indicators that will be selected for executing the model, see table 5.2.

From the table, the indicators that should be involved in building the model, since they have the greatest impact, are characterized by "+" (Telecommunication Infrastructure Index, E- Participation Index, GDP, countrycode), those that have an average influence or are subject to multicollinearity "?" (population, male, female, rural, urban, HDI, E-Government Index).

Table 5.3. Selecting elements for the model according to their meaning

Year	2017	2018	2019	2020	
Countrycode	0.0836	0.075	0.0651	0.0536	+
income_groups	0.0056	0.0124	0.0094	0.0389	-
Development Regions	0.0039	0.0109	0.0167	0.0164	-
Hdicode	0.0106	0.0147	0.0097	0.0261	-
Population	0.0644	0.0666	0.0683	0.0602	?
Male	0.0561	0.0788	0.0706	0.0557	?
Female	0.0664	0.0676	0.0574	0.0504	?
Rural	0.0624	0.0904	0.0834	0.0548	?
Urban	0.0956	0.0698	0.091	0.0667	?
GDP	0.1063	0.0974	0.0866	0.0706	+
HDI	0.0622	0.0574	0.0798	0.0865	?
E-Government Index	0.0538	0.0701	0.0525	0.1053	?
E- Participation Index	0.0781	0.058	0.0631	0.0463	+
Online Service Index	0.0611	0.0429	0.0734	0.0775	?
Human Capital Index	0.0421	0.0451	0.0442	0.0443	-
Telecommunications Infrastructure Index	0.0913	0.0952	0.0807	0.1088	+
region_encoded	0.0564	0.0476	0.048	0.038	-

For convenience selected values will be paraphrased for more comfortable and convenient view in the models: 'Development Regions' - 'devr ', 'E-Government Index' - 'egovi ', 'E-Participation Index' - 'epi', 'Online Service Index' - 'osi ', 'Human Capital Index' - 'hci ', 'Telecommunication Infrastructure Index': 'telii '.

5.2 Data separation and model selection

The choice of model depended primarily on the values contained in the data. Due to the panel type of data, as well as the multicategory nature of the dependent variable, several models were tested to estimate them (the first of which was survival model, Ordinary Least Squares and then preference was given to Multinomial logit).

The first model with subsequent indicators seeks to identify whether there is a relationship between the independent and dependent variables and how this influence changes based on the multicategory type of the dependent variable.

For this purpose, the model chosen was Multinomial logit model and, in order to react directly to the panel view of the data that we have in the desired dataset, this model is filtered by country code (df. filter(like = ' countrycode '). columns. tolist) and considered by year([' year ']).

5.2.1 First model

For testing first models were selected parameters - 'income_groups', 'devr', 'hdicode', 'population', 'egovi ', 'epi', 'HDI', 'GDP', 'region_encoded' for identification their influence on 'Status':

$$\mathbf{Status=\beta\_0\cdot income\_groups+\beta\_1\cdot devr+\beta\_2\cdot hdicode+\beta\_3\cdot population+\beta\_4\cdot egovi+\beta\_5\cdot epi+\beta\_6\cdot HDI+\beta\_7\cdot GDP+\beta\_8\cdot region\_encoded} \quad (2)$$

It looks like this when tested:

model _ h 1 = sm. MNLogit(df [' Status '], df [[' income _ groups ', ' devr ', ' hdicode ', ' population ', ' egovi ', ' epi ', ' HDI ', ' GDP ', ' region _ encoded '] + df. filter(like = ' countrycode '). columns. tolist() + [' year ']]).

This model fits data - Current function value: 0.639258, the results of which can be traced.

Table 5.4. Results of the first model - MNLogit Regression Results

========== MNLogit Regression Results ==========			
Dep. Variable:	Status	No. Observations:	732
Model:	MNLogit	Df Residuals:	704
Method:	MLE	Df Model:	24
Date:	Tue, 8 Aug 2023	Pseudo R- squ.:	0.1257
Time:	03:52:54	Log-Likelihood:	-467.94
converged:	True	LL- Null:	-535.20
Covariance Type:	Nonrobust	LLR p- value:	2.331e-17

Of the 732 parameters, 704 are residuals degrees of freedom and 24 – degrees of freedom of the model itself. The model explains approximately 12.57% - goodness of fit of the variation in the dependent variable which indicated by pseudo-R -squared.

The model is statistically significant as the likelihood ration test p-value is 2.331e-17~0.

Further indicators represent comparisons between each status category and the baseline (Status =0 – none or canceled). Each table contains a characteristic of each parameter's influence according to each stage of the status.

Table 5.4 provides indicators by Status=1 stage research of the Central Banking Digital Currency.

Table 5.5. Results of Status=1

Status=1	Coef	std err	z	P>|z|	S	0.025	0.975
income_groups	0.0842	0.273	0.309	0.757		-0.450	0.618
devr	-0.3656	0.309	-1.184	0.237		-0.971	0.240
HDI	8.0951	2.579	3.138	0.002	*	3.039	13.151
GDP	1.253e-13	5.98e-14	2.095	0.036		8.06e-15	2.43e-13
region_encoded	0.0484	0.083	0.582	0.561		-0.115	0.211
countrycode	0.0032	0.002	1.457	0.145		-0.001	0.007
year	-0.0040	0.001	-5.349	0.000	***	-0.005	-0.003
S:	Significance codes: 0 ‘***’, 0.001 ‘**’, 0.01 ‘*’, 0.05 ‘.						

For Status 1, compared to the baseline, we can see that the indicators 'income_groups', 'hdicode', 'population', 'egovi', 'epi', 'HDI' have a positive impact(increase) on 'Status=1', 'GDP', 'region_encoded', 'countrycode', which indicates that as the values of these parameters increase, an association with 'Status = 1' occurs.

'year' and 'devr', bring negative influence. With their value growth associated a decrease in the likelihood of 'Status =1' appearance.

The most significant are the changes in 'HDI'(with an impressive value of 8.0951) and 'year'(with a value of -0.0040), as they are statistically significant for this model.

Table 5.5 provides the values of indicators for Status = 2 stage proof of concept

Table 6.5. Status results Status = 2

Status=2	Coef	std err	z	P>|z|	S	[0.025	0.975]
income_groups	-0.8307	0.490	-1.696	0.090		-1.791	0.129
devr	0.1585	0.578	0.274	0.784		-0.974	1.290
HDI	12.4477	4.647	2.679	0.007	*	3.340	21.556
GDP	1.203e-13	8.1e-14	1.485	0.137		-3.85e-14	2.79e-13
region_encoded	0.3041	0.139	2.184	0.029		0.031	0.577
countrycode	0.0001	0.004	0.038	0.970		-0.008	0.008
year	-0.0059	0.001	-4.315	0.000	***	-0.009	-0.003
S:	Significance codes: 0 ‘***’, 0.001 ‘**’, 0.01 ‘*’, 0.05 ‘.						

For Status 2, compared to baseline, we can see that the indicators 'devr', 'hdicode', 'population', 'egovi', 'epi', 'HDI' have a positive impact (increase) on 'Status=2'.

'GDP', ' region _ encoded ', ' countrycode ', which indicates that as the values of these parameters increase, an association with ' Status =2' occurs.

Again, 'year' and ' income_groups ', bring negative influence, with their growth is associated with a decrease in the likelihood of 'Status =2'.

The most significant are the changes in 'HDI' (12.4477), 'region_encoded'(0.3041) and ' year '(-0.0059), as they are statistically significant for this model.

Table 5.6 provides the values of indicators for Status = 4 stage pilot.

Table 5.7. Results of Status =3

Status=3	Coef	std err	z	P>|z|	S	[0.025	0.975]
income_groups	1.9564	0.589	3.321	0.001	**	0.802	3.111
devr	-1.9534	0.644	-3.032	0.002	*	-3.216	-0.691
HDI	2.6037	5.000	0.521	0.603		-7.196	12.404
GDP	1.501e-13	8.97e-14	1.673	0.094		-2.57e-14	3.26e-13
region_encoded	0.1024	0.145	0.705	0.481		-0.182	0.387
countrycode	0.0002	0.004	0.058	0.954		-0.008	0.008
year	-0.0038	0.001	-2.762	0.006	*	-0.006	-0.001
S:	Significance codes: 0 ‘***’, 0.001 ‘**’, 0.01 ‘*’, 0.05 ‘.						

'income_groups' (1.9564), 'devr' (-1.9534) and 'year' (-0.0038) are most statistically significant for given models.

Table 5.7 provides the indicator values for Status =4 stage launched.

Table 5.8. Results of Status =4

Status=4	Coef	std err	z	P>|z|	S	[0.025	0.975]
income_groups	0.0650	1.467	0.044	0.965		-2.810	2.940
devr	-0.6258	1.602	-0.391	0.696		-3.767	2.515
HDI	9.3280	13.505	0.691	0.490		-17.141	35.797
GDP	9.957e-14	2.38e-13	0.419	0.675		-3.66e-13	5.65e-13
region_encoded	0.1321	0.412	0.321	0.748		-0.675	0.939
countrycode	-0.0014	0.011	-0.128	0.898		-0.024	0.021
year	-0.0059	0.004	-1.521	0.128		-0.014	0.002
S:	Significance codes: 0 ‘***’, 0.001 ‘**’, 0.01 ‘*’, 0.05 ‘.						

For ' Status =4' none of the predictor variables appear to be statistically significant in predicting it. This result may come from the fact that the amount of this indicator in the collected data for the selected period is the smallest.

After receiving the results of this model, which are illustrated in Table 5.4-5.7, complementary models were created, the most accurate of which is the following model, which is aimed at studying the influential indicators identified by the first model, to improve this model. To also consider robustness, the subsequent model uses HC3.

5.2.2 Second model

Variables were created for this model to eliminate the possibility of multicollinearity:

- composite index of rural/urban:

```
df [ ' Urban_Rural_Development_Index '] = (df [ 'urban'] + df [ 'rural']) / 2
```

- - composite index of female/male:

```
df [ ' Gender_Diversity_Index '] = (df [ 'male'] - df [ 'female']). abs()
```

For testing the first models were selected parameters - 'Gender_Diversity_Index', 'Urban_Rural_Development_Index', 'osi', 'telli', and 'GDP' for identification their influence on 'Status'.

The second model has the formula form:

Status=β_0·Gender_Diversity_Index+β_1·Urban_Rural_Development_Index+β_2·osi+β_3·telli+β_4·GDP+β_5·countrycode+β_6·year (3)

What was formed to build the model:

```
model_rem=sm.MNLogit(df['Status'],df[['Gender_Diversity_Index','Urban_Rural_Development_Index', 'GDP', 'osi', 'telii'] + df.filter(like= 'countrycode'). columns. tolist() + [ 'year']])
```

This model fits data - 0.602594, the results of which can be seen in tables 5.8-5.12.

Table 5.9. Results of the second model - MNLogit Regression Results

MNLogit Regression Results			
Dep. Variable:	Status	No. Observations:	732
Model:	MNLogit	Df Residuals:	704
Method:	MLE	Df Model:	24
Date:	Tue, 10 Oct 2023	Pseudo R- squ.:	0.1758
Time:	03:40:15	Log-Likelihood:	-441.10
converged:	True	LL-Null:	-535.20
Covariance Type:	Nonrobust	LLR p-value:	1.964e-27

The model explains approximately 17.58% - goodness of fit of the variation in the dependent variable which indicated by pseudo-R -squared. The model is statistically significant as the likelihood ration test p-value is 1.964e-27~0.

In the table below there are the parameters with statistical significance 'Gender_Diversity_Index', 'year', 'telli', 'GDP', 'Urban_Rural_Development_Index', from which the value of 'telli'(5.3292) and 'year'(-0.0027) are more impactful since they are statistically significant and have a larger value for this model.

Table 5.10. Results for the status Status= 1, model 2

Status=1	Coef	std err	z	P>|z|		[0.025	0.975]
Gender_Diversity_Index	-3.503e-07	9.86e-08	-3.552	0.000	***	-5.44e-07	-1.57e-07
Urban_Rural_Development_Index	2.748e-08	6.47e-09	4.245	0.000	***	1.48e-08	4.02e-08
GDP	-2.113e-13	7.6e-14	-2.779	0.005	*	-3.6e-13	-6.22e-14
osi	0.4959	0.804	0.617	0.538		-1.080	2.072
telii	5.3292	0.890	5.987	0.000	***	3.584	7.074
countrycode	0.0057	0.002	2.450	0.014		0.001	0.010
year	-0.0027	0.000	-10.140	0.000	***	-0.003	-0.002
S:	Significance codes: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.						

Table 5.11. Results of Status =2, model 2

Status=2	Coef	std err	z	P>|z|	S	[0.025	0.975]
Gender_Diversity_Index	-4.183e-07	1.49e-07	-2.808	0.005	*	-0.0	-0.0
Urban_Rural_ Development_Index	3.102e-08	0.0	3.249	0.001	**	0.0	0.0
GDP	-2.452e-13	0.0	-1.911	0.056		-0.0	0.0
osi	4.2602	1.765	2.414	0.016		0.802	7.719
telii	3.2909	1.565	2.103	0.035		0.224	6.357
countrycode	0.0038	0.004	0.903	0.367		-0.004	0.012
year	-0.0041	0.001	-6.745	0.000	***	-0.005	-0.003
S:	Significance codes: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.						

The most significant are changes in the indicators 'Gender_Diversity_Index', 'Urban_Rural_Development_Index' and the expressive value of 'year'(-0.0041) since they are statistically significant for this model.

Table 5.12. Results of Status = 3, model 2

Status=3	Coef	std err	z	P>|z|	S	[0.025	0.975]
Gender_Diversity_Index	2.782e-08	1.68e-07	0.165	0.869		-3.02e-07	3.58e-07
Urban_Rural_ Development_Index	7.247e-09	1.12e-08	0.647	0.517		-1.47e-08	2.92e-08
GDP	-2.931e-14	1.34e-13	-0.219	0.827		-2.92e-13	2.34e-13
osi	-4.9097	1.390	-3.532	0.000	***	-7.634	-2.185
telii	9.1910	1.695	5.421	0.000	***	5.868	12.514
countrycode	0.0029	0.004	0.661	0.509		-0.006	0.012
year	-0.0029	0.000	-6.024	0.000	***	-0.004	-0.002
S:	Significance codes: 0 ‘***’, 0.001 ‘**’, 0.01 ‘*’, 0.05 ‘’.						

From them most significant are changes in the indicators: 'telli' (9.1910), with large positive coefficient suggests that higher values of it are associated with a slightly higher likelihood of ' Status =3'.

'osi'(-4.9097) - negative average coefficient suggests that as the value of the 'osi' variable increases, the log-odds of the outcome being ' Status =3' decrease; and 'year' (-0.0029), are statistically significant for given models.

Table 5.13. Results of Status = 4

Status=4	Coef	std err	z	P>|z|	S	[0.025	0.975]
Gender_Diversity_Index	1.125e-09	5.06e-07	0.002	0.998		-9.9e-07	9.92e-07
Urban_Rural_ Development_Index	3.324e-09	3.95e-08	0.084	0.933		-7.41e-08	8.07e-08
GDP	-2.276e-14	3.88e-13	-0.059	0.953		-7.82e-13	7.37e-13
osi	-2.2405	4.044	-0.554	0.580		-10.167	5.686
telii	8.8252	4.970	1.776	0.076		-0.916	18.566
countrycode	0.0014	0.012	0.114	0.909		-0.022	0.025
year	-0.0045	0.002	-2.962	0.003	*	-0.008	-0.002
S:	Significance codes: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.						

For status ' Status =4', the parameter ' year '(-0.0045) is the only statistically significant for this model.

By comparing these two models, we can form values for them for each status that are the most significant in table 5.13.

Table 5.14. Model 1 and model 2 most significant parameters comparison

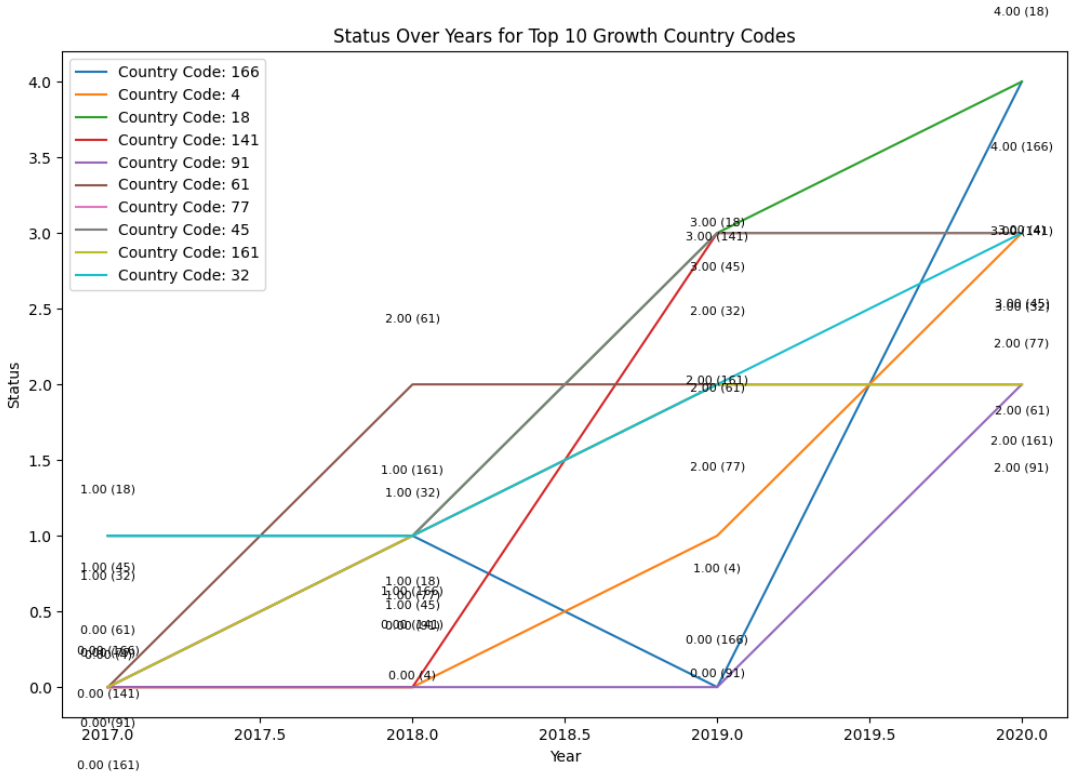
Model 1				Name	Model 2			
Status 1	Status 2	Status 3	Status 4		Status 1	Status 2	Status 3	Status 4
8.0951	12.4477	x	x	HDI	x	x	x	x
x	x	x	x	GDP	-2.113e-13	x	x	x
x	0.3041	x	x	region_encoded	x	x	x	x
-0.0040	-0.0059	-0.0038	x	year	-0.0027	-0.0041	-0.0029	-0.0045
x	x	1.9564	x	income_groups	x	x	x	x
x	x	-1.9534	x	devr	x	x	x	x
x	x	x	x	Gender_Diversity_Index	-3.503e-07	-4.183e-07	x	x
x	x	x	x	Urban_Rural_Development_Index	2.748e-08	3.102e-08	x	x
x	x	x	x	osi	x	x	-4.9097	x
x	x	x	x	telii	5.3292	x	9.1910	x

We can observe a certain stability that with changes in years (over a span of years), the number of countries in a being certain status (in none, cancelled, research, proof of concept, pilot, launched) change.

5.3. The top 10 countries with changed status over time from 2017-2020.

To better analyze the data, we analyzed them and selected the most outstanding countries in terms of changes (by calculating the average status value for countries for 2017-2020 and calculating the changes between them for 2017-2020, obtaining the value of status growth), shown in Figure 5.3.

Figure 5.3. Status over years for top 10 growth country codes



On the figure we can observe selected countries with most interesting (progressive) development and change in the status that can be traced using the table in Appendix: 4 – United Arab Emirates (none to pilot), 18 – Bahamas (research to launched), 32 – China (research to pilot), 45 – Dominica (research to pilot), 61 – Ghana (none to proof of concept), 77 – Iran (none to proof of concept), 91 - South Korea (none – proof of concept), 141 - Saudi Arabia (none - pilot), 161 – Thailand (none to proof of concept), 166 – Tunisia (none to launched).

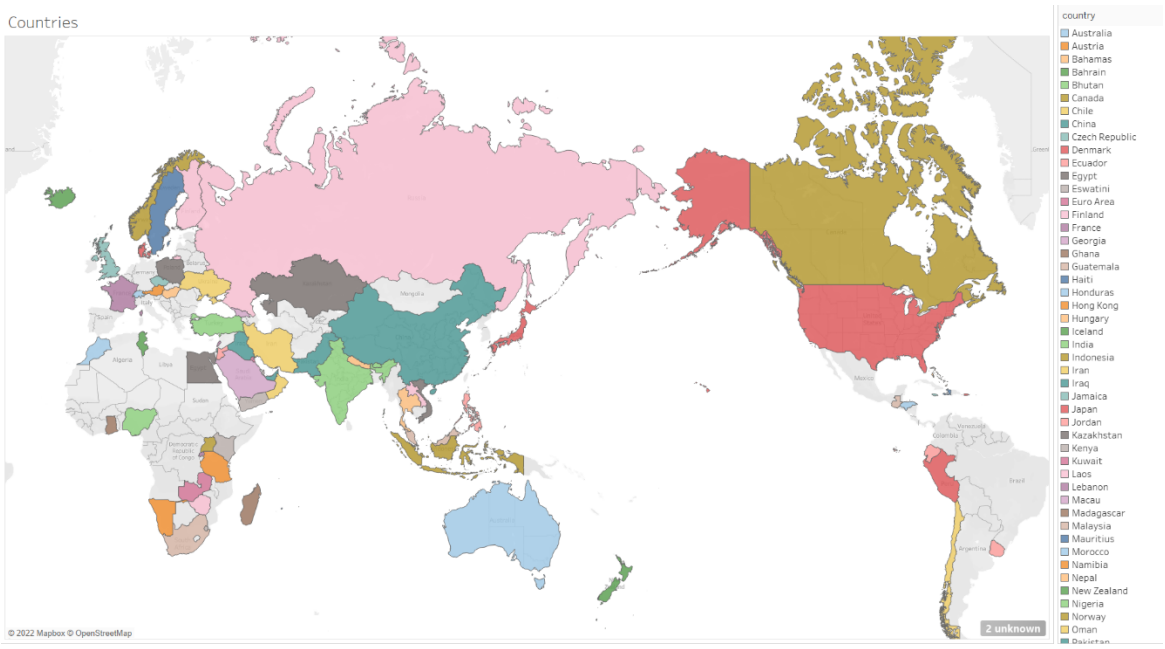
CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

This study determines the criteria and factors influencing the introduction of digital currency into the payment system of the banking sector. By analyzing the stages of development and studying the digital currency of the central bank for 183 countries, a certain pattern of success for the project being studied was identified.

The dataset consists of several types of data obtained from reliable sources.

The dataset consists of several types of data obtained from reliable sources.

Figure 6.1. Country distribution of a dataset using Tableau



All data was collected using the Microsoft Excel application, which was later used for analysis directly using the programming language and later Python.

For convenience, some types of data have been divided into categories to analyze each of them using the methods mentioned in the methodology. For example,

for a separate analysis of the dependence of gender, age and type of household, these data were divided into categories.

Using models that best suited the type of data collected, we were able to identify the factors that influence the desired variable. The factors analyzed in the project do influence the new currency, namely the status of its implementation. We can distribute the conclusion according to the types of factors that had the most significant impact on a certain status.

For example, we can see and confirm that over time - ' year ' (in this case from 2017 to 2020) - the status in one category or another changes, which leads to a negative relationship between time and status (over the years, the number of countries in a certain status change in favor of another stage of status).

Socio-economic factors:

Socio-economic factors such as ' HDI ' had a big influence on the change in status towards research (' Status =1') and proof of concept (' Status =2') according to Model 1. This is a good insight for countries that have not started the study, which is in the status none / canceled (' Status =0').

The socio-economic factor 'income_groups' influences and is inherent in the achievement of pilot ('Status =3') according to Model 1. With an increase in the value in 'income_groups' (high income level - 3, above average income level - 2, lower-middle income - 1 or low income - 0) increasing log-odds of the outcome being 'Status =3'. That is, when a country is high-income or upper-middle income it is most influential in relation to this pilot CBDC achievement.

Another socio-economic factor 'Development Regions' or 'devr'(which is described by a categorical value and can be least developed - 0, less developed - 1 or

more developed - 2) is correlated with transition to the pilot status (' Status =3') according to Model 1.

While for Model 2 the ' GDP ' factor had a slight negative impact in relation to the research status (' Status =1'), with its increase the probability of adoption of this status decreases, but this effect is negligible on the log-odds due to the value approaching zero (-0.0000000000002113).

(E - Government) Development factors:

These types of factors are also important, since they have an impressive influence in relation to pilot (' Status =3') according to Model 2.

'Online Service Index' or 'osi' has negative influence. When its variable increases the log-odds of the outcome being ' Status = 3' decrease significantly.

'Telecommunications Infrastructure Index' or ' telii ' provides significant positive influence. When this variable increases, the log-odds of the outcome being pilot increase very significantly. The same effect for this parameter can be seen in relation to the log-odds of the outcome being 'Status =1'.

Demographic factors:

Based on values of rural and urban, composite index 'Urban_Rural_Development_Index' was created to except multicolinearity. It renders minor positive influence toward research (' Status =1') and proof of concept ('Status =2') according to Model 2. The log-odds of the outcome being 'Status = 1' or 'Status=2' also negligibly increasing.

Composite index of female and male – 'Gender_Diversity_Index', renders minor positive influence on research ('Status =1') and proof of concept ('Status =2')

according to Model 2, which means that with its growth the log-odds of the outcome being 'Status =1' or 'Status = 2' also negligibly decrease.

Geographical factors:

Geographical factor ' region_encoded ' turned out to be influential and distinctive of achievement of proof of concept ('Status =2') according to Model 1. We can say that there is a dependence between regions, which gives us the opportunity to think about the presence of competition according to regions, and countries located in the same region are more inclined to act and participate in the adoption and development of new technology. However, we must also consider the fact that the influence of these factors is not massive (0.3041).

The recommendations that can be given to countries to advance in status according to the analysis performed by the models:

1. Not all factors that have been identified as important directly influence the model.
2. In order to move from the none/cancelled position to the research position, countries need to improve indicators such as Gross domestic product (in order to more actively move through the stages of research/implementation status) and focus on the sectors of the composite rural/urban (it is possible to conduct and disseminate information about this type of payment for each person that makes up the population of the country). It is also necessary to work on disseminating and maintaining awareness among residents of both sexes in an option such as Central Banking Digital Currency (since we can observe a negative effect from Gender Diversity Index).
3. To switch to status of proof of concept, we need to concentrate on increasing GDP, Online Service Index (scope and quality of online services in the country) and consider Human Development Index. At the same time, it is necessary to

work with the population's awareness of the new type of payment, regardless of location (rural/urban) or gender (female/male).

4. To move to the pilot and launched stages, you need to focus your attention on income groups, increase the level of income in the country (which is distributed by income level: countries with high income - 3, lower middle income - 1, upper middle income - 2 or low income - 0) and take into account 'Telecommunication Infrastructure Index' (development status of telecommunication infrastructure) with a development plan in mind, taking into account rapid changes and the emergence of new technologies every year.

The findings can be used by participating countries and future players in the study when implementing a central bank digital currency.

Further work with the collected data may include inspection and research for 2021-2023 (and beyond those points), information on which is missing due to the update time of the sources from which the data was taken. Forecast data can be implemented using machine learning techniques (considering the panel data type of the collected dataset). Also, for countries where data is missing, you can fill in with synthetic data, which will expand the number of observations and help get new insights.

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APPENDIX. FIGURES

In this appendix there are introduced correlation and importance feature plot outputs per each time point.

Figure Appendix_1. Correlation matrix year 2017

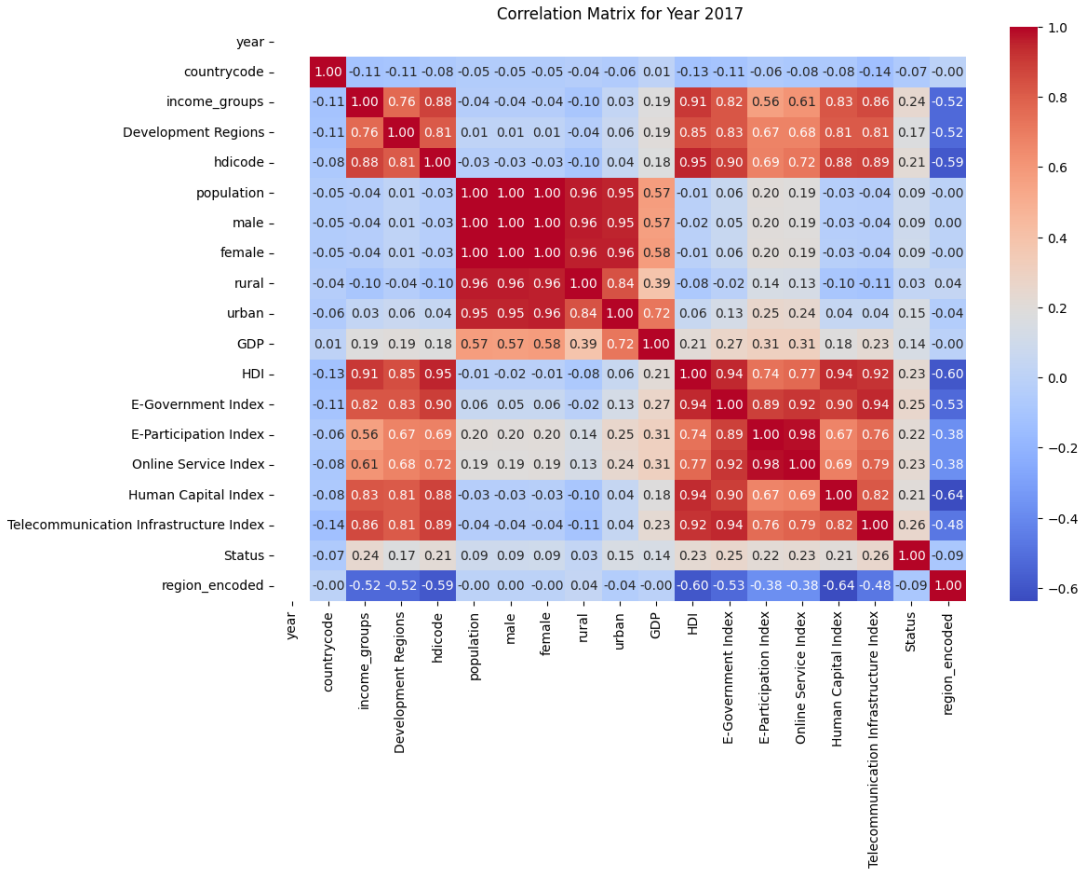


Figure Appendix_2. Correlation matrix year 2018

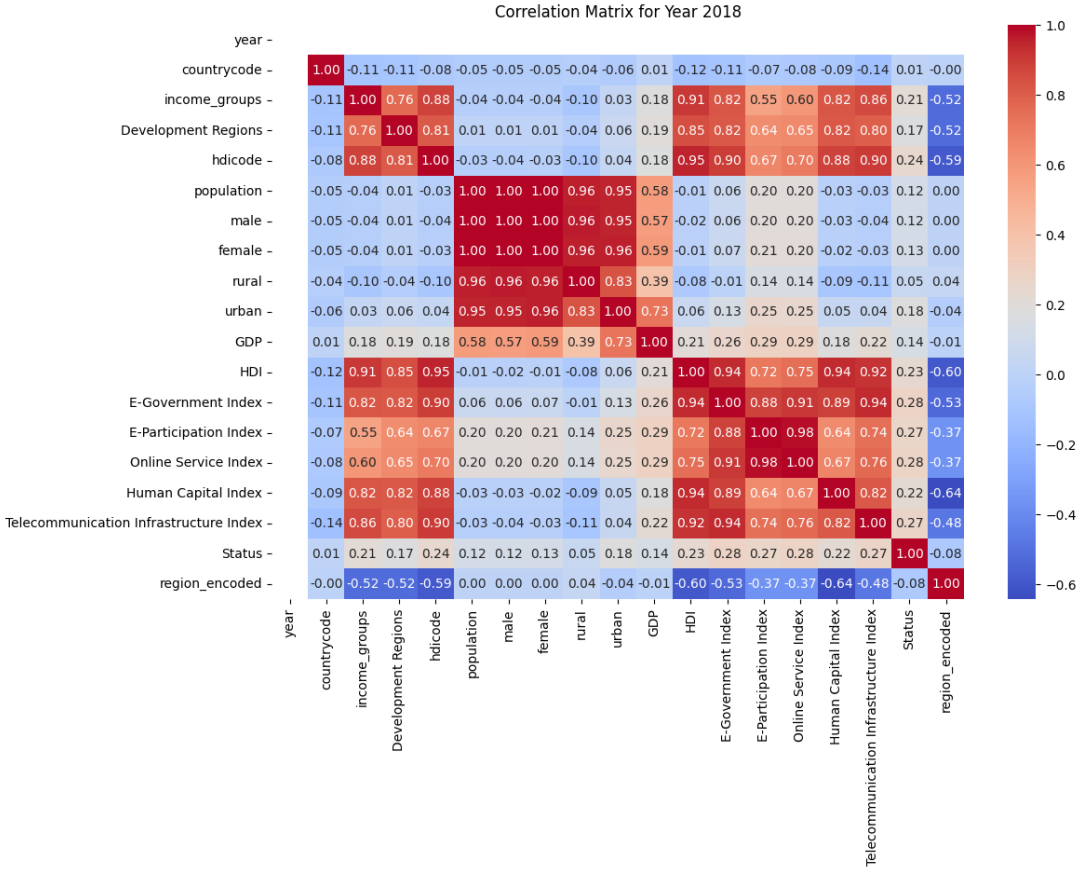


Figure Appendix_3. Correlation matrix year 2019

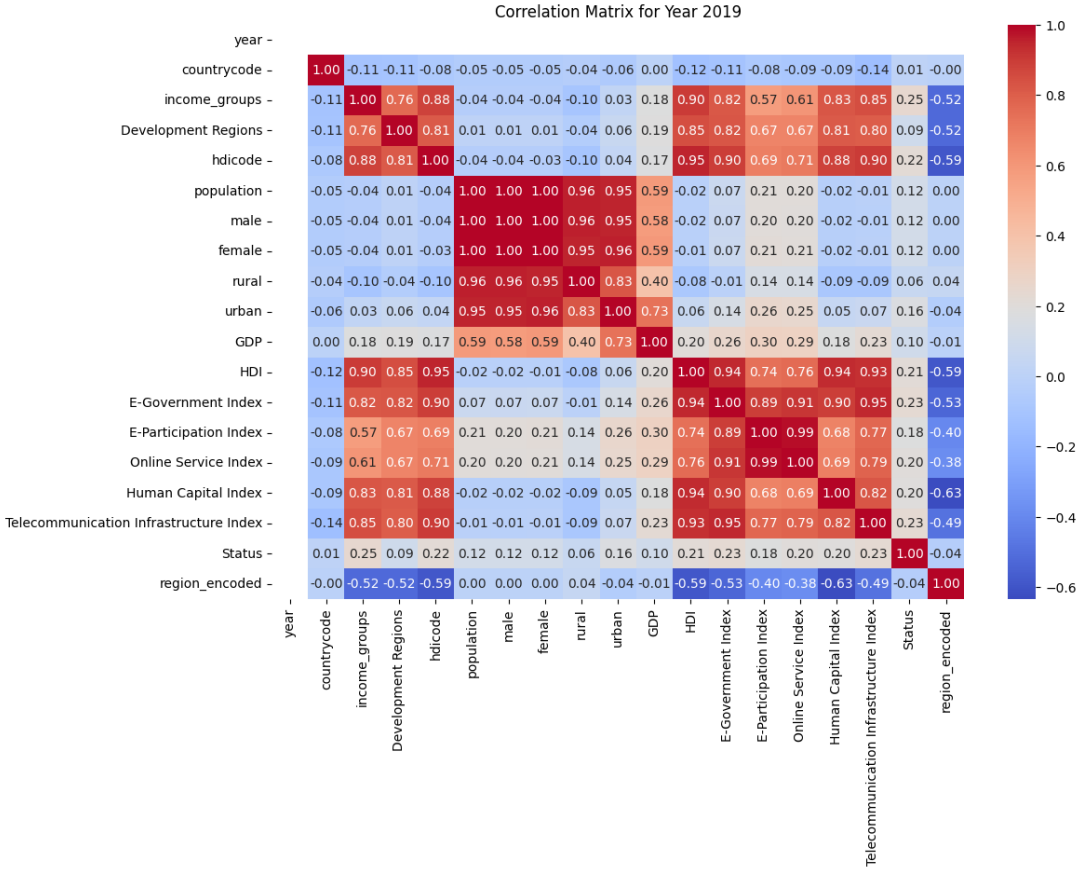


Figure Appendix_4. Correlation matrix year 2020

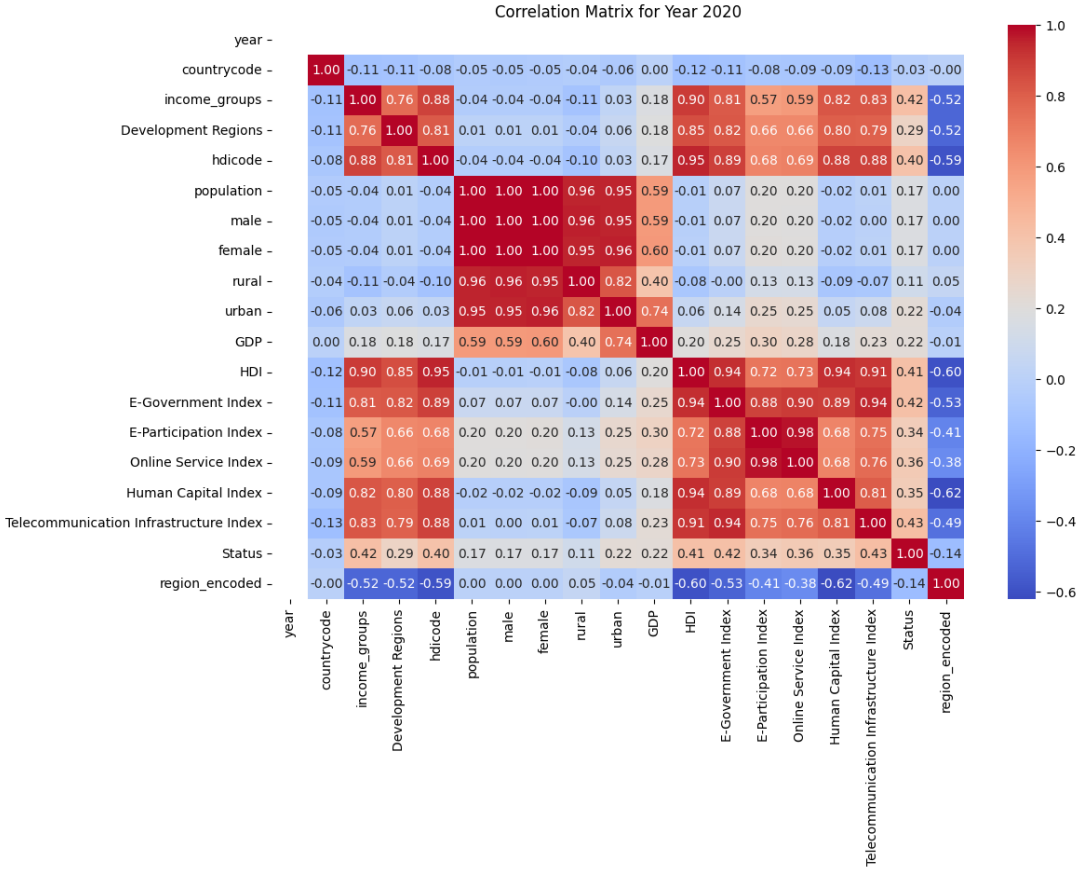


Figure Appendix_5. Feature importance year 2017

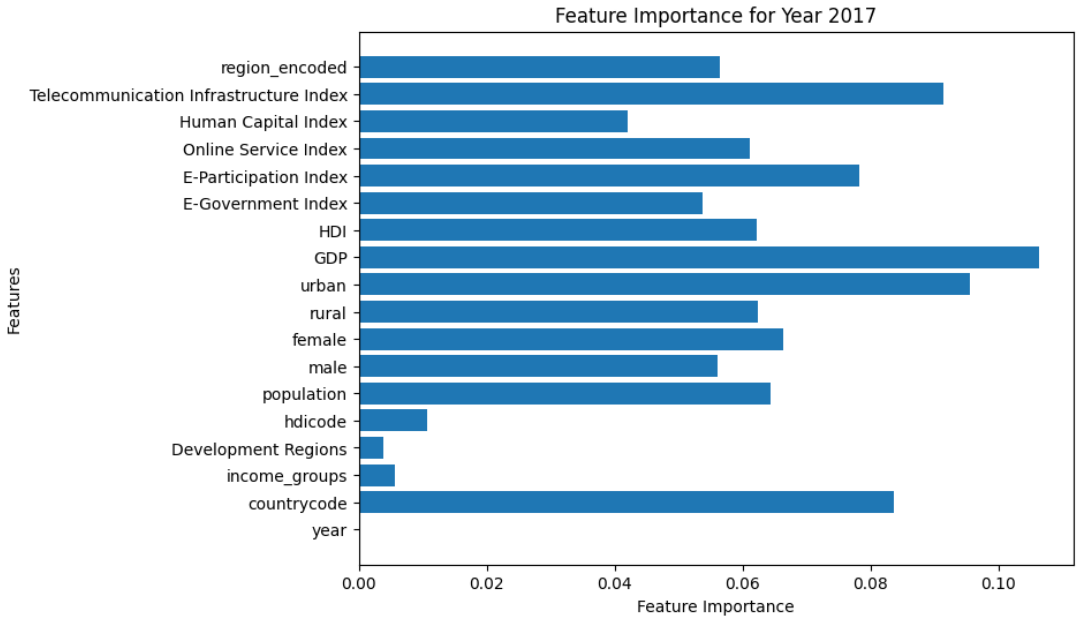


Figure Appendix_6. Feature importance year 2018

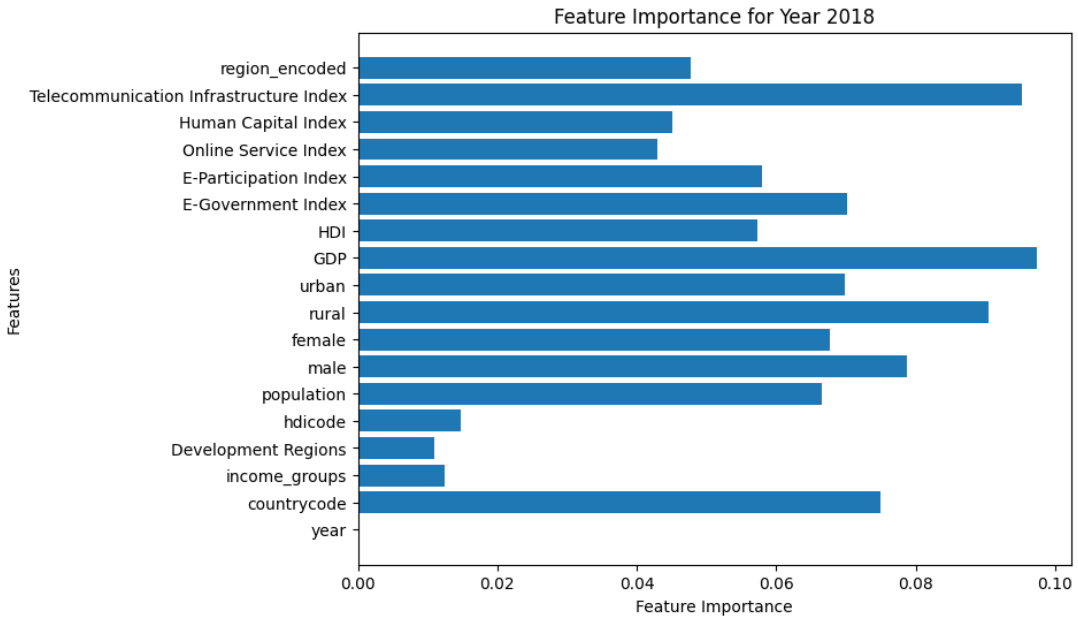


Figure Appendix_5. Feature importance year 2019

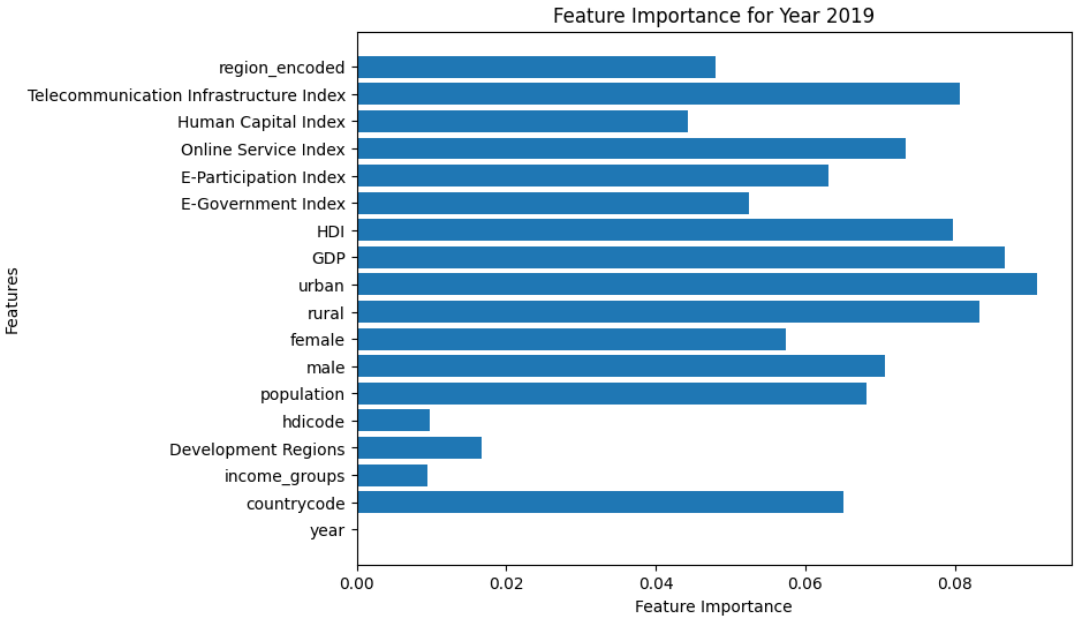
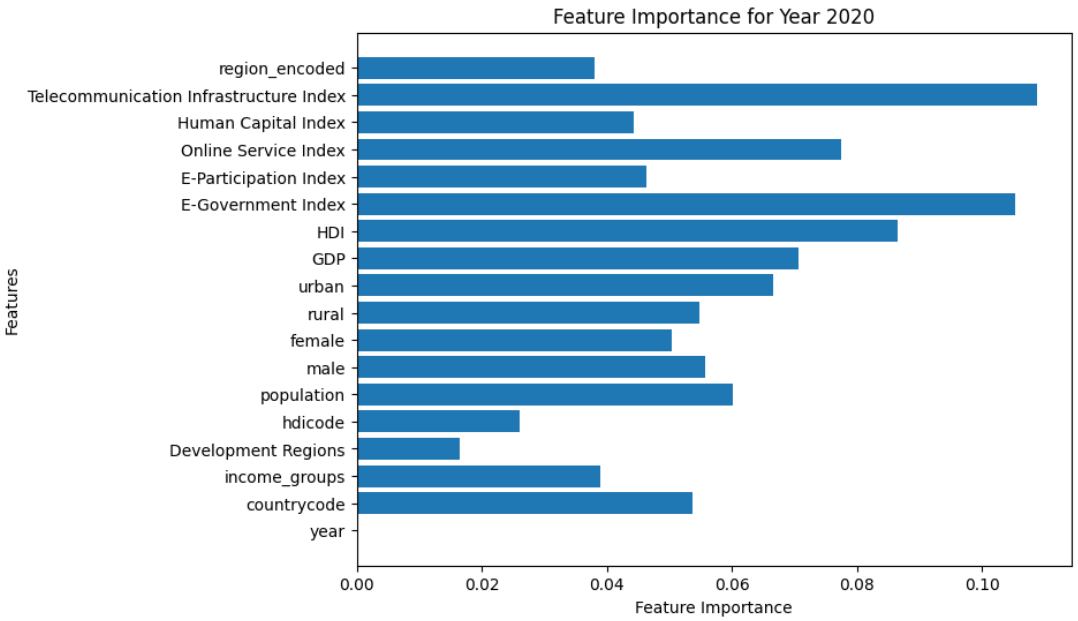


Figure Appendix_5. Feature importance year 2020



Feature Counts per Principal Component:

Principal Component 1

urban: 69

female: 50

Telecommunication Infrastructure Index: 43

Human Capital Index: 42

population: 39

Development Regions: 37

E-Government Index: 35

income_groups: 32

hdicode: 32

rural: 30

Online Service Index: 24

E-Participation Index: 23

Status: 23

male: 21

countrycode: 19

GDP: 17

HDI: 13

Principal Component 2

HDI: 101

GDP: 93

Online Service Index: 71

E-Participation Index: 61

Human Capital Index: 43

Telecommunication Infrastructure Index: 38

rural: 31

E-Government Index: 29

Status: 21

urban: 14

male: 13

female: 12

countrycode: 6

hdicode: 5

Development Regions: 4

income_groups: 4

population: 3

Principal Component 3

HDI: 76

GDP: 76

Online_Service_Index: 76

E-Participation_Index: 62

Status: 40

Human_Capital_Index: 39

rural: 34

Telecommunication_Infrastructure_Index: 25

E-Government_Index: 25

male: 20

female: 20

population: 14

urban: 11

income_groups: 11

countrycode: 10

Development_Regions: 7

hdicode: 3

APPENDIX. TABLES

Table appendix – Top 10 countries

year	countrycode	Country Code	country	Status	Status name
2017	4	ARE	United Arab Emirates	0	none
2018	4	ARE	United Arab Emirates	0	none
2019	4	ARE	United Arab Emirates	1	research
2020	4	ARE	United Arab Emirates	3	pilot
2017	18	B.H.S.	Bahamas	1	research
2018	18	B.H.S.	Bahamas	1	research
2019	18	B.H.S.	Bahamas	3	pilot
2020	18	B.H.S.	Bahamas	4	launched
2017	32	CHN	China	1	research
2018	32	CHN	China	1	research
2019	32	CHN	China	2	proof of concept
2020	32	CHN	China	3	pilot
2017	45	DMA	Dominica	1	research
2018	45	DMA	Dominica	1	research
2019	45	DMA	Dominica	3	pilot
2020	45	DMA	Dominica	3	pilot
2017	61	G.H.A.	Ghana	0	none
2018	61	G.H.A.	Ghana	2	proof of concept
2019	61	G.H.A.	Ghana	2	proof of concept
2020	61	G.H.A.	Ghana	2	proof of concept
2017	77	IRN	Iran	0	none
2018	77	IRN	Iran	1	research
2019	77	IRN	Iran	2	proof of concept
2020	77	IRN	Iran	2	proof of concept
2017	91	KOR	South Korea	0	none

2018	91	KOR	South Korea	0	none
2019	91	KOR	South Korea	0	none
2020	91	KOR	South Korea	2	proof of concept
2017	141	SAU	Saudi Arabia	0	none
2018	141	SAU	Saudi Arabia	0	none
2019	141	SAU	Saudi Arabia	3	pilot
2020	141	SAU	Saudi Arabia	3	pilot
2017	161	THA	Thailand	0	none
2018	161	THA	Thailand	1	research
2019	161	THA	Thailand	2	proof of concept
2020	161	THA	Thailand	2	proof of concept
2017	166	TUN	Tunisia	0	none
2018	166	TUN	Tunisia	1	research
2019	166	TUN	Tunisia	0	canceled
2020	166	TUN	Tunisia	4	launched

Table appendix – cropped data overview

country	year	Count	income_gr	Developm	hdicode	region	population	digital_cu	Central_B	Status	Retail_or_	Structure
Angola	2017	AGO	Lower Mic	Least Deve	Medium	SSA	30208628		Banco Nac	none		
Angola	2018	AGO	Lower Mic	Least Deve	Medium	SSA	31273533		Banco Nac	none		
Angola	2019	AGO	Lower Mic	Least Deve	Medium	SSA	32353588		Banco Nac	none		
Angola	2020	AGO	Lower Mic	Least Deve	Medium	SSA	33428486		Banco Nac	none		
Angola	2021	AGO	Lower Mic	Least Deve	Medium	SSA	34503774		Banco Nac	none		
Antigua an	2017	ATG	High Incor	Less Deve	High	LAC	91119	Dcash	Eastern Ca	research	Retail	Token
Antigua an	2018	ATG	High Incor	Less Deve	High	LAC	91626	Dcash	Eastern Ca	research	Retail	Token
Antigua an	2019	ATG	High Incor	Less Deve	High	LAC	92117	Dcash	Eastern Ca	pilot	Retail	Token
Antigua an	2020	ATG	High Incor	Less Deve	High	LAC	92664	Dcash	Eastern Ca	pilot	Retail	Token
Antigua an	2021	ATG	High Incor	Less Deve	High	LAC	93219	Dcash	Eastern Ca	pilot	Retail	Token
Antigua an	2022	ATG	High Incor	Less Deve	High	LAC		Dcash	Eastern Ca	pilot	Retail	Token
Antigua an	2023	ATG	High Incor	Less Deve	High	LAC		Dcash	Eastern Ca	pilot	Retail	Token