ECONOMIC AND TECHNOLOGICAL DRIVERS OF CENTRAL BANK DIGITAL CURRENCY DEVELOPMENT: A CROSS – COUNTRY ANALYSIS AND FUTURE DIRECTIONS OF DIGITAL MONEY

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Abstract
In response to technological advancements and the decreasing use of physical currency, an increasing number of central banks are exploring the feasibility of central bank digital currencies as an alternative to traditional cash. This research study investigates the relationship between economic and technological factors and their impact on the development of central bank digital currencies in different countries. While previous studies have explored the effects of fixed broadband subscriptions and financial development, this study breaks new ground by analyzing the correlation between high-tech exports and the advancement of central bank digital currencies utilizing multiple regression analysis. Research findings indicate a positive correlation between fixed broadband subscriptions, high-tech exports, and financial development, with financial development being the most influential factor. This study provides valuable insights into the economic and technological factors driving central bank digital currencies projects. However, it underscores the need for further research to examine the barriers and risks associated with CBDC implementation.

Key words: *high-tech exports, cryptocurrency, digital payment, fintech, distributed ledger technology*

JEL Classification: *E42, E44, E58,* G18, *G21, G28, G38, K23, 016, 031*

I. INTRODUCTION

Undoubtedly, the usage of physical money is decreasing, and digital money is becoming more popular, but what drives central banks towards the implementation of CBDC projects? In response to the growth of fintech, distributed ledger technology, and private virtual currencies, governments, professionals, and scholars have recently focused on the theoretical implications of CBDCs. According to the Bank for International Settlements, a CBDC is defined as a digital representation of a nation's currency that is distributed and regulated by the central bank or the monetary authority of that particular country. Besides, incidents like the COVID-19 pandemic emphasize the importance of having access to a variety of payment means to be accessible, safe, and resistant to a wide range of risks. Therefore, it is very important to explore the advantageous implications of CBDC payment services and to make them sustainable for future generations.

The concept of CBDC was initially proposed by Tobin back in 1987. Subsequent works by Bech and Garrat (2017) and the Market Committee (2018) provided relevant definitions of CBDC, distinguishing between retail and wholesale variants. The research literature on CBDCs is evolving quickly to keep up with changes in global economies, integrating theory and practice. However, obvious gaps are apparent in the existing literature. Most of the literature is based on macroeconomic implications. While there have been some studies in the last few years that explore individual countries' motivations, there is a gap in comprehensive cross-country comparisons that analyze commonalities and differences in motivations based on economic, technological, and regulatory factors. Some of the drivers, which may have been overlooked or not fully explored in earlier studies, can provide further insights into the motivations and implications of CBDC development, including the predictor variable of high-tech exports that was not explored in the previous studies. Exploring these gaps in the literature could provide a deeper understanding of the multifaceted motivations that drive central banks to pursue CBDC projects and contribute to the ongoing discourse on the topic.

The main goal of this research is to investigate the relationship between economic and technological drivers and the CBDC overall index across countries, as well as to provide empirical proof as to the impact of these drivers on CBDC development across countries. Another objective is to investigate which indicators are essential in driving countries to pursue this initiative. The results of this study provide useful information in the field of research on cross-country drivers of CBDC projects. We found that independent variables such as fixed

broadband subscriptions, high-tech exports, and financial development are positively correlated to the CBDC project index used as a measure of CBDC projects' development across countries. We have also analyzed and discussed the differences in CBDC progress made by developing and developed countries.

While analyzing the results, we have recognized that CBDC development is not solely dependent on technological and economic advancement. While previous studies have identified key drivers of CBDC development, it is important to acknowledge that multiple factors can coexist and have a significant influence on CBDC initiatives. By examining these driving motivators, researchers can gain insights into the specific challenges and opportunities that CBDCs offer to developed and developing countries, contributing to the broader adoption of digital currencies and their implications.

II. LITERATURE REVIEW

Blockchain technology has been described as the technology of the future, designed for secure information storage, faster payment processing, and the elimination of intermediary entities (Sichinava, 2019). Several authors have examined the institutional, economic, and technological drivers behind the development of CBDCs in developing and developed countries. A survey conducted in 2019, revealed that emerging market economies displayed stronger motivations for general-purpose CBDCs, focusing on enhancing domestic payment efficiency, ensuring payment safety, and promoting financial inclusion (Boar and Wehrli, 2021). Interesting research on the economic performance of diverse rural areas emphasized the importance of understanding the factors behind variations in economic achievements within rural regions (Tandir and Konakli 2017). This understanding can serve as a crucial component in creating effective strategies and programs for sustainable rural development, encouraging innovation, and eventually financial inclusion. On the other hand, advanced economies prioritized payment safety as a key driver. Study on the theory that the existence of secure systems enhances system quality evaluated a model of online banking acceptability (Ozlen and Djedovic, 2017). Numerous individuals and organizations are actively engaged in research and development projects to make blockchain systems more reliable and secure, however an actual example of these accomplishments is still awaited (Halilbegović and Ertem, 2020).

The impact of CBDCs on regulatory systems and the diverse approaches taken by countries like Canada and England, which emphasized comprehensive research before committing to CBDC adoption, were examined (Wang & Gao, 2021). In the comparative analysis of CBDCs in China and the US, China adopted a more aggressive approach, whereas the US pursued a gradual strategy (Chorzempa, 2021). Financial innovation, including new delivery channels and products, can make financial services more accessible and increase financial inclusion (Beck, 2020). Another study examined the effect innovations on financial inclusion and highlighted both the benefits and risks associated with technologies like cryptocurrencies, fintech, and CBDCs (Ozili, 2021, 2022, 2023). Analysis of the motivations and challenges of CBDC adoption in Africa, shows that central banks in this area are following the global trend of evaluating CBDCs (Alberola and Mattei, 2022).

An important study for this research paper is based on the examination of the institutional and economic determinants of CBDC programs and aims to answer questions related to the motives of central banks in establishing CBDCs (Auer, Cornelli et al, 2020). Findings suggest that the development of retail CBDCs is more prevalent in regions marked by substantial informal economies (Auer, Cornelli et al, 2020). In addition to this, the study of in the context of the transition economy of Bosnia and Herzegovina highlights the major economic concerns faced by SMEs, including the presence of a gray economy (Buljubašić Mušanović and Halilbegović, 2021). This is because countries with a considerable informal economy often find it more beneficial to establish audit trails on transaction records, thereby encouraging the adoption of digital money. Over the past two decades, retail lending has become an increasingly attractive market for commercial banks in Central and Eastern Europe (Pašić and Omerbegović-Arapović, 2016). This is supported by the research that shows that retail CBDCs are more present in developing countries with significant informal economies and low levels of financial inclusion (Maryaningsih, Nazara, et al, 2022). The research study that builds upon the CBDC project index developed by Auer, Cornelli et al. (2020) employs data-driven analysis using various machine learning technologies to quantify the predictive power of economic and technological factors on the progression of CBDC within a country (Matsui and Perez, 2021).

The emerging markets aim to enhance financial inclusion and economic stability, while higher-income nations focus on improving payment system functionality and security (IMF, 2022). The IMF study also reveals that the implementation of private digital assets, including cryptocurrencies, is higher in nations with higher levels of remittances and less stable macroeconomic fundamentals, such as rapid inflation. Inflation forecasts have a significant impact on a range of economic decisions involving savings, spending, portfolio management, and mortgages (Kratovac, Mekić et al, 2023). The financial system, monetary systems, and the overall economic framework are all negatively impacted by inflation (Chikobava, 2019). CBDC activities are more progressive in

highly digitized economies and countries with a high capacity for innovation (Auer, Cornelli et al, 2020). This suggests that innovation capacity plays a vital role in driving the development of CBDC projects. The Global Innovation Index (GII) report (2022), published by the World Intellectual Property Organization (WIPO), provides insights into the innovation performance of different economies, and shows that some developing economies such as Turkey, India, Pakistan, Indonesia, and Uzbekistan have remarkable innovation performance compared to their level of development.

This study builds upon the researches conducted by on the drivers of CBDC development and their correlation to CBDC initiatives (Auer, Cornelli et al, 2020; Matsui and Perez, 2021). The most significant drivers of CBDC development projects are financial development, the informal economy, and innovation capacity (Auer, Cornelli et al 2020). Subsequently, another study shows that a crucial factor in the model is financial development index, followed by GDP per capita and a measure of the country's population's voice and accountability (Matsui and Perez, 2021). Authors of these studies did not, however, investigate the connection between innovation output and the advancement of CBDC initiatives. During the research, we identified that factors influencing high-tech exports play a crucial role in elevating technological sophistication and promoting economic growth. Consequently, this study acknowledges the need for a more comprehensive exploration of the innovation environment as a research gap, given its significant importance. Prior studies show a positive connection between research and development, innovation, and high-tech exports (Sandu and Ciocanel, 2014). Recent research by on 48 OECD and emerging countries emphasizes the positive impact of R&D expenses, patents, and FDI on high-tech exports (Gurler, 2021). Additionally, internal innovation, particularly R&D investment as a percentage of GDP, notably influences high-tech exports and employment in OECD countries (Navarro Zapata, Arrazola et al, 2023). The study by Cero and Mustafić (2021) emphasizes the importance of GDP as a key measure of economic development. CBDC projects tend to be more developed in countries with a higher GDP per capita (Auer, Cornelli et al, 2020).

This study aims to overcome a research gap by examining innovation-related determinants, specifically high-tech exports, as potential drivers for CBDC development across countries. It stands out as one of the few studies looking into the motivations and factors driving the development of CBDC. Particularly, it is the first study that examines the relationship between high-tech exports and the progress of CBDC projects. Focusing on the drivers of CBDC, this research aims to contribute to a more comprehensive understanding of the motivations, challenges, and implications associated with CBDCs across developed and developing countries.

III. METHODOLOGY

Only quantitative data is used in the study. The CBDC project index was developed by Auer et al. (2020) and will be used as a measure of the development of CBDC projects in this study. Data for this dependent variable is collected from the Bank of International Settlements website. The dataset created by Auer et al. (2020) and available on the Bank of International Settlements website offers up-to-date information on CBDC projects, speeches related to them, and search interest as of January 1, 2022. Scientists, authorities, students, professionals, and the general public can use this dataset as a public resource. Data for independent variables is collected from the online databases of the World Bank and the International Monetary Fund. Data for independent variables was collected for the period 2013–2021 for 154 countries. In total, this research will have 8,316 observations.

Table 1. Description of dependent and independent variables and their sources

Variables	Description	Source
FBS	Fixed broadband subscription per 100 people from 2013-2021 for 154 countries.	World Bank
HTE	High-tech exports (current US$) from 2013-2021 for 154 countries.	World Bank
FD	Financial development index from 2013-2020 for 154 countries.	IMF
Overall CBDCPI	Overall Central bank digital currency project index as measure of the development of CBDC projects developed by Auer, Cornelli et al (2020), as of January 10, 2022 for 154 countries.	Bank of International Settlement (BIS), from the research "Rise of the central bank digital currencies: drivers, approaches, and technologies" (Auer, Cornelli et al, 2020).

Source: Created by author

The main goal is to investigate the relationship between technological and economic drivers and the

overall CBDC project index across countries, as well as to provide empirical proof of the impact of these drivers on the overall CBDC project index across countries. Based on the literature review, the following model and hypotheses are developed:

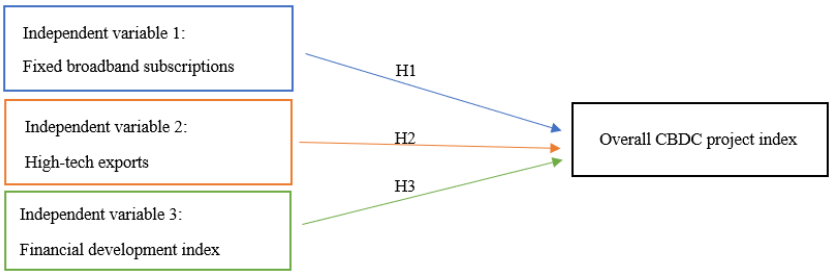

Figure 1 - Research model

The research model uses the overall CBDC project index as the dependent variable and indicators determining a country's technological capabilities and economic development as independent variables. This study suggests that there is a positive correlation between fixed broadband subscriptions, high-tech exports, and overall CBDC project index. CBDCs should be more developed where digital infrastructure (as a measure of broadband subscriptions per 100 people) is more developed, where innovation capacity is higher (measured by high-tech exports), and where financial development is higher (measured by the financial development index).

Only quantitative data is used in the study. FBS, HTE, and FD are introduced in SPSS as independent variables over which the overall CBDCPI is tested for dependability. An overall CBDCPI is equal to the maximum of the two sub-indices (retail and wholesale), according to the model proposed by Auer et al. (2020). The CBDCPI represents a categorical variable because it ranges from 0 to 3. Score 0 means there are no announced projects; score 1 is for public research projects; score 2 is for an ongoing or pilot project; and score 3 is for a live CBDC. Full data for FBS and HTE are used, both available on the World Bank online database. For the FD, we aggregated the data. The IMF base only provides data up to the 2019 year, so the average formula in Microsoft Excel for the period 2014–2019 is used to obtain data for the years 2020 and 2021. The Bank of International Settlements dataset file considers 193 countries in total. However, 39 countries are excluded with an overall CBDC score of 0 because the IMF report did not include data on financial development for these countries. The data is collected and systemized in Microsoft Office Excel. Computed variables are transmitted into SPSS, where analysis is conducted. The study provides an empirical examination of the factors that influence CBDC projects. Multiple regression analysis is applied in this study to evaluate the relationship between independent variables and the development of CBDC projects across 154 countries, utilizing the CBDC project index as a measure of CBDC development.

IV. DATA ANALYSIS

Figure 2 shows categorization of countries into developed, developing, and economies in transition to get a better understanding of CBDC project development across these groups of countries. Data was collected from the World Bank and edited by the author.

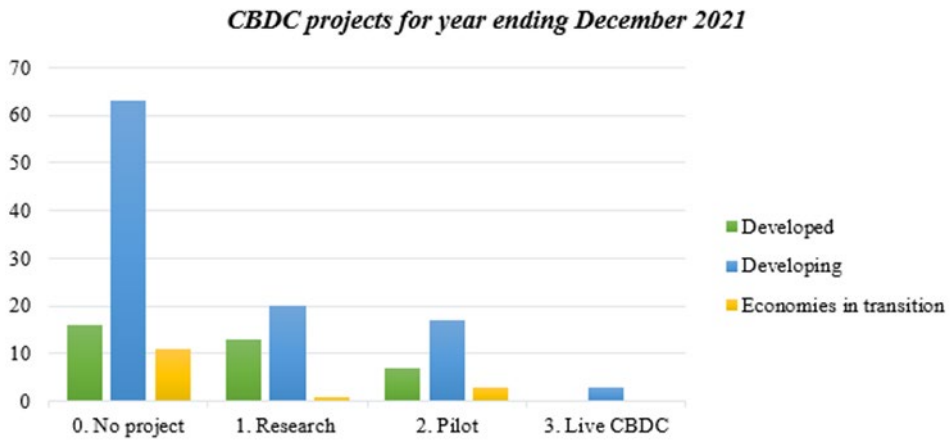

Figure 2 - Status of CBDC projects across 154 countries, for the year ending December 2021

Figure 2. illustrates the status of CBDC projects across 154 countries that have been categorized into three groups based on their level of economic development as defined by the World Bank's publication for 2021. Upon observation of the CBDC indices for three groups of countries, an intriguing trend emerges: developing countries are directing greater investments toward CBDC projects. This is evident from Figure 2, which indicates that developing countries have a larger number of research and pilot projects than developed countries. Furthermore, all three live projects were launched in developing countries. However, a more detailed analysis involving the correlation and regression analysis of the drivers of CBDC projects reveals that the progress of CBDCs is closely linked to higher levels of economic and digital development. The illustration from Figure 2. aligns with the results of the Bank of International Settlements central bank survey on CBDCs, indicating that emerging markets and developing economies exhibit a stronger motive for issuing CBDCs compared to advanced economies (Boar and Wehrli, 2021).

Table 2. summarizes a descriptive statistic of 4 variables for 154 selected companies for the period 2013–2021. Table 2. indicates that the minimum value for the dependent variable CBDCPI is 0, meaning that for some countries there was no published project on the topic of CBDC. The maximum value for the overall CBDC projects index is 3, meaning that live CBDC projects were detected.

Table 2. Descriptive statistics

Variable	Min	Max	M	SD
FBS	.00	408.21	132.4267	122.39184
HTE	.00	6163718394732.00	152486625369.0936	580720195178.96610
FD	.42	8.49	3.1810	2.04051
Overall CBDCPI	.00	3.00	.6299	.83979

Source: Created by author

Descriptive statistics entail the summarized values across all years for every country. Notably, Switzerland stands out with the highest recorded value of 408.21 for variable FBS, whereas South Sudan has the lowest. Sierra Leone, ranked 154th in the database, has no recorded data for variable FBS. The HTE value of China, with a value of 6,163,718,394,732.00, represents the highest score, while the Maldives has the lowest. Switzerland's FD index assumes the maximum value, whereas the value of this variable in Comoros is the lowest. It is impressive that 3 live projects have been recorded, namely in the Bahamas, the Eastern Caribbean, and Nigeria. The aforementioned data encapsulates a comprehensive overview of descriptive statistics.

For this research, the Pearson correlation coefficient is used to identify the relationship between variables. Table 3. shows the correlation coefficients between the predictor variables FBS, HTE, FD, and the dependent variable CBDCPI. The relationship between dependent and independent variables should be positive. From Table 3. it can be concluded that variables FBS, HTE, and FD have a positive relationship with overall CBDCPI. This is consistent with the studies of Auer et al. (2020) and Matsui and Perez (2021).

Table 3. Correlation coefficient

Variable	FBS	HTE	FD	Overall CBDCPI
FBS	1	0,295**	0,774**	0,310**
HTE		1	0,391**	0,277**
FD			1	0,466**

** Correlation is significant at the 0.01 level (2-tailored).
** p<0,01

Source: Created by author

A statistically significant positive correlation coefficient between FBS and CBDC project overall score was found (r = 0,310; p = 0,000; p<0,01). The presented findings indicate that there is a statistically significant positive correlation between FBS and the CBDC project overall score. The correlation coefficient of 0.310 implies that there is a moderately positive relationship between the two variables. As FBS increases, the overall score of the CBDC project is also likely to increase, suggesting a direct linear relationship between the two variables. The p-value of 0.000 indicates that the correlation is statistically significant.

Based on the Bank of International Settlements online database updated in January 2022, 40 developing countries and 4 economies in transition are investing in CBDC projects, in contrast to 20 developed countries. In Table 4. shows ranking of 20 countries with the highest FBS value and their CBDC indices.

Table 4. Ranking by FBS for the top 20 countries and their overall CBDCPI

Ranking	Country Name	Economy	FBS (per 100 people)	Overall CBDCPI
1	Switzerland	Developed	408.21	2
2	France	Developed	393.37	2
3	Denmark	Developed	389.22	1
4	Netherlands	Developed	383.53	1
5	Malta	Developed	375.24	0
6	Korea, Rep.	Developing	368.88	2
7	Norway	Developed	368.10	1
8	Germany	Developed	359.06	0
9	Iceland	Developed	355.44	1
10	United Kingdom	Developed	347.68	1
11	Canada	Developed	344.47	2
12	Belgium	Developed	344.19	0
13	Sweden	Developed	343.00	2
14	Luxembourg	Developed	322.93	0
15	Hong Kong SAR, China	Developing	321.90	2
16	Greece	Developed	319.70	0
17	Portugal	Developed	309.76	0
18	Cyprus	Developed	302.88	0
19	New Zealand	Developed	302.49	1
20	United States of America	Developed	300.90	1

Source: Data collected from the World Bank and Bank of International Settlements

Our prediction is that that digital infrastructure is one of the driving forces behind CBDC's progress. Thus, economies with more developed internet use, as measured by FBS, have a more advanced digital framework to establish CBDC projects. Upon examining the top 20 countries ranked by their FBS values in Table 4, it is notable that 6 of these countries have a score of 2, indicating that they have pilot CBDC projects underway. Furthermore, 7 out of these top 20 countries are in the research phase. It is worth mentioning that 7 of the top 20 countries, have not yet published any work on CBDCs. Notably, it is surprising to observe that the countries with live CBDC projects (the Eastern Caribbean, the Bahamas, and Nigeria) are not among the countries with the highest FBS score. However, The Bahamas, where approximately 93% of the population owns a mobile phone, could benefit from CBDCs, particularly in remote communities reliant on cash (Boar et. al, 2020). Inconsistencies aside, the correlation analysis reveals a moderately positive relationship between FBS and overall CBDC project index variables. This finding aligns with the studies from the literature review, which emphasize the greater motivation of emerging markets and developing economies to issue CBDCs compared to advanced economies (Boar and Wehrli, 2021).

Based on the statistical analysis conducted, it can be noted that a positive correlation exists between the variables of HTE and the overall score of CBDC projects. This correlation is supported by a positive correlation coefficient of 0.277, signifying that as HTE values increase, so does the overall score of CBDC projects. In Table 5. shows ranking of 20 countries with the highest HTE values and their CBDC indices.

Table 5. Ranking by HTE for the top 20 countries and their overall CBDC project index

Ranking	Country Name	Economy	HTE (USD)	Overall CBDCPI
1	China	Developing	6,163,718,394,732.00	2
2	Germany	Developed	1,816,993,001,184.11	0
3	Hong Kong SAR, China	Developing	1,731,063,036,466.17	2
4	United States of America	Developed	1,439,599,215,376.61	1
5	Korea, Rep.	Developing	1,426,887,942,739.61	2
6	Singapore	Developing	1,331,843,843,005.71	2
7	France	Developed	992,536,045,104.54	2
8	Japan	Developed	942,611,910,873.75	2
9	Netherlands	Developed	729,686,345,062.50	1
10	Malaysia	Developing	703,230,128,414.25	2
11	United Kingdom	Developed	650,512,454,636.68	1
12	Vietnam	Developing	632,555,303,472.32	1
13	Mexico	Developing	611,011,811,574.86	1
14	Thailand	Developing	373,961,580,165.00	2
15	Switzerland	Developed	360,435,638,481.32	2
16	Ireland	Developed	317,645,513,434.61	0
17	Italy	Developed	291,063,432,951.43	1
18	Czech Republic	Developed	284,756,010,658.82	1
19	Canada	Developed	257,805,656,159.25	2
20	Belgium	Developed	254,722,747,378.71	0

Source: Data collected from the World Bank and Bank of International Settlements

Countries in Table 5. are ranked from the highest to the lowest HTE value for the period 2013–2021. In addition, three countries, namely Germany, Ireland, and Belgium, possess a high HTE value but have not yet started working on the CBDC projects. Conversely, 10 countries have initiated pilot CBDC projects, while 7 are presently engaged in the research phase. Out of the 10 countries that have commenced pilot projects, 6 are classified as developing nations, whereas the remaining four are developed nations. The high ranking of these developing countries is supported by their advancement in innovation capacity. As stated in the Global Innovation Index report for 2022, within the region of South Asia, East Asia, and Oceania, Vietnam, the Philippines, Indonesia, Cambodia, and the Lao People's Democratic Republic have made the greatest advances over the past decade. The Philippines and Indonesia are in the research stage of retail CBDC projects, while other countries have not started CBDC projects. Also, it is interesting to see Mexico in 13th place as the 4th leading country in Latin America and the Caribbean (after Chile, the Caribbean region, and Brazil) and as the leading country in indicators such as creative goods exports, high-tech imports, and exports (Global Innovation Index report, 2022).

The correlation coefficient of 0.466 between the overall score of CBDC projects and FD indicates a positive relationship between these two variables. The correlation coefficient value of 0.466 suggests that the strength of the relationship is moderate to strong. Specifically, as the value of FD increases, so does the overall CBDC project index. The statistical significance of this correlation is supported by the p-value, which is less than 0.01. In the Table 6. shows ranking of 20 countries with the highest (FD) index and overall CBDC project index.

Table 6. Ranking by FD for the top 20 countries and their overall CBDC project index

Ranking	Country Name	Economy	FD index	Overall CBDCPI
1	Switzerland	Developed	8.50	2
2	United States of America	Developed	8.09	1
3	United Kingdom	Developed	8.02	1
4	Australia	Developed	7.97	2
5	Canada	Developed	7.94	2
6	Japan	Developed	7.89	2
7	Spain	Developed	7.67	1
8	Korea, Rep.	Developing	7.39	2
9	France	Developed	6.97	2
10	Sweden	Developed	6.87	2
11	Italy	Developed	6.80	1
12	Hong Kong SAR, China	Developing	6.80	2
13	Luxembourg	Developed	6.53	0
14	Finland	Developed	6.49	1
15	Netherlands	Developed	6.43	1
16	Thailand	Developing	6.41	2
17	Singapore	Developing	6.38	2
18	Germany	Developed	6.38	0
19	Portugal	Developed	6.15	0
20	Denmark	Developed	6.02	1

Source: Data collected from the IMF and Bank of International Settlements

After analyzing the top 20 countries ranked by their FD index, it is noteworthy that half of these countries (Switzerland, Australia, France, Canada, Japan, the Republic of Korea, Sweden, Hong Kong, Thailand, and Singapore) have already initiated pilot CBDC projects, with four of them being developing nations. It is interesting to see that China is not included in the top 20 countries, as was the case for the previous two variables. On the other hand, 7 developed countries (the United States of America, the United Kingdom, Spain, Italy, Finland, Denmark, and the Netherlands) are in the research phase. Interestingly, countries with live CBDC projects (the Bahamas, Eastern Caribbean, and Nigeria) are not among the top 20 countries with a high FD index. The underlying motivations for conducting CBDC research are comparable between developed and developing economies. However, developing countries tend to prioritize financial inclusion and domestic payment efficiency more highly due to the notable discrepancy with levels seen in advanced economies. Furthermore, the main drivers for CBDC work in advanced economies are maintaining and strengthening the institutional foundations of modern monetary systems in the digital era, promoting competition in payment systems, and facilitating the tokenization of finance (IMF, 2023). On the other hand, CBDC work in emerging markets and developing economies is also motivated by financial inclusion-related goals. In the past two years, there has been an increased emphasis on cross-border payment efficiency as a motivation for CBDC work in emerging markets and developing economies.

As proved by other researchers in the literature review, the expected relationship between independent variables (FBS, HTE, and FD) and the overall CBDC project index should be positive, meaning that CBDC projects are more sophisticated in countries with more established financial or technological systems.

Table 7. Multiple regression analysis with independent variables FBS, HTE, and FD, and CBDC project score overall as the dependent variable

Variable	Standardized beta coefficient	t	p
FBS	-0,119	-1,048	0,296
HTE	0,111	1,423	0,157
FD	0,512	4,343	0,000

R=0,480; R^2=0,231; p=0,000; p<0,01

Source: Created by author

The outcomes of the multiple regression analysis revealed a notable level of statistical significance (F = 14.892, df = 3; p = 0.000; p<0.01). The R-squared (R2) value, serving as an indicator of the percentage of the dependent variable's variance in the dependent variable elucidated by the independent variables within the regression model, indicates that 23.1% of the variance in FBS, HTE, and FD can be accounted for by the overall CBDC project score. Notably, the R-squared (R2) results for the comprehensive CBDC project index derived from this study closely align with the findings of prior research, which reported a comparable result of 16.7%. Moreover, the outcomes of this study underscore the significance of FD as a predictor factor for the overall CBDC project score. According to the results of multiple regression analysis, the most significant indicator of CBDC project development is FD. The second most important indicator of CBDC project development is HTE, followed by FBS. The results for two independent variables (FBS and FD) are in line with the previous studies from the literature review. Results for a new variable that was not examined in any studies before show that there is a positive relationship between HTE and the overall CBDC project index.

V. FINDINGS

The results of the study reveal a positive relationship between fixed broadband subscriptions, high-tech exports, financial development, and the overall CBDC project index. The examination of CBDC indices across developed, developing, and transition countries reveals an interesting trend where developing nations are making larger investments in CBDC initiatives. Figure 2. visually depicts this pattern, showing that developing countries have a higher number of research and pilot projects compared to developed countries. The motives behind CBDC projects are not the same in all countries. In advanced economies, CBDC efforts are primarily driven by the need to maintain and strengthen institutional foundations in the digital era, promote competition in payment systems, and enable finance tokenization (IMF, 2023). In contrast, emerging markets and developing economies are motivated by incentives related to financial inclusion (World Bank, 2022). Throughout the last two years, improving international payment efficiency has emerged as a significant driver of CBDC initiatives in these economies (IMF, 2023).

Analyzing the relationship between fixed broadband subscriptions and CBDC initiatives across countries, certain developed countries with high fixed broadband subscriptions scores haven't started CBDC research, while certain developing countries with low fixed broadband subscriptions values are already in the live stage of development. This is consistent with findings that emerging markets and developing economies are more motivated to issue CBDCs compared to advanced economies (Boar and Wehrli, 2021). The findings from this research support the hypothesis by showing a positive correlation between fixed broadband subscriptions and the overall CBDC project index. However, there are exceptions to this trend. Several countries with low fixed broadband subscriptions values, including Indonesia, South Africa, Bhutan, India, and Haiti, are actively engaged in CBDC projects. African central banks are primarily driven by the goal of enhancing payment system efficiency and financial inclusion (Alberola and Mattei, 2022). This could explain why certain developing nations with lower fixed broadband subscription scores are still pursuing CBDCs. On the other side, some developed countries with high fixed broadband subscriptions have not yet started CBDC projects, while developing nations with low fixed broadband subscriptions are investing in CBDC initiatives. After analyzing the leading 20 countries based on the financial development index, it was discovered that half of these countries, including Switzerland, Australia, France, Canada, Japan, the Republic of Korea, Sweden, Hong Kong, Thailand, and Singapore have initiated pilot CBDC projects, and four of these are developing countries. Seven countries, including the United States, the United Kingdom, Spain, Italy, Finland, Denmark, and the Netherlands, are still in the research phase. Germany, Luxembourg, and Portugal, which are among the top 20 developed countries, have not yet made any progress towards CBDCs. Furthermore, The Bahamas, Eastern Caribbean, and Nigeria, all with active CBDC projects, are not among the top 20 countries by financial development. This indicates that a country's financial development doesn't exclusively dictate its progress in CBDC development. Advanced economies prioritize institutional frameworks, payment system competition, and finance tokenization, whereas emerging markets and developing economies emphasize financial inclusion and cross-border payment efficiency (IMF, 2023). Countries such as Ukraine, Bhutan, Ecuador, and Ghana, with lower financial development, have acknowledged CBDCs' capacity to enhance financial inclusion and have initiated retail pilot projects. This

underscores the potential of CBDC to encourage financial inclusion in developing nations. Furthermore, the importance of financial inclusion in emerging markets and developing economies is confirmed by the report of the CPMI and the World Bank Group (2021). The assessment and evaluation of these CBDC projects to determine their success and effectiveness will be particularly interesting.

The regression analysis reveals that countries with greater high-tech exports tend to have more CBDC projects. Prior research by Matsui and Perez (2021) and Auer, Cornelli et al. (2020) found a positive link between innovation capacity and CBDC development. Unlike previous studies, this research introduces a new angle, examining the impact of high-tech exports on CBDC progress. In our research, it was predicted that technologically advanced economies with strong innovation, modern technology adoption, and increased R&D spending would be more predisposed to pursue CBDC projects. Surprisingly, despite their established high-tech industries, not all developed countries have embraced the significance of initiating CBDC projects. Conversely, the spotlight on innovation and technological progress, especially in Asia, with a focus on China, has positioned these nations as pioneers in CBDC development. An analysis of advanced Asia, including China, underscores their substantial innovation capacity and prominent positioning (Global Innovation Index report, 2022). These findings confirm research hypotheses linking CBDC advancement to innovative environments. Furthermore, Asia is witnessing the emergence of robust innovation hubs (McKinsey, 2019), contributing to the region's advancement through a dynamic, innovative ecosystem. In fact, sizeable investments are flowing into technology startups across Asia, fostering a knowledge-driven economy and consequently driving economic growth. Another motivation behind the development of CBDC projects in China is the potential for the promotion of the internationalization of the renminbi and reducing reliance on the US dollar (Shen and Wang, 2021). Apart from China, developing countries like Indonesia and Pakistan, characterized by significant high-tech exports, have embarked on CBDC research initiatives and are exceeding expectations in terms of innovation considering their economic development levels (Global Innovation Index report, 2022). Additionally, for example Mauritius doesn't have large high-tech exports, but it is the first innovative country in the Sub-Saharan Africa region (GII Global Ranking, 2022), followed by South Africa. Moreover, in the MENA region, Saudi Arabia is becoming a prominent technology and digital market, a commitment reflected in its CBDC development efforts through pilot projects. The number of active fintech companies increased by 37% in Saudi Arabia in 2021, and a sizable sum of SAR 1.3 billion ($347 million) in venture capital was invested in regional fintech enterprises (Fintech Saudi Annual Report, 2021). Crafting a digital economy is a necessity, reflecting economic vitality and resilience. In the GCC, Saudi Arabia stands out for its proactive approach to shaping flexible regulations, enhancing digital payment channels, promoting innovation, and expanding digital goods and services production (PWC report, 2021).

The results of the study indicate a positive correlation between a country's innovation capacity, measured by high-tech exports, and CBDC project development. These findings suggest that countries with high high-tech exports and/or strong innovation capacity are more likely to invest in CBDC projects, regardless of their level of economic development, indicating the importance of technological and innovative capabilities in the adoption of new financial technologies. Given their large populations as well as rapidly expanding economies, developing nations with considerable high-tech exports and WIPO-measured innovation capacities have the potential to make a big impact on the global CBDC scene. However, it is important to note that this relationship varies across countries, and significant CBDC developments often occur in countries with a strong innovation environment.

VI. CONCLUSION

The primary goal of this study was to investigate the relationship between economic and technological drivers and the CBDC overall index across 154 countries from 2014 to 2021, as well as provide empirical proof as to the impact of these drivers on the CBDC overall index across countries. Based on the results of Pearson’s correlation research, it is proven that there is a positive relationship between economic and technological drivers and all CBDC project indices. Also, the results of multiple regression analysis confirmed that there is statistical significance in each correlation between the independent and dependent variables. This suggests that countries with higher levels of digital and financial development tend to have more developed CBDC projects. The outcomes of this research show that financial development is the most significant predictor of results. The second most important predictor of results for the overall CBDC index is high-tech exports, followed by fixed broadband subscriptions. Thus, CBDC development is positively related to economic and technological cross-country drivers. This means that countries with higher economic and technological development will have more developed CBDC projects. Previous data-driven analyses used the same independent variables. However, as high-tech exports had not been previously explored, we chose to examine the influence of this indicator on the progression of CBDC projects. Additionally, this study uses the most recent data, up to and including the year 2021, unlike other published studies on cross-country analysis, giving it the broadest time span in the published literature on cross-country analysis to date.

Like most research studies, this one has its limitations. One challenge we encountered was the lack of dependable data for the financial development index, as the IMF's data were only available up to 2019, and this was the only available database we could find. To address this, averages for the years 2014–2019 were calculated to estimate data for 2020 and 2021. Additionally, this research relies on an index developed by Auer, Cornelli et al. (2020) and published by the Bank of International Settlements. For future studies, it's worth considering alternatives, such as the PWC Global Index, which other researchers could employ to validate the results of this study. The assumption was that developed countries would make more significant developments in CBDC implementation compared to developing nations. However, the results of research revealed discrepancies with this assertion, indicating the presence of other factors that require exploration when it comes to understanding the motivations of both developed and developing countries to adopt CBDCs. It was revealed that for some countries, the development of CBDC projects was not strongly related to their economic and digital development. This implies that numerous unexplored variables, including government policies, financial infrastructure, the informal economy, innovation capacity, and more, could substantially impact the advancement of CBDC projects in each country. Consequently, it underscores the need for future research to consider these various unexamined factors in the context of CBDC development.

The findings of this study run parallel to the findings of Auer, Cornelli et al. (2020) and Matsui and Perez (2021), who assert that fixed broadband subscriptions and financial development contribute to the progress of CBDC. Through the examination of the effects of high-tech exports, this study has added valuable research contributions to the exploration of cross-country factors influencing CBDCs. It has also paved the way for other scholars to further investigate the importance of innovation capacity for CBDC development. The outcomes of this study may encourage governments to invest in technology infrastructure like broadband access, understanding its importance for CBDC implementation and broader digitalization efforts. Understanding the drivers behind CBDC development helps central banks and governments shape their economic policies. These research contributions are closely related to the practical ones, providing actionable insights for policymakers, central banks, financial institutions, and governments, ultimately guiding CBDC development in ways that align with economic and technological goals and address potential challenges. This research can help identify the motivations for developing CBDCs to streamline payment processes and enhance the overall user experience for consumers and businesses. The financial sector in some emerging market economies has already started using the benefits of CBDC for financial inclusion. Likewise, developing countries and countries in transition should start considering the way this will affect them and how to make that impact beneficial for their economies. Finally, the results of the study identify the significance of each driver of CBDC project adoption across countries, thus allowing regulators and bankers to design CBDC solutions that will align with the expectations of both payment and financial systems.

Meanwhile, knowledge from this study can be used to build public trust and acceptance, supporting the success of CBDC initiatives. As an addition to this study, it would be interesting to explore the correlation between human capital and research (for example, R&D expenditures), knowledge and technology outputs (such as patents per GDP), and CBDC development. This research belongs to those groups of studies that investigate the main motivations behind issuing a CBDC. Nevertheless, it's crucial to recognize that motivation represents just one aspect of examination when undertaking CBDC projects. Investigating these drivers allows researchers to assess potential risks associated with CBDC implementation, such as cybersecurity, financial stability concerns, and privacy issues. This research can inform strategies to mitigate these risks. For the successful implementation of CBDC strategies, research on risk assessment is necessary. Motivation alone is not enough; authors of future studies should focus more on identifying, analyzing, and mitigating potential risks associated with the development and implementation of CBDCs. These studies aim to provide a comprehensive understanding of the risks and challenges that CBDC projects may encounter. Risk management strategies, regulatory frameworks, and best practices from the countries that have successfully implemented CBDCs should be proposed to ensure the successful and secure implementation of CBDCs.

VII. REFERENCES

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