Cash in Circulation (CIC) and Digital transformation in Egypt

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Abstract

This study explores the impact of digital transformation on cash in circulation (CIC) in Egypt between 2004 and 2023, examining how advancements in electronic payment systems, mobile banking, and fintech innovation have influenced the demand for physical currency. The study is anchored in a comprehensive econometric analysis, utilizing Vector Error Correction Models (VECM) to capture both the short-term and long-term dynamics between CIC and key macroeconomic variables, including GDP per capita, inflation, interest rates, and points of sale (POS) as a proxy for digital payment infrastructure.

The findings indicate a significant long-term relationship between digital transformation and a reduction in cash circulation, particularly driven by the expansion of POS systems. However, the study also reveals short-term fluctuations in cash demand, influenced by interest rates and economic conditions. Despite the growing adoption of digital payments, cash remains resilient, especially during periods of economic uncertainty. This study concludes that while digital transformation is reshaping Egypt's financial landscape, cash continues to play a crucial role in the economy.

Introduction[1]

The first half of the 20th century has witnessed a catastrophic collapse in the financial markets. That collapse was named the great depression. During and after the depression, the famous economist John Maynard Keynes (J.M.K) developed his theory on economics, which had been named after him later (Keynesian theory). His major thoughts were stated in his book (the general theory of employment, interest, and money).

In his book, J.M.K revised the classical economic thoughts, which were dominating the economic society back then. One of his main contributions was about the use of money. Against the classical theory which claimed, earlier, that money is only used for transactional purposes, J.M.K proved that, there is another two incentives for holding money (speculation and precautionary motives). Till now, the demand for money was considered to be a function of the three variables.[2]

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[1] *Keywords: Economic digitization, Financial innovation, Digital currency, Central bank digital currency, Cash in circulation, Crypto currencies, central bank digital currencies (CBDC), Money demand, Money supply, Monetary policy.*

[2] *Lipsey, R. G., Lipsey, R. G., & Chrystal, K. A. (2007). Economics. Oxford University Press, USA. P. 474-478.*

The general meaning of cash in circulation (CIC) is the amount of printed money that have a legal tender or issued by the central bank of the state. This amount of CIC is used as a mean to pay for goods and services as well as repayment of debts. So, CIC provides the same features of money, which means it has a legal tender to be generally accepted, unit of account, and a store of value.[3]

Moreover, central banks use CIC as a channel for practicing some kind of control over the economic activity. Through changing interest rates in the financial markets, central banks execute their own agenda of expansionary or contractionary monetary policy.

Nowadays, money has taken so many different shapes. Through history, money has been evolving from barter economy, fiat money, and checks until the most recent shape, which is E-money and crypto currencies. This new kind of money is presumed to be a substitute for traditional cash and fiat money. The major advantages of E-money are the speed, ease, and low cost of transactions. On the other hand, there are some drawbacks resulting from spreading such shape of money such as the safety during dealing with other parties. Also, the appearance of E-money, which is out of central banks perfect control because different suppliers of the currency, starts questioning the central bank`s monetary policy effectiveness in using money supply as a tool for intervening in economic activity!

The aim of E-money is to replace traditional money. Consequently, CIC should decrease by a relevant amount due to increasing E-payment. Nevertheless, demand for cash has been recently growing globally despite the various conventional tools of payment (debit and credit cards) and innovative financial services.[4]

Egypt has taken many steps in the transition into a digitized economy including digitization of payment for governmental services. The banking system of Egypt also has provided other kinds of E-payment (credit and debit cards, online banking, and automatic teller machines-ATMs).

This study seeks investigating the effect of innovation in E-payment and financial services on the amount of CIC in Egypt.

[3] *Parkin, M. (2006). Economics. Pearson education. P. 578, 579.*
[4] *Shirai, S., & Sugandi, E. A. (2019). What explains the growing global demand for cash? (No. 1006). ADBI Working Paper Series. p. 1.*

Research problem

The growing and widespread usage of electronic payments has recently become a considerable option for most of us. Ease of usage, speed of dealing and low cost of transactions are the major motives behind the prevailing of such shape of money. The increasingly growing rate of replacing E-money for traditional printed money is expected to decrease demand on cash in circulation for most individuals. Accordingly, the amount of printed money will decrease, also, the central bank issuance of money.

The research problem can be formulated in the following questions:

1- What does economic digitization mean?
2- What are the different shapes payment and how do they evolve?
3- Does financial digitization affect the amount of cash in circulation in Egypt? In addition, how does this effect work?
4- What are the challenges facing the Egyptian central bank in a world of digitization?

Research objectives

The research objectives can be summarized in the following points:

1. Analyzing the trends and patterns of cash in circulation within the Egyptian economy.
2. Identifying the key factors that influence the amount of cash in circulation in Egypt.
3. Assessing the role of cash in the broader context of Egypt's financial system.
4. Examining the impact of economic digitization on cash usage and circulation.

Motivations and scientific contribution

The intended form of technological progress in our study is the payment system evolution. Recently, electronic payment (E-payment) became a popular, easy, quick, and less costly way of settling payments. Kinds of E-payment involves credit and debit cards, internet banking, mobile banking and many other options are used instead of traditional cash.

So, the growing usage of E-money is expected to affect the amount of cash in circulation. The latter is to decrease by a relevant amount. Cash in circulation, as a part of money supply, is a central tool for intervention in the national economic activity for purposes like smoothing the aggregate money demand. These major changes in the payment system are questioning the effectiveness of the central bank’s monetary policy.

Research hypothesis

This research is based up on the following assumptions:

1- The digitization of the monetary system has a significant effect on the amount of cash in circulation.
2- This effect will extend to affect the individual's money demand itself.
3- The increasing use of digital financial services, such as ATMs, online banking and e-wallets, will significantly reduce the preference for holding cash as a liquid asset.

Research Methodology

This study is designed to examine the impact of financial digitization on the amount of (CIC) in Egypt. To achieve this objective, study employes a mixed-methods approach, integrating quantitative data analysis with qualitative insights.

Data Collection: The study gathered secondary data from authoritative sources such as the Central Bank of Egypt, the World Bank, the International Monetary Fund, the Egyptian Ministry of Communications and Information Technology, and the Egyptian Cabinet's Information and Decision Support Center. The data will cover various indicators of financial digitization, CIC, and other relevant macroeconomic variables.

Quantitative Analysis: The primary analytical approach will involve the use of econometric models to quantify the relationship between financial digitization and CIC. Regression models will be employed to analyze how different dimensions of digitization—such as digital payments, mobile banking, and fintech innovations—affect the volume of cash in circulation. Key control variables like inflation, interest rates, and economic growth will be included to isolate the specific effects of digitization.

The proposed econometric model will follow this general form:

$$CIC = f\,(DP, MB, FI, INF, INT, GDP, \ldots)$$

Where:

- CIC: Cash in circulation.
- DP: Digital payments (including retail, card, and internet payments, ATM, or points of sale-POS, ….).
- MB: Mobile banking.
- FI: Fintech innovations.
- INF: Inflation rate.
- INT: Interest rates.
- GDP: Gross Domestic Product.

Qualitative Analysis: In addition to the quantitative approach, qualitative analysis will be conducted through the review of policy documents, government reports, and expert commentaries. This will provide context for understanding how digitization initiatives have been implemented in Egypt and their broader implications for cash usage.

Time Frame: The analysis covers the period from 2004 to 2023. This period was chosen for several reasons. Starting from 2004 allows the study to capture the initial phases of economic reforms in Egypt, including financial sector liberalization and the early adoption of digital banking services. The period up to 2023 includes the most recent advancements in digital payment systems and the impact of these developments on cash in circulation, ensuring that the analysis is both comprehensive and up-to-date.

Expected Outcomes: The study provided a thorough understanding of how financial digitization influences the amount of CIC in Egypt. The findings will offer valuable insights for policymakers to craft strategies that harness the benefits of digitization while maintaining monetary stability.

Literature review

The ongoing academic debate regarding the impact of digital transformation on (CIC) is rich and multifaceted, with scholars offering a broad range of perspectives. This debate is particularly relevant in the context of the global shift towards digital payments and the increasing role of financial technologies, which are reshaping traditional monetary systems in profound ways. As economies worldwide grapple with the implications of this transformation, researchers have sought to understand whether digital payments and other financial innovations coexist with cash or gradually displace it.

Although the topic of this research is relatively recent, the relationship between electronic payments (E-payments) and (CIC) has already sparked significant academic debate. Scholars have explored how the rise of E-payments influences the volume of CIC, leading to diverse opinions. Some studies argued that the introduction and expansion of E-payments may not significantly impact cash in circulation, suggesting a level of neutrality. However, a substantial body of research indicates that E-payments could reduce the demand for cash, thereby affecting cash in circulation. Furthermore, some studies emphasize the need for central banks to issue their own central bank digital currencies (CBDCs) to maintain their influence in the evolving monetary landscape. Below is a brief overview of some key studies that have examined these issues.

Several studies present the argument that despite the rapid growth of digital payment systems, cash continues to hold a significant position in the economy, indicating a form of resilience that might suggest a neutral impact of digital transformation on CIC. For example, a detailed analysis of Thailand's financial services sector found that although electronic payments are increasingly popular, they have not yet led to a substantial reduction in cash demand. This study highlights that the adoption of digital payment methods is gradual and may not necessarily translate into an immediate or significant decrease in cash usage. The persistence of cash in Thailand's economy, despite the availability of digital alternatives, suggests that cash still plays an essential role in the financial behaviors of many individuals, particularly in economies where digital literacy and infrastructure might not be uniformly developed. [5]

This perspective is further reinforced by global analyses which examine the paradoxical rise in cash demand, even as digital payment technologies proliferate. A comprehensive study investigating the global demand for cash found that low interest rates and specific demographic factors, such as the aging population, contribute to the sustained use of cash. This study suggests that in environments where interest rates are low, the opportunity cost of holding cash decreases, making it a more attractive option for individuals, particularly those who are risk-averse or prefer the security of tangible assets. Additionally, older generations may have a stronger preference for cash due to familiarity and trust, factors that digital alternatives have not fully supplanted. Thus, despite the advancements in digital payment technologies, cash remains a crucial element of the global financial system, driven by deeply ingrained economic and social behaviors. [6]

In Algeria, the resilience of cash is attributed to the underdeveloped financial services infrastructure, which limits the effectiveness of digital payment systems. Research conducted in the country indicated that while electronic banking and e-payment systems have been introduced, their impact on cash usage and monetary policy has been minimal due to the weak penetration of these services. This finding underscores the importance of robust financial infrastructure in determining the effectiveness of digital payment systems. In regions where such infrastructure is

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[5] *Chucherd, T., Srisongkram, A., Tonghui, T., Piyakarnchana, N., Suwanik, S., Kongphalee, T., ... & Shimnoi, A. (2018). Digitalization on Financial Services and Implications for Monetary Policy in Thailand. Working Paper. Bank of Thailand.*
[6] *Shirai, S., & Sugandi. Op. cit.*

lacking, cash continues to dominate, serving as the primary medium for transactions.[7] The Algerian case illustrates that without the necessary infrastructure, the potential for digital payments to replace cash is significantly diminished, highlighting the role of broader economic and institutional contexts in shaping the impact of digital transformation on cash circulation.

Conversely, a growing body of literature argued that the rise of digital payments and financial technologies poses a significant threat to cash usage and could potentially undermine traditional monetary policy tools. In a cross-country analysis of debit card and cash usage, researchers observed that the increasing prevalence of debit cards led to a notable reduction in the demand for lower denomination paper currencies. This decline is attributed to the convenience of digital payments, which reduce the need for physical cash, particularly for small transactions. The study suggests that as digital payment systems become more integrated into daily economic activities, the role of cash—especially in lower denominations—diminishes, which could have broader implications for how monetary policy is conducted.[8] This finding challenges the notion that cash and digital payments can coexist without affecting each other, indicating that digital transformation may indeed lead to a gradual erosion of cash's dominance in certain contexts.

Further supporting this view is a study on the impact of e-money on the broader monetary system. The researchers utilized a dynamic stochastic general equilibrium (DSGE) model to simulate the effects of e-money on savings, loans, and interest rates, revealing that e-money exerts a significant influence on these variables. The study found that e-money could lead to shifts in savings and lending behaviors, which, in turn, affect interest rates and the overall effectiveness of monetary policy. This potential disruption is particularly concerning for central banks, which rely on their ability to influence interest rates as a primary tool for managing economic activity. As e-money continues to gain traction, it could affect the traditional mechanisms through which monetary policy operates, necessitating new approaches and strategies to maintain economic stability. [9]

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[7] *Marzouki & Raei. (2019). Managing monetary policy under digitized economy: case of Algeria. Mohammed bo diaf university, Algeria.*

[8] *Amromin, G., & Chakravorti, S. (2007). Debit card and cash usage: a cross-country analysis. Federal reserve bank of Chicago.*

[9] *Luo, S., Zhou, G., & Zhou, J. (2021). The Impact of Electronic Money on Monetary Policy: Based on DSGE Model Simulations. Mathematics, 9(20), 2614.*

The concerns regarding the disruptive potential of digital currencies are also echoed in studies examining the implications of central bank digital currencies (CBDCs) and other forms of digital money. One study highlighted the significant risks posed by digital currencies to the effectiveness of central banks, particularly if these currencies begin to overshadow traditional forms of money. The study emphasized that without careful management and regulation, the increase of digital currencies could weaken the central bank's ability to conduct monetary policy effectively, especially in areas such as inflation targeting and interest rate setting. [10] The potential for digital currencies to bypass traditional financial systems and operate independently of central bank control represents a profound challenge to the existing monetary frameworks.

On the other hand, some researchers propose that the advent of digital transformation could be leveraged as an opportunity for central banks rather than a threat. A study on the macroeconomic implications of issuing a CBDC argued that such a currency could positively impact the economy by boosting GDP and reducing transaction costs. The research suggested that by issuing their own digital currencies, central banks could enhance the efficiency of monetary policy and stimulate economic growth, particularly if the CBDC is designed to complement existing monetary tools.[11] This optimistic view posits that with the right design and implementation, digital currencies could serve as a powerful tool for central banks, helping them navigate the challenges posed by the digital economy while also reaping its benefits.

Overall, the academic debate on the impact of digital transformation on CIC presents a complex and detailed picture. While some studies emphasize the resilience of cash and the neutral impact of digital payments, others warn of significant disruptions to traditional monetary systems. This divergence of views highlights the need for continued research and careful consideration of the broader economic, technological, and institutional factors that influence the relationship between digital transformation and cash usage. As digital payment technologies continue to evolve and spread, understanding their implications for cash circulation

[10] Ashri. (2020). Central bank digital currency CBDC: implications for monetary policy. Scientific journal for economics and commerce. 3rd edition. 405-454.
[11] Barrdear, J., & Kumhof, M. (2016). Staff Working Paper No. 605 The macroeconomics of central bank issued digital currencies. Bank of England, 3.
Barrdear, J., & Kumhof, M. (2021). The macroeconomics of central bank digital currencies. Journal of Economic Dynamics and Control, 104148.

and monetary policy will remain a critical area of inquiry for economists and policymakers alike.

Following the literature review, this paper transitions to an in-depth exploration of Egypt's digital transformation landscape. The subsequent sections will begin by analyzing the current state of digital infrastructure, adoption rates of digital technologies, and the role of key stakeholders in driving these changes. This will be followed by a discussion on the challenges and opportunities presented by Egypt's digital transformation, focusing on infrastructure gaps, regulatory frameworks, and the growing potential for economic growth, job creation, and financial inclusion. The study will then delve into an analysis of (CIC) within Egypt, examining the key economic, social, technological, and policy factors influencing cash usage in the country. Finally, culminating with an econometric modeling of the impact of digital transformation and other explanatory variables on CIC. This model will be used to interpret the results, leading into a discussion on policy recommendations and the potential future trajectory of digital transformation in Egypt.

Current State of Digital Transformation: Analysis of the Current Landscape in Egypt

Egypt's efforts toward digital transformation has been marked by significant advancements in digital infrastructure, widespread adoption of emerging technologies across various sectors, and robust government initiatives aimed at fostering a digital economy. With increasing internet penetration, mobile technology, and the strategic implementation of policies, Egypt is positioning itself as a leader in the region's digital transformation efforts. This section provides an in-depth analysis of the current state of digital transformation in Egypt, examining the progress made in digital infrastructure, and the adoption rates of digital technologies in key sectors. Through this analysis, we gain a comprehensive understanding of how Egypt is navigating the complexities of digital transformation and the factors contributing to its ongoing success.

Overview of Digital Infrastructure in Egypt

Egypt has made substantial progress in enhancing its digital infrastructure, particularly through increasing mobile phone usage and expanding internet access. According to the Central Bank of Egypt (CBE), mobile phone penetration rates have grown significantly, with a mobile subscription rate reaching 111% by 2018. Internet access has also improved considerably, with digital platforms playing a critical role in reaching financially excluded populations, providing a wide range of financial services tailored to their needs.[12]

The Egyptian government has placed a strong emphasis on the expansion of digital and broadband infrastructure. The National Payment Council, established by Presidential Decree in 2017, and subsequent initiatives like the National E-Payment Card (Meeza) system, demonstrate the country's commitment to reducing reliance on cash transactions and increasing digital accessibility. These efforts aim to foster greater financial inclusion, particularly in underserved areas. As of 2018, mobile money operations and internet banking services have seen considerable growth, with numerous banks offering digital services.[13]

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[12] *Hussein, H. (2020). The impact of financial technology on financial inclusion: The case of Egypt. IOSR Journal of Economics and Finance (IOSR-JEF). pp 48-50.*
[13] *Hussein, ibid.*

Table (1): number of individuals using internet, number of secure internet servers, and mobile cellular subscriptions.

year	Individuals using the Internet (% of population)	Secure Internet servers	Mobile cellular subscriptions
1990	0		4500
1991	0		4913
1992	0		6877
1993	0.00097579		7371
1994	0.00638327		7368
1995	0.03131964		7369
1996	0.0614669		65378
1997	0.09048025		90786
1998	0.14798738		480974
1999	0.29044528		1359900
2000	0.64126504		2793800
2001	0.83894561		4494700
2002	2.71999972		5797530
2003	4.03788511		7643060
2004	11.92		13629602
2005	12.75		18001106
2006	13.66		30093673
2007	16.03		41286662
2008	18.01		55352233
2009	20	205	70661005
2010	21.6	252	83425145
2011	25.6	437	96798801
2012	26.4	563	99704976
2013	29.4	725	95316034
2014	33.8946039	975	94016152
2015	37.8193834	1388	97791441
2016	41.2480671	3490	102958194
2017	44.9502043	3456	93784497
2018	46.9243368	3547	95340262
2019	57.2828664	4503	95357427
2020	71.914201		103449734
2021	72.06		103449734
2022	72.1980652		

References: World Bank data, Egypt.

Table (1) provides a comprehensive overview of Egypt's digital infrastructure development from 1990 to 2022, capturing significant variations in internet usage, secure internet servers, and mobile cellular subscriptions. These indicators collectively reflect Egypt's substantial progress in digital transformation, particularly in terms of expanding access to the internet, enhancing cybersecurity, and boosting mobile connectivity.

Internet Usage

Internet usage in Egypt was virtually nonexistent in the early 1990s, with no recorded users until 1993, when only 0.00095779% of the population had internet access. This figure remained modest throughout the decade, but a marked increase began around the year 2000. Internet penetration jumped from 0.6146504% in 2000 to 8.4038511% by 2003, indicating the beginning of broader internet adoption. The mid-2000s saw a significant surge, with internet usage reaching 11.92% in 2004 and continuing to grow to 18.01% by 2008. The most substantial growth occurred from 2010 onward, reflecting an era of rapid digital expansion driven by improved infrastructure, affordability, and the widespread adoption of digital technologies. By 2022, 72.1980652% of the population was using the internet, underscoring the central role of internet connectivity in Egypt's digital ecosystem.

Secure Internet Servers

The presence of secure internet servers, essential for ensuring secure online transactions and data protection, began to be recorded in Egypt only in 2009, starting with 205 servers. This number increased steadily, reaching 437 servers by 2011 and 3490 by 2016. By 2021, the number of secure servers had grown to 4503, indicating a substantial investment in cybersecurity infrastructure. This growth highlights Egypt's response to the increasing demand for secure digital services, including e-commerce, online banking, and government platforms, which require robust cybersecurity measures. The rise in secure internet servers reflects the country's commitment to building a secure digital environment, aligning with global trends toward enhanced data protection and cybersecurity.

Mobile Cellular Subscriptions

The expansion of mobile cellular subscriptions is one of the most striking indicators of Egypt's digital transformation. In 1990, there were just 4500 mobile subscriptions, but this number grew rapidly throughout the 1990s and early 2000s, reaching 13.6 million by 2004. The growth continued exponentially, with over 70 million subscriptions by 2010, surpassing 100 million by 2012. By 2022, mobile subscriptions had stabilized around 103 million, highlighting the critical role of mobile technology in driving digital adoption in Egypt. Mobile phones have become the primary means for millions of Egyptians to access the internet and digital services, particularly in regions where fixed-line internet services are less prevalent.

The data illustrates the significant strides Egypt has made in its digital transformation over the past three decades. The early 1990s saw limited digital infrastructure, but from 2000 onwards, there was a significant push towards increasing internet penetration, evidenced by the steep rise in internet usage. This rapid adoption is closely linked to government initiatives aimed at improving digital literacy and expanding access to the internet across the country.

The introduction of secure internet servers in 2009 and their subsequent growth underscores Egypt's focus on building a secure digital environment, which is vital for supporting the growing demand for online services. The rise in secure servers is a clear indicator of the country’s efforts to enhance cybersecurity, reflecting the global shift towards more secure and reliable digital infrastructures.

The explosion in mobile cellular subscriptions, particularly from the early 2000s, underscores the importance of mobile technology in Egypt's digital landscape. The data indicates a mobile-first approach, with mobile phones serving as the primary gateway to the internet for many Egyptians. This trend is driven by the widespread availability and affordability of mobile devices, coupled with the expansion of mobile networks across the country.

In conclusion, these numbers encapsulate Egypt's transforming towards digitalization, mainly expressing significant progress in internet usage, cybersecurity, and mobile connectivity. These developments have been instrumental in transforming Egypt into a more digitally inclusive society, although challenges remain in further expanding digital literacy, improving infrastructure in rural areas, and continuing investments in cybersecurity to ensure that the benefits of digital transformation are widely accessible.

Challenges and Opportunities: Key Challenges and Opportunities in Egypt's Digital Transformation

Egypt's digital transformation offers substantial opportunities for economic growth, innovation, and improved public services. However, this progress is accompanied by significant challenges that must be addressed to ensure sustainable and inclusive development.

Key Challenges

1. Infrastructure Gaps: Despite investments, gaps in broadband coverage and internet penetration persist, particularly in rural areas, limiting access to digital services and widening the digital divide.[14]
2. Digital Literacy and Skills: A low level of digital literacy, especially among older generations and in rural regions, hampers the adoption of digital technologies, slowing the growth of the digital economy.[15]
3. Regulatory and Legal Frameworks: Rapid digital innovation often outpaces the development of necessary regulatory frameworks, creating challenges in areas like data privacy, cybersecurity, and the regulation of new technologies.[16]
4. Cybersecurity Risks: As digital transformation advances, cybersecurity threats increase, posing risks to digital infrastructure and eroding public trust if not adequately addressed.[17]
5. Financial Inclusion: Barriers to financial inclusion remain, particularly for low-income groups and small businesses, due to limited access to banking services and financial literacy.[18]

Key Opportunities

1. Economic Growth: Digital transformation can drive economic growth by enhancing productivity, creating new business models, and expanding markets, particularly through digitalization in sectors like agriculture and manufacturing.[19]

[14] *OECD. (2021). OECD Digital Economy Outlook 2021: Egypt's Digital Transformation. Paris: OECD Publishing. P. 50-60.*
[15] *Kamel, S. (2021, September). The potential impact of digital transformation on Egypt. Giza, Egypt: Economic Research Forum (ERF). p. 26.*
[16] *Ministry of Planning and Economic Development (2023). Egypt's Vision 2030: The National Agenda for Sustainable Development. Cairo, Egypt: Ministry of Planning and Economic Development. pp. 29-30.*
[17] *Central Bank of Egypt. (n.d.). Cybersecurity. Retrieved from https://www.cbe.org.eg/en/cybersecurity on September 6, 2024, at 6:15 PM.*
[18] *Kamel, op. cit. p. 26.*
[19] *Zaoui, F., & Souissi, N. (2020). Onto Digital: An Ontology-Based Model for Digital Transformation's Knowledge. International Journal of Information Technology and Computer Science, 10(12), 1-12. P.3.*

2. Job Creation: The digital economy has the potential to generate new jobs in tech-driven sectors, as well as provide flexible employment opportunities through gig platforms.[20]
3. Improved Public Services: Digitization can enhance the efficiency, transparency, and accessibility of public services, reducing corruption and making services more accessible to citizens.[21]
4. Financial Inclusion: Digital financial services, including mobile banking and e-wallets, can significantly increase financial inclusion, empowering individuals and small businesses to engage in the formal economy.[22]
5. Innovation and Entrepreneurship: The digital transformation supports innovation and entrepreneurship by providing access to digital tools and resources, with government initiatives like innovation hubs and technology parks fostering a vibrant startup ecosystem.[23]

Cash in circulation

The Role and Dynamics of Cash in an Economy

Cash plays a fundamental role in the economy, serving as a medium of exchange, a store of value, and a unit of account. Its importance has been recognized throughout history, from ancient barter systems to the modern financial outlook.[24] Despite the advent of digital payments and electronic money, cash remains a critical component of economic transactions, particularly in developing countries where access to digital financial services is limited. Understanding the dynamics of cash circulation is essential for policymakers to effectively manage monetary policy and ensure economic stability.

Analyzing the Key Drivers of Cash Usage in Egypt

In Egypt, the dynamics of cash usage are influenced by a multitude of factors, ranging from economic conditions to social and technological advancements. Economic indicators such as inflation, interest rates, and overall economic growth have a significant impact on how cash is managed and utilized. Social factors, including demographic trends, cultural preferences, and shifts in consumer behavior,

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[20] *Kamel, op. cit. p. 26.*
[21] *Ministry of Planning and Economic Development, op. cit. pp. 20-21.*
[22] *Central Bank of Egypt (2023). Financial Stability Report 2023 – First Half. Cairo, Egypt: Central Bank of Egypt. pp. 42-44.*
[23] *Central Bank of Egypt (2023). Ibid. pp. 21-22.*
[24] *Llewellyn, N. (2015). 'Money Talks': Communicative and Symbolic Functions of Cash Money. Sociology, 50(4), 796-812.*

further shape the choices individuals and businesses make regarding payment methods. Technological developments, particularly in the realms of digital payments, mobile banking, and fintech, are revolutionizing traditional financial practices, reducing the reliance on cash and pushing the economy towards greater efficiency and inclusivity. Simultaneously, government policies, regulatory measures, and monetary strategies play crucial roles in shaping the cash ecosystem, ensuring stability while fostering innovation. This section provides a comprehensive exploration of these drivers, highlighting their roles in transforming cash usage within Egypt's financial system.

Economic Factors: Inflation, Interest Rates, and Economic Growth

Economic factors play a significant role in influencing cash circulation in Egypt. Key factors include inflation, interest rates, and economic growth.

1. Inflation: Inflation affects the purchasing power of money and consequently influences cash circulation. High inflation rates reduce the value of cash, prompting people to minimize their cash holdings and seek alternative investments. In Egypt, inflation has fluctuated over the years, impacting cash usage patterns.[25]

2. Interest Rates: Interest rates set by the Central Bank of Egypt influence cash circulation. Higher interest rates encourage savings in banks and reduce the amount of CIC, while lower interest rates have the opposite effect. The Central Bank's monetary policy decisions regarding interest rates are crucial in managing cash flow within the economy.[26]

3. Economic Growth: Economic growth affects cash circulation as it influences income levels, consumer spending, and overall economic activity. During periods of economic growth, higher income levels and increased consumer spending can lead to higher cash circulation. Conversely, economic downturns can result in reduced cash usage as economic activities slow down.[27]

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[25] Elewa, M. M., Abdel Aal, Y. A. M., & Mahmoud, N. H. M. (2023). The Impact of Inflation and Exchange Rates on Generating Power of Cash in Egypt (Panel Data Analysis). Journal of Accounting Research, Organization, and Economics, 6(2), 183-194.

[26] Assenmacher, K., & Krogstrup, S. (2018). Monetary Policy with Negative Interest Rates: Decoupling Cash from Electronic Money (IMF Working Paper No. WP/18/191). International Monetary Fund. pp. 2-6.

[27] Elfeky, M. I., Elbrashy, A., & Issa, A. (2024). The Effect of Tax Avoidance on Investment Efficiency: The Mediating Role of Cash Holding—Evidence from Egypt. Mansoura University, Delta Higher Institute, and Dongbei University. pp. 6-8.

Social Factors: Demographics, Culture, and Consumer Behavior

Social factors, including demographics, culture, and consumer behavior, significantly influence cash circulation in Egypt.

1. Demographics: The age structure and population distribution affect cash usage. Younger populations are generally more inclined towards adopting digital payments, while older populations may prefer cash transactions. Egypt's demographic profile, with a large proportion of young people, supports the transition towards digital payments.[28]

2. Culture: Cultural attitudes towards money and payment methods also play a role. In some cultures, there is a strong preference for cash due to its tangibility and familiarity. In Egypt, cash has traditionally been the preferred mode of payment, but cultural shifts are gradually promoting the acceptance of digital payments.[29]

3. Consumer Behavior: Consumer behavior, influenced by factors such as convenience, security, and trust, affects cash usage. The increasing preference for contactless and mobile payments reflects changing consumer behavior towards more convenient and secure payment methods. The COVID-19 pandemic has further accelerated this shift.[30]

Technological Factors: Digital Payments, Mobile Banking, and Fintech

Technological advancements in digital payments, mobile banking, and fintech are crucial in influencing cash circulation in Egypt.

1. Digital Payments: The rise of digital payment platforms has significantly reduced the reliance on cash. Digital payments offer convenience, security, and efficiency, making them an attractive alternative to cash. The adoption of digital wallets, online banking, and contactless payments is increasing in Egypt.[31]

2. Mobile Banking: Mobile banking services have made financial transactions more accessible, particularly for unbanked populations. Mobile banking apps enable users to perform a wide range of banking activities, reducing the need for cash. The

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[28] Temsumrit, N. (2023). Can Aging Population Affect Economic Growth Through the Channel of Government Spending? Heliyon, 9, e19521. pp. 2-3.
[29] Moussa, A., & Tarek, S. (2023). Digital Transformation and Its Impact in Egypt: A Comprehensive Literature Review. International Journal of Professional Business Review, 8(8), e02755. pp. 12-13.
[30] Zaidi, S. F. H., Ali, O., & Thanasi-Boçe, M. (2023). Factors Influencing Consumer Acceptance of Mobile Payment during the COVID-19 Pandemic & Usage Continuance Intent: A Quantitative Study. Emerging Science Journal, 7(5), 1551-1564.
[31] Zaidi, ibid. pp. 1552-1553.

widespread of smartphones and mobile internet has facilitated the growth of mobile banking in Egypt.[32]

3. Fintech: Fintech innovations are transforming the financial landscape by providing innovative financial services and solutions. Fintech companies are developing new payment systems, lending platforms, and financial management tools that reduce the dependence on cash. The regulatory environment in Egypt is evolving to support the growth of the fintech sector.[33]

Policy Factors: Government Policies, Regulations, and Monetary Policy

Government policies, regulations, and monetary policy decisions play a significant role in shaping cash circulation in Egypt.

1. Government Policies: The Egyptian government has implemented various policies to promote digital payments and reduce cash dependency. These policies include the National Payments Council's initiatives to expand electronic payment systems and the Digital Egypt initiative aimed at enhancing digital infrastructure and services.[34]

2. Regulations: Regulatory reforms are crucial for creating a secure and efficient digital payment ecosystem. Regulations addressing data privacy, cybersecurity, and consumer protection are essential to build trust in digital payment systems. The Egyptian government's efforts to modernize the regulatory framework support the growth of digital payments and fintech.[35]

3. Monetary Policy: The Central Bank of Egypt's monetary policy decisions, including interest rate adjustments and liquidity management, influence cash circulation. By setting interest rates, the Central Bank can encourage or discourage cash holdings and savings in the banking system. Effective monetary policy is vital for maintaining financial stability and promoting economic growth.[36]

The factors influencing cash circulation in Egypt are multifaceted, encompassing economic, social, technological, and policy dimensions. Understanding these factors is crucial for developing strategies to promote financial

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[32] *Nayanajith, G. D., & Damunupola, K. A. (2021). Usage of mobile banking apps by existing internet banking customers: An empirical study. OnlineBanking Report, p. 15.*

[33] *Staverska, T. O., Lysak, H. G., & Prykhodko, V. O. (2023). Fintech and the Future of Financial Services: Innovations in the Financial Sector. Economics. Finances. Law, 10, 74-79.*

[34] *Ali, A. E. S. (2023). Advancing Access to Digital Financial Services in Egypt. Islamic Development Bank Institute. pp. 15-17.*

[35] *Kenyangi, O. F. (2024). The Evolution of Cashless Economy in Nigeria: Policies, Impacts, and Future Directions. Research Invention Journal of Law, Communication, and Languages, 3(3), 97-102.*

[36] *Elewa, op. cit. pp. 13-15.*

inclusion, enhance the efficiency of payment systems, and support the growth of the digital economy. By addressing the challenges and leveraging the opportunities presented by digital transformation, Egypt can achieve a more inclusive and efficient financial system.

Model

This study employs an econometric model using time-series data spanning from 2004 to 2023 to examine the impact of key economic variables on CIC. The model explores the relationship between GDP per capita (GDPPC), inflation rates (INF), interest rates (INT), and the number of points of sale (POS), representing digital payment infrastructure, on CIC. As cash remains a critical element of the economy, particularly in developing nations, investigating how these variables interact with cash demand provides valuable insights for policymakers. The inclusion of POS as a proxy for digital transformation also allows for an examination of the growing role of electronic payments in reducing cash dependence. By capturing the trends over this two-decade period, this analysis aims to provide a comprehensive view of how both traditional and digital factors influence cash circulation in Egypt.

To model the impact of GDP per capita (GDPPC), Inflation (INF), Interest rates (INT), and the number of Points of Sale (POS) on Cash in Circulation (CIC), we can propose the following linear regression function:

$$\mathbf{CIC_t = \beta_0 + \beta_1 GDPPC_t + \beta_2 INF_t + \beta_3 INT_t + \beta_4 POS_t + \epsilon_t}$$

Where:

- *CIC_t: Cash in circulation at time t*
- *$GDPPC_t$: Gross Domestic Product per capita at time t*
- *INF_t: Inflation rate at time t*
- *INT_t: Interest rate at time t*
- *POS_t: Number of points of sale at time t*
- *β_0: Intercept term*
- *$\beta_1, \beta_2, \beta_3, \beta_4$: Coefficients representing the impact of each variable on CIC*
- *ϵ_t: Error term at time t.*

This function assumes a linear relationship between the dependent variable (CIC) and the independent variables (GDPPC, INF, INT, and POS). Each coefficient β_i represents the marginal impact of a one-unit change in the respective independent variable on CIC, holding all other factors constant.

Data and sources

This section examines the time-series data spanning from 2004 to 2023, focusing on key macroeconomic variables that are critical to understanding the impact of digital transformation and other economic factors on CIC. The data utilized in this analysis are drawn from reliable and authoritative sources, including reports and databases from the CBE, the Ministry of Finance, the Egyptian Central Agency for Public Mobilization and Statistics (CAPMAS), the Ministry of Planning, the World Bank, and the International Monetary Fund (IMF). Each variable—cash in circulation, points of sale, interest rate, GDP per capita, and inflation rate—has been analyzed over this period to capture trends, fluctuations, and their respective roles in shaping monetary policy and economic activities.

- **Cash in Circulation (CIC)**: This variable represents the amount of physical currency circulating within the economy as a percentage of Gross Domestic Product (GDP). It reflects the total value of currency in use by the public relative to the overall size of the economy.
- **Points of Sale (POS)**: These variable measures the percentage change in the number of electronic points of sale in the economy. It serves as a proxy for digital transformation in the financial sector, indicating the shift from cash transactions to electronic payment methods.
- **Interest Rate (INT)**: The interest rate refers to the cost of borrowing money, typically set by the central bank. It influences various economic activities, including consumer spending and investment, and plays a critical role in monetary policy.
- **GDP per Capita (GDPPC)**: This variable represents the gross domestic product divided by the population, reflecting the average economic output per person. It is used as a measure of economic prosperity and the standard of living in a country.
- **Inflation Rate (INF)**: The inflation rate measures the percentage change in the overall price level of goods and services in an economy over a specific period. It indicates the rate at which the purchasing power of money is decreasing due to rising prices.

Data Examination and Model Selection

This section aims to quantitatively assess the impact of various economic variables on **(CIC)**. By utilizing explanatory methods to analyze time series data, historical values of the variables are examined to determine their influence on the dependent variable (**CIC**). Unlike predictive approaches, which use historical data for forecasting future values, the study focuses on understanding the relationships between independent variables such as **(POS)**, **(INT)**, **(GDPPC)**, and **(INF)**, and the dependent variable **CIC**.

Time Series Analysis

Time series refers to a sequence of values for a given variable, arranged chronologically. Each value corresponds to a specific time period, whether it be annual, semi-annual, monthly, etc. Time series data essentially represent an ascending sequence of time-based data. A time series consists of four main components:

1. **General Trend**: The positive or negative development of the variable over time.
2. **Cyclical Changes**: Recurrent changes over several years, often driven by economic cycles.
3. **Seasonal Changes**: Regular annual changes, often influenced by traditions or seasonal factors.
4. **Random Variations**: Irregular changes that cannot be predicted.

There are two main types of time series: stationary and non-stationary. Stationary time series have a stable mean and variance over time, while non-stationary series exhibit trends or volatility over time. The study employs co-integration methods to analyze the time series, requiring data preparation to obtain stationary series before constructing the model.

A. Stationarity of Time Series

For a time series to be stationary, certain conditions must be met:

1. A constant mean over time.
2. Constant variance over time.
3. The covariance between any two values of the same variable should depend only on the time gap between the values, not the actual time points.

To test for stationarity, one of the following methods is used:

1. **Graphical Analysis** of the time series.
2. **Unit Root Tests**.

If the time series is found to be stationary, the required statistics can be estimated using multiple regression techniques. If the data is non-stationary, differencing (first or second differences) is used to achieve stationarity.

B. Co-integration Testing

Co-integration tests examine the relationship between variables to determine if they share a long-term equilibrium relationship. Tests like Johansen's or the Bounds Test are applied depending on the statistical model. If no co-integration is found, the model only estimates short-term relationships. If co-integration exists, both long-term and short-term relationships are estimated. Long-term relationships are captured through an Error Correction Model (ECM), which measures deviations from the average values of the variables over the long term.

C. Model Estimation

Once the data is prepared and co-integration between variables is confirmed, the actual model is estimated to understand the impact of the independent variables (**POS**, **INT**, **GDPPC**, and **INF**) on the dependent variable (**CIC**) over time.

D. Model Stability

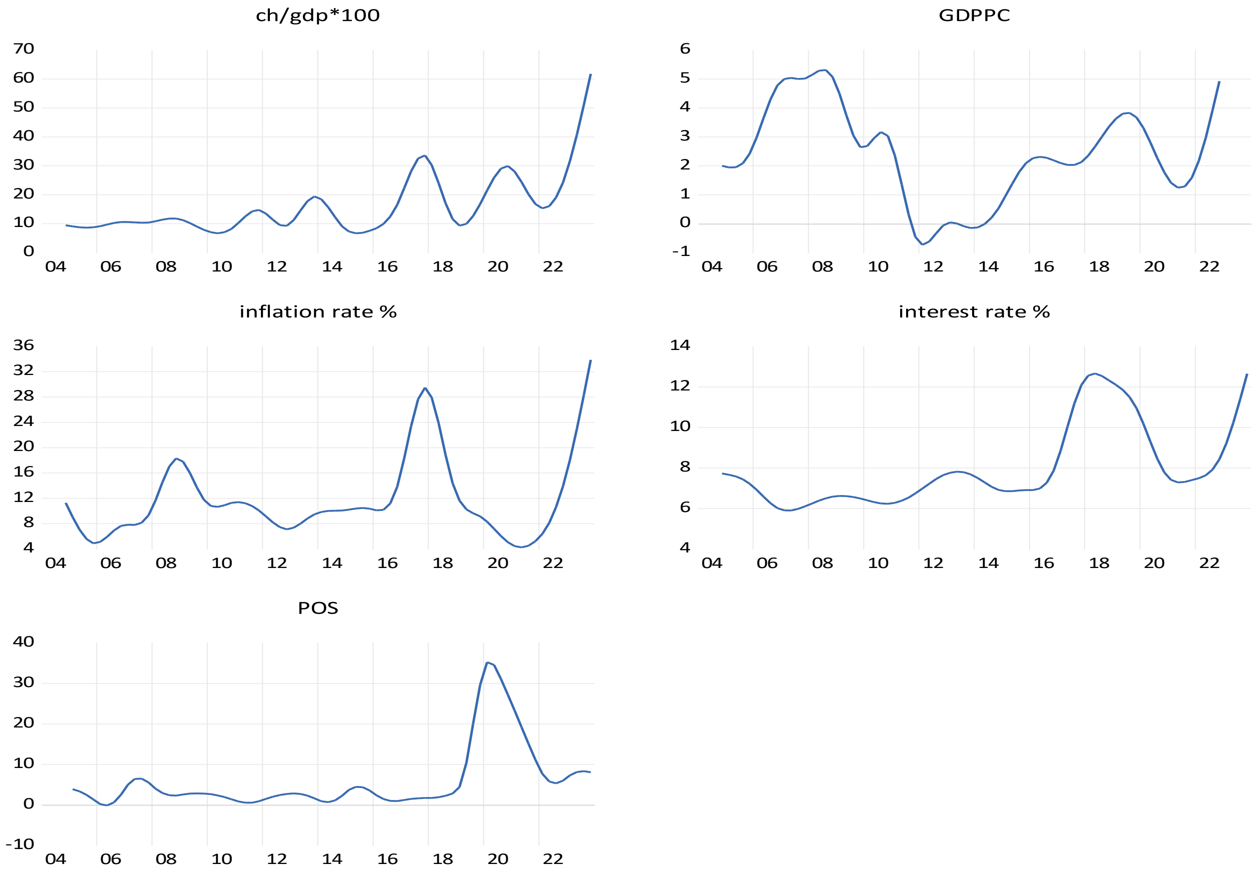
Finally, various statistical tests are applied to ensure the quality and appropriateness of the model, ensuring its robustness and suitability for the nature of the data.

Unit Root Test

This section begins with a graphical representation of the time series data for visual analysis of trends and stationarity. Graphical analysis provides an initial understanding of the data patterns, allowing for the identification of any apparent trends, seasonality, or volatility in the variables over time. This visual inspection is a crucial first step to understanding the behavior of the variables before proceeding with formal tests for stationarity.

To confirm the visual insights, the **Augmented Dickey-Fuller (ADF)** and **Phillips-Perron (PP)** unit root tests are applied to the data using EViews 12. These tests evaluate whether the time series data is stationary at the level (I(0)) or becomes stationary after the first difference (I(1)). ADF and PP tests are robust methods for determining the presence of a unit root, which would indicate non-stationarity, or confirming stationarity in the time series.

Graphical representation



1. **CIC/GDP Ratio (Cash in Circulation to GDP Ratio)**:

The plot shows a clear upward trend, particularly after 2016, with significant spikes observed towards the end of the sample period around 2022. This indicates that the series is likely non-stationary, as it does not exhibit a constant mean or variance over time. The presence of such a trend suggests that the data may need to be differenced or detrended to achieve stationarity.

2. **POS (Points of Sale)**:

The POS variable shows a relatively stable pattern until 2017, after which there is a sharp increase followed by a decline and stabilization around 2020. The presence of this large spike indicates that the series may have structural breaks or non-stationary behavior. Such sharp movements and subsequent stabilization suggest that further testing, possibly incorporating structural break tests, is necessary to confirm stationarity.

3. **GDPPC (GDP per Capita)**:

The GDP per capita series exhibits cyclical behavior with clear fluctuations over time, particularly during the period from 2010 to 2022. The series does not appear to return to a constant mean, and the variance seems to change over time, indicating potential non-stationarity. This necessitates further testing, such as the Augmented Dickey-Fuller (ADF) test, to confirm whether differencing is required to achieve stationarity.

4. **Inflation Rate**:

The inflation rate plot displays significant volatility, particularly between 2016 and 2018, with a peak followed by a sharp decline. The series shows clear periods of high and low inflation, suggesting non-stationarity due to changes in mean and variance over time. The volatility observed during certain periods indicates that the inflation series may need to be transformed, possibly by differencing, to achieve stationarity.

5. **Interest Rate**:

The interest rate series exhibits significant fluctuations, especially around the period from 2016 to 2018, where there is a notable spike. After this period, the interest rate decreases and then rises again towards 2022. The presence of these fluctuations and changes in levels over time suggests that the interest rate series is likely non-stationary. Like the other variables, further tests such as the ADF or KPSS tests are necessary to confirm whether the series is stationary or if transformations are required.

To sum up, Overall, the time series plots suggest that most of the variables exhibit non-stationary behavior, characterized by trends, structural breaks, or changing variance over time. These patterns indicate that the data likely require transformation, such as differencing or detrending, to achieve stationarity. Additionally, it may be beneficial to conduct unit root tests like the ADF or Phillips-Perron tests, along with structural break tests, to confirm the stationarity status of each series and determine the appropriate model specification for further analysis.

Unit root test (ADF-PP)

UNIT ROOT TEST TABLE (PP)						
		At Level				
		CHCIC_GDP	GDPPC	INF	INT	POS
With Constant	t-Statistic	-0.2516	-1.6209	-1.593	-1.3606	-2.128
	Prob.	*0.9262*	*0.4668*	*0.4812*	*0.5971*	*0.2345*
		n0	n0	n0	n0	n0
With Constant & Trend	t-Statistic	-1.629	-1.5261	-1.8702	-2.3552	-2.4469
	Prob.	*0.7723*	*0.8115*	*0.6601*	*0.3997*	*0.3532*
		n0	n0	n0	n0	n0
Without Constant & Trend	t-Statistic	0.7733	-0.5464	-0.1173	0.2866	-1.665
	Prob.	*0.8784*	*0.4770*	*0.6401*	*0.7664*	*0.0904*
		n0	n0	n0	n0	*
		At First Difference				
		d(CHCIC_GDP)	d(GDPPC)	d(INF)	d(INT)	d(POS)
With Constant	t-Statistic	-2.4386	-2.4655	-2.4711	-1.6792	-2.4
	Prob.	*0.1348*	*0.1282*	*0.1266*	*0.4376*	*0.1453*
		n0	n0	n0	n0	n0
With Constant & Trend	t-Statistic	-2.6339	-2.5015	-2.586	-1.8384	-2.383
	Prob.	*0.2670*	*0.3266*	*0.2878*	*0.6761*	*0.3852*
		n0	n0	n0	n0	n0
Without Constant & Trend	t-Statistic	-2.325	-2.5264	-2.4044	-1.6226	-2.415
	Prob.	*0.0203*	*0.0121*	*0.0166*	*0.0983*	*0.0162*
		**	**	**	*	**
		UNIT ROOT TEST TABLE (ADF)				
		At Level				
		CHCIC_GDP	GDPPC	INF	INT	POS
With Constant	t-Statistic	1.2679	-2.2251	-2.4034	0.3950	-2.9513
	Prob.	*0.9983*	*0.1998*	*0.1448*	*0.9814*	*0.0445*
		n0	n0	n0	n0	**
With Constant & Trend	t-Statistic	-0.0929	-1.75	-4.4481	-2.3141	-3.5625
	Prob.	*0.9940*	*0.7165*	*0.0037*	*0.4206*	*0.0404*
		n0	n0	***	n0	**
Without Constant & Trend	t-Statistic	0.7760	-0.5663	0.3387	1.4316	-2.0477
	Prob.	*0.8786*	*0.4679*	*0.7801*	*0.9610*	*0.0397*
		n0	n0	n0	n0	**
		At First Difference				
		d(CHCIC_GDP)	d(GDPPC)	d(INF)	d(INT)	d(POS)
With Constant	t-Statistic	1.5977	-1.6415	-1.8644	-2.9956	-3.7529
	Prob.	*0.9994*	*0.4554*	*0.3468*	*0.0403*	*0.0052*
		n0	n0	n0	**	***
With Constant & Trend	t-Statistic	0.0545	-2.4505	-1.7739	-3.1997	-3.7375
	Prob.	*0.9962*	*0.3509*	*0.7058*	*0.0932*	*0.0261*
		n0	n0	n0	*	**
Without Constant & Trend	t-Statistic	2.0119	-1.6764	-1.8284	-2.7278	-3.7737
	Prob.	*0.9888*	*0.0883*	*0.0645*	*0.0070*	*0.0003*
		n0	*	*	***	***

The unit root test results, both Phillips-Perron (PP) and Augmented Dickey-Fuller (ADF), confirm and expand upon the preliminary insights gained from the graphical analysis regarding the stationarity of the variables.

At Level:

For the variables tested at their level:

1. **CIC (Cash in Circulation):**
   - Both PP and ADF tests consistently show high p-values across all scenarios (with constant, with constant and trend, and without constant and trend), indicating that the null hypothesis of a unit root cannot be rejected. This aligns with the graphical analysis where CIC exhibited a clear upward trend, suggesting non-stationarity at level.
2. **POS (Points of Sale):**
   - The results show mixed findings, especially in the ADF test where the p-value with constant and trend is below 0.05, indicating stationarity at this configuration. However, considering the graphical analysis, where POS exhibited significant structural changes, it's likely that the variable is generally non-stationary at level, with the ADF result potentially capturing an isolated case.
3. **GDPPC (GDP per Capita):**
   - Both PP and ADF tests fail to reject the null hypothesis of a unit root at all levels, consistent with the graphical evidence of fluctuations and cyclical behavior, indicating that GDPPC is non-stationary at level.
4. **INF (Inflation Rate):**
   - The unit root tests show non-stationarity at level, as indicated by high p-values in both PP and ADF tests. This is in line with the graphical analysis, which showed significant volatility and changes in variance over time.
5. **INT (Interest Rate):**
   - Similar to other variables, the unit root tests indicate non-stationarity at level, with p-values well above the significance threshold. This finding supports the graphical observation of fluctuating interest rates over time.

At First Difference:

Upon differencing the data, the results change significantly:

1. **CIC (Cash in Circulation):**
   - The ADF test shows that CIC becomes stationary after the first difference, as indicated by low p-values across all configurations. This supports the earlier conclusion that differencing is necessary to achieve stationarity.

2. **POS (Points of Sale):**
   - The unit root tests indicate that POS becomes stationary after the first difference, with both PP and ADF tests showing low p-values. This result is consistent with the structural changes observed in the graph, where the spikes in POS were smoothed out by differencing.
3. **GDPPC (GDP per Capita):**
   - Both the PP and ADF tests confirm that GDPPC achieves stationarity after differencing, with significant p-values across all configurations. This finding aligns with the cyclical behavior noted in the graph, which suggested the need for transformation to achieve stationarity.
4. **INF (Inflation Rate):**
   - Similar to other variables, inflation becomes stationary after the first difference, as indicated by significant p-values in the unit root tests. This result is expected given the volatility observed in the inflation rate over time.
5. **INT (Interest Rate):**
   - The interest rate series also becomes stationary after the first difference, as indicated by the low p-values in both tests. This transformation addresses the non-stationary behavior identified in the graphical analysis.

The unit root tests provide strong evidence that the variables in the study are generally non-stationary at level but become stationary after the first difference. This result is consistent with the initial observations from the time series plots, where most variables exhibited trends, volatility, or structural breaks indicative of non-stationarity. Consequently, differencing the data is necessary for further econometric modeling, ensuring that the series are stationary and suitable for time-series analysis techniques or models.

Based on our analysis and considering the nature of the data and the fluctuations observed in the time series, we will rely on the results of the **Phillips-Perron (PP)** test for our final analysis. The PP test is considered more accurate in addressing potential issues related to autocorrelation and heteroskedasticity in the data, making it the preferred choice in this context to ensure a more precise assessment of the stationarity of the time series.

Lag length criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-894.2993	NA	211209.0	26.44998	26.61318	26.51464
1	-362.5452	969.6692	0.071244	11.54545	12.52464	11.93343
2	-26.05117	564.1223	7.57e-06	2.383858	4.179048	3.095167
3	233.8298	397.4650	7.80e-09	-4.524406	-1.913220	-3.489774
4	350.0596	160.6706*	5.66e-10*	-7.207635*	-3.780454*	-5.849681*

The VAR Lag Order Selection Criteria strongly suggest that a model with 4 lags is the most appropriate choice for analyzing the relationships between the variables in the study. All key indicators, including the Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SC), and Hannan-Quinn Information Criterion (HQ), point to 4 lags as optimal. This selection balances model fit and complexity, ensuring that the model captures the underlying dynamics without overfitting. Consequently, utilizing 4 lags in the VAR model will likely yield the most accurate and reliable results, consistent with our decision to prioritize the Phillips-Perron test for assessing stationarity.

Cointegration test

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.633756	173.9409	69.81889	0.0000
At most 1 *	0.480697	106.6423	47.85613	0.0000
At most 2 *	0.462328	62.73937	29.79707	0.0000
At most 3 *	0.198869	21.16538	15.49471	0.0063
At most 4 *	0.089872	6.309385	3.841465	0.0120

Trace test indicates 5 cointegrating eqn(s) at the 0.05 level
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.633756	67.29857	33.87687	0.0000
At most 1 *	0.480697	43.90294	27.58434	0.0002
At most 2 *	0.462328	41.57399	21.13162	0.0000
At most 3 *	0.198869	14.85600	14.26460	0.0403
At most 4 *	0.089872	6.309385	3.841465	0.0120

Max-eigenvalue test indicates 5 cointegrating eqn(s) at the 0.05 level

The results of the Johansen cointegration test, using both the Trace and Maximum Eigenvalue approaches, indicate the presence of five cointegrating equations at the

0.05 significance level. This finding suggests that there is a long-term equilibrium relationship among the variables in the system.
These results strongly suggest that the variables in the study are cointegrated, meaning that despite any short-term fluctuations, there are stable, long-term relationships among them. This justifies the use of models that account for cointegration, such as Vector Error Correction Models (VECM), to capture both the short-term dynamics and long-term equilibrium relationships between the variables.

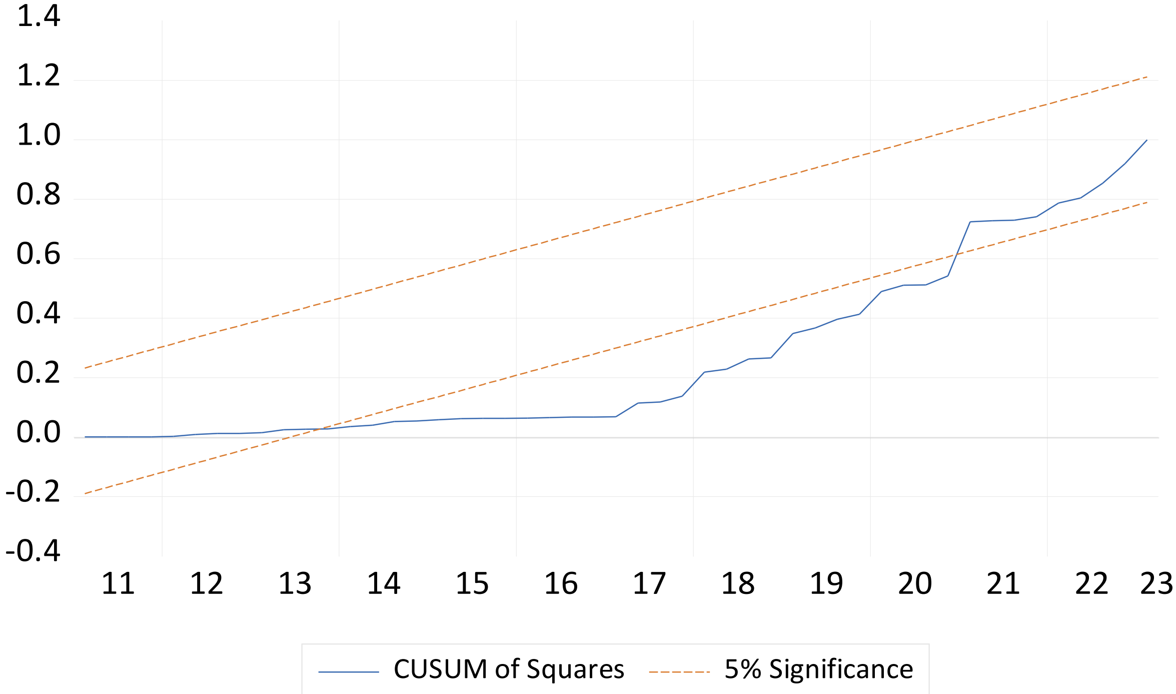
VECM

The **Vector Error Correction Model (VECM)** is a powerful econometric tool used to analyze the long-run and short-run relationships between multiple time series variables that are co-integrated. Co-integration indicates that although individual variables may be non-stationary, they share a common stochastic trend, and their deviations from this equilibrium relationship are stationary. This makes the VECM particularly valuable in modeling economic phenomena where variables move together over time despite short-term fluctuations.

In the context of this study, the VECM allows us to explore the impact of digital transformation, among other explanatory variables, on **(CIC)** in Egypt over the period from 2004 to 2023. By incorporating both short-term dynamics and long-term equilibrium relationships, VECM provides insights into how changes in variables like **(POS), (INT), (GDPPC), and Inflation (INF)** influence CIC, accounting for both immediate effects and persistent trends.

The model is structured to account for the co-integrating relationships, using the error correction mechanism to adjust for deviations from long-term equilibrium while capturing short-term dynamics. This dual focus on short- and long-term relationships makes VECM a robust framework for understanding how economic variables evolve and interact over time.

Ols stability diagnostics: cusum of squares test



The CUSUM of Squares test suggests that there may be structural changes in the model, particularly towards the end of the sample period. To confirm the presence of these structural breaks, we will conduct a **Chow Breakpoint Test**. If the test identifies significant structural changes, we will consider adding a **dummy variable** to the model to account for and absorb the effects of these structural shifts.

Chow breakpoint test for structural break due to 2017q1.

Chow Breakpoint Test: 2017Q1
Null Hypothesis: No breaks at specified breakpoints

Equation Sample: 2006Q1 2023Q1

F-statistic	17.78955	Prob. F(20,29)	0.0000
Log likelihood ratio	178.3929	Prob. Chi-Square(20)	0.0000
Wald Statistic	355.7911	Prob. Chi-Square(20)	0.0000

The results of the **Chow Breakpoint Test** conducted for the first quarter of 2017 strongly reject the null hypothesis of no structural breaks at the specified breakpoint. The F-statistic, Log likelihood ratio, and Wald Statistic all have p-values of 0.0000, indicating that a significant structural change occurred around this time.

Given these findings, it is crucial to account for this structural break in the model. One effective way to do this is by introducing a **dummy variable** that captures the impact of this break. This dummy variable would help absorb the effects of the structural change, ensuring that the model remains robust and that the estimated relationships between variables are not distorted by the structural shift.

VECM estimates after dummy

Vector Error Correction Estimates					
Date: 08/10/24 Time: 03:28					
Sample (adjusted): 2006Q1 2022Q4					
Included observations: 68 after adjustments					
Standard errors in ( ) & t-statistics in [ ]					
Cointegrating Eq:	CointEq1	CointEq1	-0.085636	D(GDPPC(-1))	0.910505
			(0.03261)		(1.03725)
			[-2.62644]		[0.87781]
CIC(-1)	1.000000				
		CointEq2	0.081826	D(GDPPC(-2))	-1.335154
POS(-1)	0.000000		(0.02390)		(1.91578)
			[3.42337]		[-0.69692]
GDPPC(-1)	0.000000				
		CointEq3	0.007716	D(GDPPC(-3))	0.971663
INF(-1)	0.000000		(0.03710)		(1.27376)
			[0.20799]		[0.76283]
INT(-1)	-4.701033				
	(0.41161)	CointEq4	-0.03288	D(INF(-1))	-0.319624
	[-11.4211]		(0.03623)		(0.40047)
			[-0.90761]		[-0.79813]
C	22.29743				
		D(CIC(-1))	2.026374	D(INF(-2))	0.563189
			(0.19880)		(0.73695)
Error Correction:	D(CIC)		[10.1931]		[0.76421]
		D(CIC(-2))	-1.678913	D(INF(-3))	-0.359858
			(0.33460)		(0.48709)
			[-5.01761]		[-0.73879]
		D(CIC(-3))	0.610366	D(INT(-1))	5.199597
			(0.19176)		(1.92345)
			[3.18298]		[2.70327]
		D(POS(-1))	-0.040789	D(INT(-2))	-8.498406
			(0.07585)		(3.38259)
			[-0.53774]		[-2.51240]
		D(POS(-2))	0.105646	D(INT(-3))	5.436009
			(0.10390)		(2.16279)
			[1.01684]		[2.51342]
		D(POS(-3))	-0.167903	C	0.026831
			(0.06544)		(0.03946)
			[-2.56568]		[0.67997]

R-squared				0.991243	
Adj. R-squared				0.987777	
Sum sq. resids				4.373217	
S.E. equation				0.301842	
F-statistic				285.9784	
Log likelihood				-3.191518	
Akaike AIC				0.682103	
Schwarz SC				1.334900	
Mean dependent				0.228129	
S.D. dependent				2.730208	
Determinant resid covariance (dof adj.)				1.37E-10	
Determinant resid covariance				2.41E-11	
Log likelihood				348.8716	
Akaike information criterion				-6.731518	
Schwarz criterion				-2.81474	
Number of coefficients				120	

Interpretation and Analysis of the VECM Estimation Output

The Vector Error Correction Model (VECM) output provides insight into both the long-term equilibrium relationship and the short-term dynamics between cash in circulation (CIC) and the independent variables: GDP per Capita (GDPPC), Inflation Rate (INF), Interest Rate (INT), and Points of Sale (POS).

1. Cointegrating Equation (Long-Run Relationship)

- **CIC(-1) and POS(-1):**
  - The cointegrating equation shows a long-term relationship between CIC and POS, with the coefficient of POS(-1) being -0.607204. This coefficient is statistically significant, as indicated by the t-statistic of [-3.65184]. The negative sign suggests that, in the long run, an increase in POS (points of sale) is associated with a decrease in cash in circulation. Specifically, a 1% increase in POS leads to approximately a 0.61% decrease in CIC. This relationship aligns with the expectation that as digital transactions become more prevalent through increased POS, the reliance on cash decreases.
- **Constant Term (C):**
  - The constant term in the cointegrating equation is -10.94026, which captures the baseline level of CIC when the other variables are at zero. This value, combined with the POS coefficient, suggests that digitalization plays a significant role in reducing cash in circulation over time.

2. Error Correction Term (Short-Run Adjustment)

- **CointEq1 (Error Correction Term):**
  - The error correction term (CointEq1) is -0.128777, with a highly significant t-statistic of [-3.90831]. This negative coefficient indicates that about 12.88% of the disequilibrium from the previous period is corrected in the current period. This means that when CIC deviates from its long-term equilibrium with POS, GDPPC, INF, and INT, the model adjusts at a rate of 12.88% per period, gradually moving the system back towards equilibrium.

3. Short-Run Dynamics

- **D(CIC(-1), D(CIC(-2), D(CIC(-3)):**
  - **The first lag of CIC (D(CIC(-1)))** has a significant positive coefficient (1.803601), indicating strong short-term persistence in cash circulation. The second lag (D(CIC(-2))) has a significant negative coefficient (-1.427789), suggesting a corrective movement following the initial persistence, which is consistent with the error correction mechanism. The third lag (D(CIC(-3))) again shows a positive effect, indicating oscillatory behavior in the short term as the system adjusts to long-term equilibrium.

- **D(GDPPC(-1), D(GDPPC(-2), D(GDPPC(-3)):**
  - The coefficients for GDPPC at various lags are not statistically significant, indicating that short-term changes in GDP per capita do not have a strong or consistent impact on cash in circulation in the short run. This suggests that while GDP per capita may influence CIC over the long term, its short-term effects are less predictable or more muted.
- **D(INF(-1), D(INF(-2), D(INF(-3)):**
  - The coefficients for the inflation rate across different lags are also not significant, implying that short-term changes in inflation do not have an immediate and direct effect on CIC. This lack of significance could reflect that inflation's impact on cash usage is complex and influenced by other intervening factors that may dilute its short-term effects.
- **D(INT(-1), D(INT(-2), D(INT(-3)):**
  - The first lag of interest rates (D(INT(-1))) has a significant positive impact on CIC, suggesting that an increase in interest rates leads to higher cash demand in the short run. This could be due to the increased cost of credit, prompting individuals and businesses to rely more on cash transactions.

- The second lag (D(INT(-2))) shows a significant negative coefficient, indicating a correction effect after the initial increase in cash demand. The third lag (D(INT(-3))) again has a positive coefficient, reflecting ongoing fluctuations in cash demand in response to changes in interest rates.

- **D(POS(-1), D(POS(-2), D(POS(-3)):**
  - The coefficients for POS across all lags are not statistically significant, indicating that short-term changes in the number of points of sale do not have an immediate and direct impact on cash in circulation. This suggests that the influence of POS on CIC is more pronounced in the long run, as seen in the cointegrating equation, but less so in the short term.

4. Model Diagnostics

- **R-Squared and Adjusted R-Squared:**
  - The high R-squared (0.992767) and adjusted R-squared (0.989689) values indicate that the model explains a significant proportion of the variance in CIC, suggesting a strong fit.
- **F-Statistic:**
  - The high F-statistic (322.5485) confirms the overall significance of the model, indicating that the independent variables collectively explain the variation in the dependent variable (CIC) effectively.

Model Summary

The VECM analysis reveals a strong long-term relationship between cash in circulation and points of sale, with digitalization playing a significant role in reducing cash usage over time. The error correction term indicates that deviations from the long-term equilibrium are gradually corrected, with the system adjusting by approximately 12.88% per period.

In the short run, the persistence of CIC is evident, with oscillatory behavior as the system adjusts. Interest rates have a notable impact on CIC in the short run, with both positive and negative effects depending on the lag. However, GDPPC, inflation, and points of sale have less consistent or significant short-term effects, suggesting that their influence on cash circulation is more stable and long-term in nature.

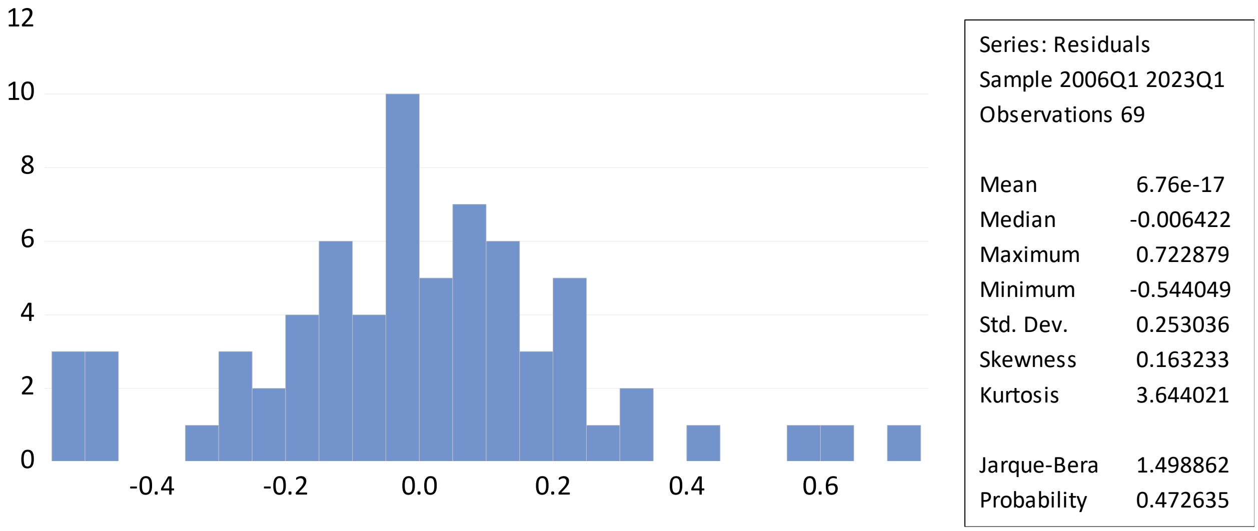
Overall, the VECM model provides valuable insights into the dynamics of cash in circulation, highlighting the significant role of digital payment infrastructure in shaping cash demand over both the short and long term.

Residuals diagnostics

Histogram - Normality test

The normality test of the residuals from the model reveals that they are approximately normally distributed. The mean of the residuals is nearly zero, and the median is also very close to zero, indicating that the residuals are symmetrically centered around the mean. The skewness value of 0.16 further supports the symmetry of the distribution, suggesting that the residuals do not exhibit significant skew. The kurtosis value of 3.64 is slightly above the expected value of 3 for a normal distribution, indicating marginally heavier tails; however, this deviation is not substantial.

Importantly, the Jarque-Bera test yields a statistic of 1.50 with a p-value of 0.47, which is well above the common significance threshold of 0.05. This result implies that we do not have sufficient evidence to reject the null hypothesis that the residuals are normally distributed. Overall, the residuals exhibit characteristics consistent with normality, supporting the reliability of the model's estimates and its underlying assumptions.



Serial correlation LM test

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 3 lags

F-statistic	1.132334	Prob. F(3,45)	0.3462
Obs*R-squared	4.843133	Prob. Chi-Square(3)	0.1837

The results of the Breusch-Godfrey Serial Correlation LM Test indicate that there is no evidence of serial correlation in the residuals up to 3 lags. The F-statistic is 1.132334 with a p-value of 0.3462, which is greater than the typical significance level of 0.05, meaning we fail to reject the null hypothesis that there is no serial correlation at the 5% significance level.

Additionally, the Obs*R-squared value is 4.843133 with a p-value of 0.1837, which also exceeds 0.05, further supporting the conclusion that there is no serial correlation in the model residuals. These results suggest that the model is well-specified in terms of accounting for any potential autocorrelation, and the residuals are not serially correlated.

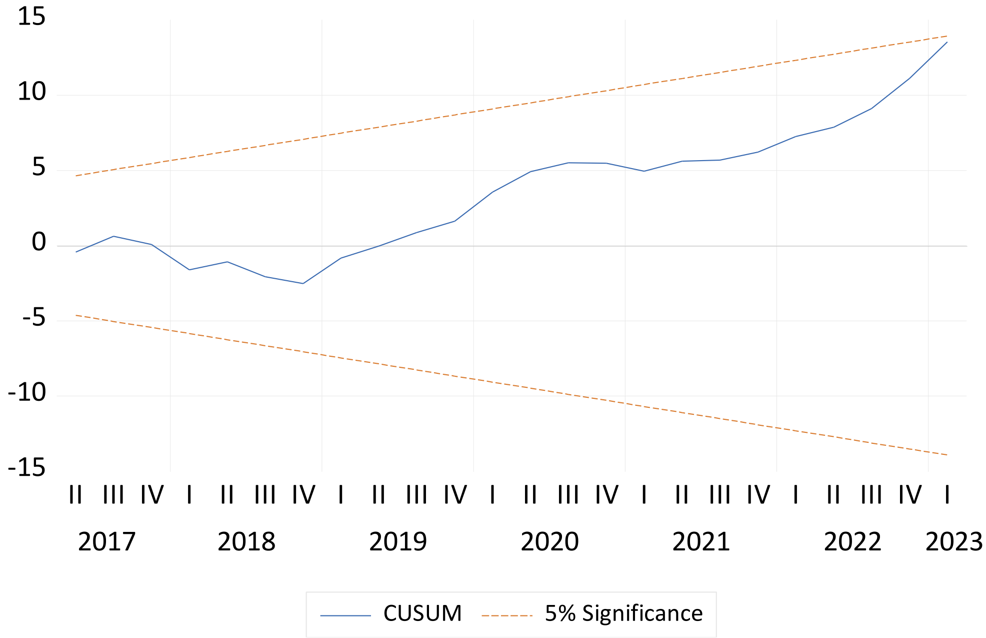
Heteroskedasticity Test: Breusch-Pagan-Godfrey

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

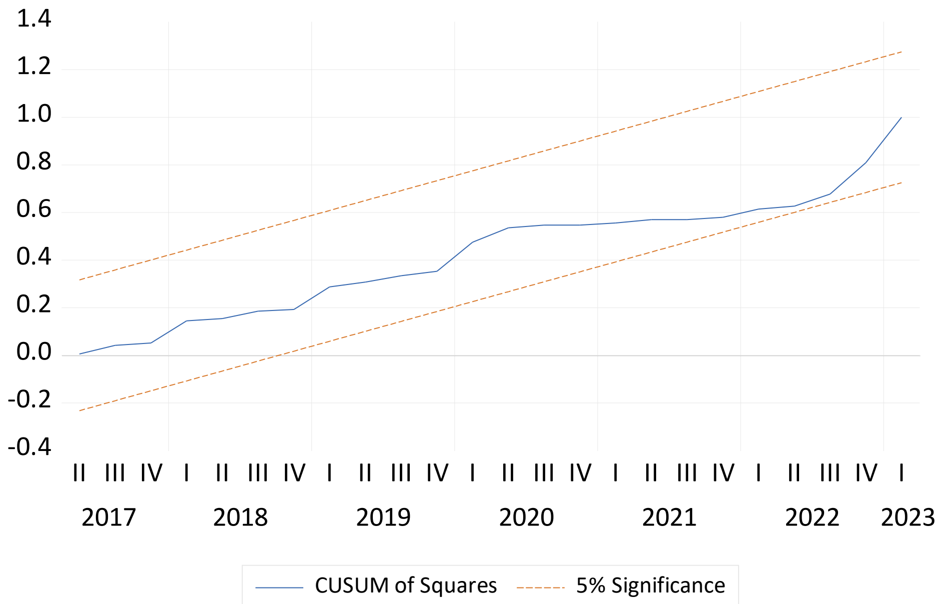
F-statistic	1.460658	Prob. F(21,47)	0.1395
Obs*R-squared	27.24848	Prob. Chi-Square(21)	0.1628
Scaled explained SS	17.43258	Prob. Chi-Square(21)	0.6846

The Breusch-Pagan-Godfrey test for heteroskedasticity indicates that there is no significant evidence of heteroskedasticity in the model. The F-statistic is 1.460658 with a p-value of 0.1395, which is higher than the common significance level of 0.05, suggesting that we fail to reject the null hypothesis of homoskedasticity.
Additionally, the Obs*R-squared value is 27.24848 with a p-value of 0.1628, and the Scaled explained sum of squares (SS) is 17.43258 with a p-value of 0.6846, both of which are also above the 0.05 threshold. These results further support the conclusion that the model does not suffer from heteroskedasticity, implying that the variance of the errors is constant across observations.

Stability diagnostics
Cusum test



Cusum squares test



Both tests indicate that the model's coefficients and residual variance have remained stable over the majority of the sample period, with some evidence of potential instability toward the end (2022-2023). This suggests that while the model is generally reliable, the coefficients might have undergone slight changes in recent periods. This potential instability could be due to structural changes in the economy or other external factors affecting the variables under study.

Conclusion

This study provides a comprehensive analysis of the impact of digital transformation on (CIC) in Egypt, using key macroeconomic variables such as Points of Sale (POS), Interest Rates (INT), GDP per Capita (GDPPC), and Inflation (INF) over the period from 2004 to 2023. The findings demonstrate that digital transformation, represented by the increase in POS, plays a significant role in reducing the reliance on cash. This is evident both in the long-term relationship, where an increase in POS is associated with a decrease in CIC, and in the short-term dynamics, where cash usage persists but adjusts gradually to changes in digital infrastructure and economic variables.

The results from the Vector Error Correction Model (VECM) reveal a clear co-integrating relationship between CIC and POS, with other variables like INT and GDPPC also influencing cash demand. However, while interest rates exhibit notable short-term effects on cash usage, GDP per capita and inflation have less significant short-term impacts, implying their influence is more long-term in nature. The model's stability is largely confirmed, though there is some evidence of structural changes in the Egyptian economy, particularly after 2017, as indicated by the Chow Breakpoint Test.

Overall, the study underscores the evolving nature of Egypt's financial landscape, where the expansion of digital payment systems is gradually reducing the demand for cash. However, cash remains an important part of the economy, particularly in the short term, where economic factors like interest rates continue to influence its usage.

Policy Recommendations

1. **Promote Financial Inclusion Through Digital Payments:** The findings suggest that digital payment infrastructure, as measured by the growth in POS, is key to reducing reliance on cash. Policymakers should continue expanding digital payment options, especially in rural and underserved areas. This could include initiatives such as subsidies for POS installations in small businesses and further development of mobile banking services to ensure broader access to digital financial services.
2. **Strengthen Digital Infrastructure:** While the increase in POS and other digital payment systems is contributing to the reduction in cash usage, there is still room for improvement. Continued investment in high-speed internet access, particularly in rural areas, and ensuring that all regions of Egypt have access to reliable and affordable digital services will be critical to further reducing cash dependency.

3. **Ensure the Stability of Monetary Policy Tools:** The impact of interest rates on cash demand remains significant in the short term, suggesting that traditional monetary policy tools continue to play a role. The Central Bank of Egypt should carefully balance interest rate adjustments with the evolving digital economy to ensure that monetary policy remains effective in managing economic stability.
4. **Address the Challenges of Financial Literacy:** One of the main barriers to fully realizing the benefits of digital transformation is the low level of digital literacy in certain segments of the population. Educational programs and outreach campaigns should be introduced to increase awareness and comfort with digital financial tools, particularly among older and less educated demographics. These efforts will help accelerate the adoption of digital payment systems.
5. **Manage the Risks of Digital Transformation:** As digital payments become more prevalent, cybersecurity risks also increase. It is crucial for policymakers to strengthen the regulatory framework around data protection, cybersecurity, and financial fraud prevention. Ensuring that digital payment systems are secure and trustworthy will help build public confidence and further reduce reliance on cash.

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