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THE IMPACT OF COVID-19 PANDEMICS ON THE USE OF CASH

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ATM – Automated Teller Machine

BC – Before Christ

BIS – Bank for International Settlements

CBDC – Central Bank Digital Currencies

COVID-19 – Coronavirus Disease 2019

DC – Digital Commerce

ECB – European Central Bank

Eurostat - Statistical Office of the European Union

FINTECH – Financial Technology

GDP – Gross Domestic Product

LSDV – Least Squares Dummy Variable

M-PESA – Mobile Money (with "PESA" meaning "money" in Swahili)

MPOS – Mobile Point-of-Sale Payments

NPISH – Non-Profit Institutions Serving Households

OECD – Organization for Economic Co-operation and Development

OLS – Ordinary Least Squares

PIN – Personal Identification Number

UAE – United Arab Emirates

USA – United State of America

WHO – World Health Organization

1 INTRODUCTION

Payment methods have undergone significant changes over the past decade (2012–2022). Advances in technology have played a transformative role in payment systems, with the emergence of the COVID-19 pandemic further accelerating these changes. Concerns about virus transmission through physical banknotes led to a decline in cash circulation (Auer et al., 2021). Consequently, the use of physical currency for payments has significantly decreased across many countries. At the same time, the demand for high-denomination banknotes often utilized as a store of value has risen disproportionately compared to lower denominations, especially by 2020. This trend underscores that cash is increasingly being used as a store of value rather than for everyday transactions (Zamora-Pérez, 2021).

The aim of this thesis is to examine whether there has indeed been a decrease in cash circulation and to determine the period during which this reduction became evident, if at all. Specifically, it seeks to answer whether the outbreak of the COVID-19 pandemic initiated this decline or merely accelerated a pre-existing trend.

To achieve this, the study will first quantify the level of cash held within the economies of the countries included in the research. It will then explore whether the observed decline in cash use is attributable solely to the pandemic or if other factors, such as demographic and technological shifts, play a significant role. Demographic factors analysed include the age distribution of the population and the level of education, while the degree of technological development is assessed to determine its relationship with the demand for cash as a means of payment. Additionally, socio-economic conditions such as income disparities and consumer preferences will be considered to enrich the analysis. These variables will be tested for linear correlation with the level of cash in the economy.

This study examines 30 countries across four continents, grouped as follows: Europe (Austria, Belgium, Croatia, Denmark, France, Germany, Greece, Hungary, Italy, North Macedonia, Netherlands, Norway, Poland, Portugal, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland and the UK), North America (Canada, Mexico and the USA), Asia (China, Japan, Türkiye and the UAE) and Australia. It spans the period from 2012 to 2022, with a special focus on the years 2020 to 2022 due to the impact of the COVID-19 pandemic. Data from the World Bank, central banks and other relevant sources will be employed, utilizing regression analysis to investigate the relationships between cash use, demographic trends and technological advancements.

By conducting this analysis, the thesis aims to provide evidence of whether the level of cash in the economy has indeed declined and to assess whether this decline can primarily be attributed to the pandemic. The findings will contribute to understanding the dynamics of cash circulation, which is essential for interpreting consumer behaviour, enhancing financial policies and adapting monetary systems to evolving payment practices globally.

2 LITERATURE REVIEW

2.1 Evolution of Cash Circulation

Imagine standing in a bustling market around 9000 BC, where buying a few tomatoes would require offering something of value in return, perhaps a handful of berries or a few cucumbers (Chapman, 1980). This simple act of exchange marks the dawn of commerce, laying the foundation for what would eventually become the complex systems of currency and money used today. During these early periods, barter was the primary system, where goods and services were directly exchanged for other goods and services (O'Neill, 2016). Over time, as societies grew and economies became more complex, the limitations of exchange became apparent, leading to the development of more standardized forms of exchange (Anbugeetha & Nandhini, 2021).

As early as 5000 BC, trade began to develop beyond the simple exchange of foodstuffs. Instead of trading grains, fruits and vegetables, people started exchanging tools, weapons and other metal objects (Chapman, 1980). These items, valued for their utility and rarity, marked a shift towards more sophisticated trade practices, where the intrinsic value of goods became more recognizable and standardized (Anbugeetha & Nandhini, 2021). With the domestication of cattle around 9000 BC, animals quickly became the basic unit of exchange (Chapman, 1980). Domestic animals such as cattle, sheep and camels were highly valued, not only for their practical use but also as a measure of wealth and status. The use of livestock as a medium of exchange underscores the transition from barter to a more organized economic system, where the value of goods was measured in a more consistent and reliable manner (Makarewicz & Rose, 2011). By 1300 BC, in various parts of the world, including Asia, Africa, Oceania and some areas of Europe, cowrie shells had become a widely accepted medium of exchange (National Museum of African American History and Culture, n.d.). These small, durable shells were prized for their beauty and rarity, serving as an early form of currency in many cultures. The use of cowrie shells persisted until about 1000 BC, when the Chinese began producing imitations made of bronze and copper. These imitations were not only a practical innovation but also an early form of coinage, serving as precursors to the metal coins that would become widespread in later centuries (Gregory, 1996).

The arrival of the Bronze Age around 3000 BC brought about significant changes in trade and currency (Chapman, 1980). In China, by 1300 BC, the use of bronze objects as a medium of exchange began to take hold. The first bronze coins, often in the shape of small tools or knives, appeared in China, marking the beginning of the era of true currency (Hansen, 2011). This period also saw the introduction of metal money into Europe, where bronze objects were similarly used as a means of trade. The global transition to metallic forms of currency currently reflects a wider shift towards more permanent and standardized means of exchange. The appearance of coins around 600 BC in Lydia (today's Türkiye) was a pivotal moment in the

history of money. The standardized coins of Lydia, made of electrum, a natural alloy of gold and silver. They had fixed values, which greatly facilitated trade. These early coins represented a significant advance in economic systems, enabling more efficient and secure transactions, paving the way for the widespread use of money in everyday life (Millman, 2015). As the ancient world progressed, different regions developed unique forms of currency. In some parts of antiquity, salt became a highly valued medium of exchange, especially in regions where it was scarce (Cartwright, 2021). Salt was so valuable that it was often called "white gold" and in some places it was even used to pay soldiers, hence the word "salary" (Smith, 2014). In other regions, such as the island of Yap in Micronesia, large stone discs known as rai were used as a means of payment. These huge stones, about 12 feet in diameter, had symbolic value and were revered as a medium of exchange despite their impracticality in everyday transactions (Baker, 2018). During the Middle Ages, different regions adopted different forms of currency that reflected their local economies and resources. In Virginia, for example, tobacco became an important medium of exchange. Tobacco was so integral to the economy that it served as a form of currency, especially in the 17th century (Chapman, 1980). Although metal coins remained the primary means of trade in much of the world, the use of commodities such as tobacco underscores the diversity of currency systems that coexisted with more standardized forms of money exchange (Anbugeetha & Nandhini, 2021).

From 1500 to 1800 CE, the use of paper money began to gain traction, although it faced initial resistance. The first recorded use of paper money dates back to China during the Tang Dynasty¹ (618-907 CE), with widespread issuance occurring during the Song Dynasty² (960-1279 CE) (Szczepanski, 2019). Despite its early adoption in China, the overproduction of paper money during the Ming Dynasty led to hyperinflation, causing significant economic challenges. In Europe, Sweden became the first country to issue banknotes in 1661, setting the stage for the broader adoption of paper money across the continent (Szczepanski, 2019). As paper money became more accepted, it played a crucial role in modernizing economies and facilitating large-scale trade (European Central Bank, 2023). The modern era, from the 1800s onwards, witnessed the standardization of banknotes and coins as the primary means of exchange (Anbugeetha & Nandhini, 2021). The Industrial Revolution and the rise of global trade necessitated more efficient and reliable forms of currency, leading to the widespread use of banknotes, which were easier to carry and exchange than metal coins.

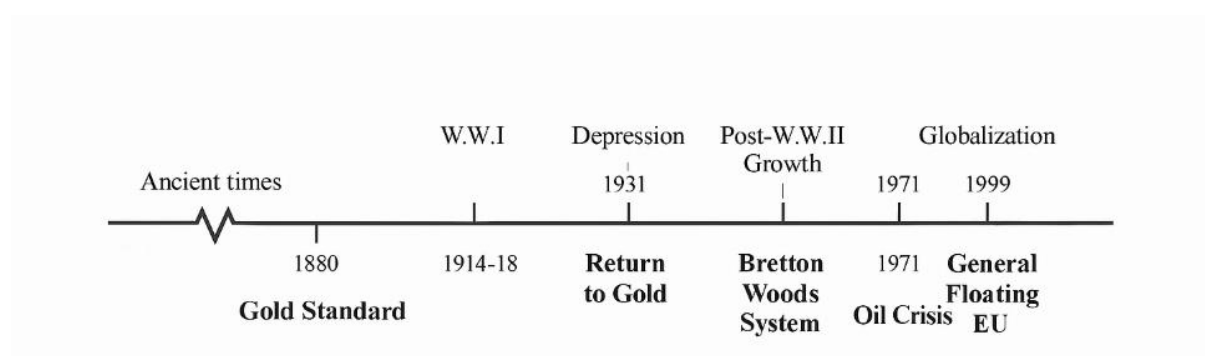
Overall, the late 19th and early 20th centuries were a critical time in the evolution of cash circulation and its effects on the economy (Smiley, 2004). The systems and practices established during this period laid the foundation for modern financial systems, where money

¹ The Tang dynasty or the Tang Empire, was an imperial dynasty of China that ruled from 618 to 907, with an interregnum between 690 and 705 (The Metropolitan Museum of Art, 2001).

² The Song dynasty (960–1279) was culturally the most brilliant era in later imperial Chinese history (The Metropolitan Museum of Art, 2001).

supply management and cash circulation remain central to economic stability, growth and the daily functioning of society. As World War I loomed over Europe in July 1914, a financial crisis gripped the continent, leading to a drastic shift from gold to paper money in Britain as shown in Figure 1. Panic over the stability of the financial system prompted people and businesses to rush to convert their bank balances into gold sovereigns, fearing that paper currency might lose its value in the chaos of war (NatWest Group, n.d). This sudden demand for gold depleted the Bank of England's reserves, with £12.3 million paid out in just six days, leaving the Bank with less than half its gold reserves and the British pound at risk of collapse (Roberts, 2013).

Figure 1: Timeline of the different monetary regimes



Source: Van Den Berg, (2016)

Faced with this dire situation, the British government needed to prevent a complete bank run and the subsequent economic catastrophe. Additionally, with the expected long and costly war, the need for gold to finance the war effort became more urgent (Bank of England, 2018). The government soon recognized that existing gold reserves would be insufficient to cover all war expenses. It became clear that maintaining and creating gold reserves was essential to keep the currency stable and avoid inevitable inflation (Anbugeetha & Nandhini, 2021). To achieve this, the government had to fundamentally change the nation's approach to currency. The primary strategy involved transitioning from gold coins to paper money, which needed to be widely accepted by the public to succeed. At that time, paper money was not commonly used in England, especially for small transactions (Bank of England, 2018). The Bank of England issued banknotes, but only for amounts of £5 and above a sum too large for most everyday transactions. The government responded by introducing smaller banknotes as £1 and £10 shilling to replace gold in daily use. These new notes, known as Treasury notes or "Bradburys" after Sir John Bradbury, the Treasury Secretary whose signature appeared on them, were introduced with unprecedented speed. Within days of the decision, £2.5 million in £1 notes were printed and distributed to banks, ensuring that there was enough money in circulation when banks reopened after the initial crisis (Fisher-Hoyrem, 2013). This transition was not without its challenges. The rushed production of the banknotes led to practical issues such as

the small size of the notes, making them difficult to handle, particularly for bank clerks (Bank of England, 2023). Additionally, the lack of time to incorporate advanced anti-counterfeiting measures made the new notes susceptible to forgery. This problem was compounded by the fact that the English population, unaccustomed to using banknotes, was less skilled at detecting counterfeit money (Bank of England, 2018). Despite these difficulties, the circulation of paper money quickly increased, helping to stabilize the British economy during the war (Palma, 2019). In contrast, Scotland had long been familiar with paper money, with commercial banks issuing their own banknotes for nearly two centuries. Amid the war, Scottish banknotes were also designated as legal tender to prevent creditors from demanding gold. The circulation of paper money in Scotland also significantly expanded during the war, reflecting the broader shift towards a paper-based monetary system across the United Kingdom (Fisher-Hoyrem, 2013). This period marked the beginning of the end for gold as the primary medium of exchange in Britain, leading to the dominance of paper money and eventually paving the way for the modern fiat currency system. The transition during World War I was a crucial step in adjusting the national economy to function with less reliance on gold, laying the groundwork for the financial practices that would dominate the 20th century and beyond (Bank of England, 2018).

The shift to fiat money after the collapse of the Bretton Woods system in 1971 had a profound impact on cash circulation, transforming the global financial landscape and introducing new dynamics in economic management (Mudasser, 2022). Under the gold standard, the amount of money in circulation was closely tied to a country's gold reserves, which provided a natural limit on the money supply and helped maintain stable currency values. The transition to fiat money removed this constraint, allowing governments and central banks much greater control over the money supply (Fisher-Hoyrem, 2013). This newfound flexibility enabled them to print money as needed, which was particularly useful in responding to economic crises or managing inflation. One of the most significant effects of the shift to fiat money on cash circulation was the potential for increased inflation (Abi Karam, 2023). Without gold reserves backing the currency, the money supply could be expanded without the need for additional gold, leading to a greater risk of inflation if the money supply grew too quickly. This was evident in the 1970s when many countries, particularly the United States, experienced high inflation rates (Fisher-Hoyrem, 2013). The ability to print money without constraint led to concerns about currency devaluation, as the more money in circulation, the less each unit was worth. This inflationary pressure was one of the key challenges that arose from the adoption of fiat money (Federal Reserve Bank of St. Louis, 2010).

Furthermore, the change to fiat money introduced greater volatility in currency markets. Under the gold standard, exchange rates were fixed, providing stability in international trade and investment. The adoption of fiat money led to greater exchange rate flexibility, making them more responsive to market forces (Mulqueeney & Livermore, 2023). This led to fluctuations in currency values based on economic conditions, investor sentiment and central bank policies (Fisher-Hoyrem, 2013). Exchange rate volatility made international transactions more complex

and introduced new risks for businesses and investors involved in global trade. The shift also affected how central banks managed economies. With fiat money, central banks had more tools at their disposal to influence the economy, such as adjusting interest rates, conducting open market operations and controlling the money supply through quantitative easing or tightening. This greater control over monetary policy allowed central banks to respond more effectively to economic downturns, but it also required careful management to avoid causing hyperinflation or deep recessions. In terms of cash circulation, the move to fiat money led to a more dynamic and responsive financial system. Cash could be printed and circulated more freely, supporting economic growth and liquidity. At the same time, it required careful management to ensure that the increased money supply did not undermine the currency's value (Fisher-Hoyrem, 2013). The shift to fiat money marked the beginning of a new era in global finance, where central banks played a more active role in managing economies and the relationship between money supply and economic stability became more complex (Erh, 2021).

The introduction of credit and debit cards in the mid-20th century significantly transformed cash circulation and consumer spending habits. Initially, credit cards like the Diners Club³ card (launched in 1950) and Bank Americard (now Visa, introduced in 1958) offered a new way to pay for goods and services without the immediate need for cash, allowing consumers to buy on credit and pay later (Trütsch, 2020). This innovation provided unprecedented convenience, especially for higher-income consumers who frequently traveled or dined out and gradually became more accessible to the broader population. As these cards became more popular in the 1960s and 1970s, especially with the advent of revolving credit (where consumers could carry a balance and pay interest), reliance on physical cash began to decline. The ability to pay by card rather than carrying large amounts of cash became a preferred option for many, reducing cash circulation, particularly for larger transactions (Federal Reserve Bank of Philadelphia, 2021). Debit cards, which emerged later, allowed direct access to a consumer's bank account funds, further reducing the need for cash as they became widely accepted in the 1980s and 1990s.

The proliferation of credit and debit cards also led to changes in the overall financial landscape. As more people used these cards, the flow of cash through the economy shifted, with less physical currency circulating in everyday transactions. Instead, electronic transactions became the norm, contributing to the rise of digital banking and e-commerce (Bank for International Settlements, 2023). This shift not only changed how people spent money but also how businesses and banks managed cash flow and credit. Overall, the rise of card-based payments has been a key factor in the decline of cash use, reflecting broader changes in technology and consumer behaviour that have reshaped the financial ecosystem (Karanikolos et al., 2013). With the rise of credit and debit cards beginning in the mid-20th century, the use of cash in circulation

³ The Diners Club card, introduced in 1950 by Frank McNamara, is widely recognized as the first general-purpose charge card, initially accepted at 14 New York City restaurants and requiring full monthly repayment (Rosenberg, J, 2020).

started to decline, particularly for larger and more frequent transactions. As consumers increasingly embraced card payments for their convenience and security, the demand for physical cash began to decrease. This trend became more pronounced in the late 20th and early 21st centuries as electronic payment systems and digital banking further reduced the need for cash (Federal Reserve Bank of Boston, 2023).

The decline in the level of cash held within economies was not uniform across sectors and regions. In many advanced economies, the use of cash for everyday purchases began to decline significantly, particularly in urban areas where card payments became more widely accepted. In contrast, cash remained more prevalent in rural areas and in economies with less developed financial infrastructure (Bank of England, 2022). Additionally, certain types of transactions, such as small purchases or informal exchanges, continued to rely on cash even as digital payments became more common.

Although there was an overall decline in the demand for cash as a means of payment, the total amount of cash in circulation (the total value of physical currency issued) did not decrease proportionally. In fact, in many countries, the total value of cash in circulation continued to grow, albeit at a slower rate (Das et al., 2023). This apparent paradox can be attributed to several factors: the continued demand for money as a store of value, particularly during periods of economic uncertainty, the use of cash for transactions in the informal economy and the role of cash in certain cultures where it is still preferred for privacy and tradition (Pacilo, 2024).

2.2 Impact of Technology on Cash Circulation

The impact of digital payment technologies, such as credit and debit cards, on cash circulation has been profound, leading to a significant shift in how money is used and managed in modern economies (Ahnert et al., 2023). From the late 20th century onwards, the widespread adoption of these technologies has transformed consumer behaviour, particularly in developed economies, where the use of physical cash has declined markedly (Trütsch, 2020). Credit and debit cards offer unparalleled convenience, speed and security, making them the preferred payment method for many, especially in urban areas where electronic payment infrastructure is well-established (European Central Bank, 2022). This shift has been further accelerated by the advent of contactless payment technologies, which allow consumers to make transactions quickly without the need for PIN entry or signatures, significantly reducing the demand for low-denomination banknotes and coins. As contactless payments became more prevalent, particularly in retail environments where quick transactions are crucial, the necessity for cash diminished even further (Adrian & Mancini, 2021). Despite the declining use of cash for everyday transactions, the total value of cash in circulation has not decreased in proportion to its usage (Trütsch, 2020).

In many countries, the amount of cash in circulation has continued to grow, though at a slower rate. This phenomenon can be attributed to several factors. Firstly, cash remains an essential

medium in certain sectors of the economy, particularly in the informal economy, where transactions are often unrecorded and untaxed. In these sectors, cash is preferred for its anonymity and ease of use. Secondly, during periods of economic uncertainty, individuals and businesses tend to hoard cash as a safe store of value (Adrian & Mancini, 2021). This behaviour was particularly evident during the global financial crises, where the demand for cash surged as people sought to protect their wealth from potential banking system failures and currency devaluations (Trütsch, 2020).

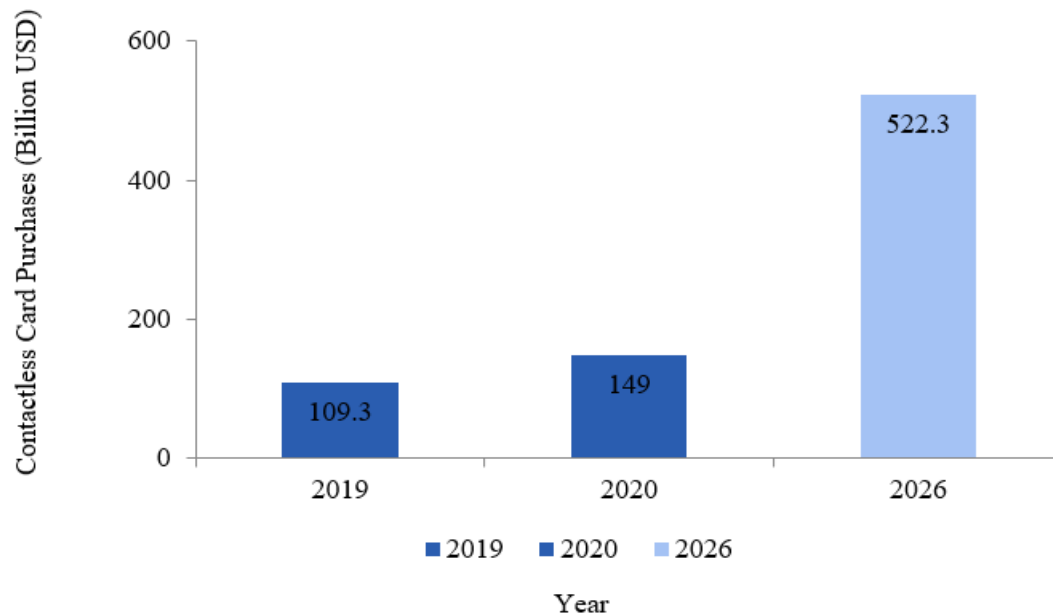
In many societies, cash is still regarded as a reliable and straightforward means of payment, especially for small transactions and in rural or less developed areas where access to digital payment infrastructure may be limited (Trütsch, 2020). The persistence of these practices has ensured that, even as digital payment methods become more widespread, cash continues to play a crucial role in the financial system. This is particularly true in developing economies, where mobile money platforms like M-Pesa⁴ have made significant inroads, bringing financial services to millions who previously relied solely on cash (Trütsch, 2020). In the broader context, the rise of digital payments has also had significant implications for monetary policy and financial stability. Central banks have had to adapt to the changing landscape by developing new tools and strategies to manage the money supply and ensure the stability of their currencies (Bank of Canada et al., 2021).

The increasing use of digital payments has raised concerns about the potential decline in demand for central bank-issued currency, leading some central banks to explore the possibility of issuing their own digital currencies as a way to maintain their role in the financial system (Andolfatto, 2020).

This trend is further supported by data shown in Figure 2, which illustrates the rapid increase in the number of contactless card purchases worldwide. In 2019, there were approximately 109.3 billion such transactions, which rose to 149.0 billion in 2020. This growth reflects the accelerating adoption of contactless payment methods during the early stages of the COVID-19 pandemic, as consumers sought safer and more efficient alternatives to cash. The figure also includes a forecast for 2026, projecting a significant rise to 522.3 billion contactless transactions globally (Phillips, 2022). This sharp increase suggests not only continued consumer preference for digital payments, but also improvements in payment infrastructure and broader access to banking services. The rising trend underscores the global shift toward cashless societies, especially in urban and technologically advanced regions and further explains the declining practical need for physical currency in daily transactions, even though cash remains present in the financial system (NFCW, 2022).

⁴ M-PESA is a mobile money service launched in 2007 by Safaricom and Vodafone in Kenya (Vodafone,n.d).

Figure 2: Number of contactless card purchases worldwide (in billions)



Source: RBR (2022)

Overall, while the rise of digital payment technologies has led to a decline in the use of cash for transactions, it has not resulted in a corresponding decrease in the total value of cash in circulation. Instead, cash remains an important component of the financial system, serving as a store of value and a medium of exchange in certain contexts (Chen & Hossain, 2021). The ongoing evolution of payment technologies suggests that the role of cash will continue to diminish, but it is unlikely to disappear entirely. The complexity of cash use in an increasingly digital world reflects the diverse needs and preferences of consumers, as well as the varying levels of development in different regions (Heinonen, 2019). As such, cash will likely remain a significant part of the global financial landscape for the foreseeable future.

2.3 Consumer Preferences and Behaviour in Cashless Transactions

Consumer preferences and behaviour in cashless transactions have evolved significantly with digital payment technologies, leading to a notable shift in how people manage their finances and make purchases (Ohlan et al., 2019). The increasing adoption of cashless payment methods, such as credit and debit cards, mobile wallets and contactless payments has been driven primarily by the convenience, speed and security these options offer compared to traditional cash transactions (Jiang, 2022). Consumers today prefer cashless transactions for a variety of reasons (Esselink & Hernández, 2017). The ease of use is a major factor, particularly with contactless payments, which allow for quick transactions without the need for PIN entry or signatures. This convenience aligns well with the fast-paced nature of modern life, where consumers value speed and efficiency in their shopping experiences (Trütsch, 2020).

Businesses that adopt cashless payment systems often see increased customer satisfaction and loyalty, as these methods reduce the friction associated with traditional cash payments. The behavioural shift towards cashless transactions is also influenced by the psychological aspects of spending (Gupta, 2022). Research has shown that consumers tend to spend more when using cashless payment methods because they are less aware of the immediate financial impact compared to using physical cash (Schomburgk et al., 2024). This detachment from the physical exchange of money makes it easier for consumers to make purchases without feeling the same level of restraint as they would with cash. This phenomenon has encouraged businesses to embrace cashless options to increase sales, particularly in retail environments where impulse purchases are common (Jiang, 2022). Moreover, the integration of digital wallets and mobile payment apps has further shaped consumer behaviour by offering additional features such as loyalty programs and rewards. These incentives encourage repeat business and foster brand loyalty, as consumers are more likely to return to establishments where they can easily accumulate and redeem rewards (Foster & Greene, 2021). The seamless integration of payment and rewards in digital wallets enhances the overall shopping experience, making cashless transactions more attractive to consumers (Schomburgk et al., 2024).

Despite the growing popularity of cashless transactions, it is important to recognize that not all consumers have fully embraced this shift. Some segments of the population, particularly older individuals or those in less urbanized areas, still prefer cash for its simplicity, anonymity and the absence of transaction fees. Younger generations, who are more tech-savvy and comfortable with digital platforms, are driving the momentum towards a cashless society. These consumers often feel awkward using cash and prefer the convenience of digital payments for their daily transactions (Holetić, 2023).

As the trend towards cashless transactions continues, it is shaping not only how consumers spend but also how they manage their finances (Kauangal & Paschal, 2023). The rise of fintech⁵ apps that help users track and manage their spending is a direct response to the challenges posed by a cashless economy (Clere, 2023). These apps provide insights into spending patterns, helping consumers make more informed financial decisions and avoid the pitfalls of overspending (Jiang, 2022).

3 METHODOLOGY

As discussed in the previous chapter, money as a medium of exchange has evolved from the Stone Age to our current digitalized society, influenced by various factors including economic conditions, technological advancements and demographic preferences.

⁵ Examples of popular fintech apps include Mint, YNAB (You Need a Budget), Revolut and Monzo, which offer features such as budgeting tools, spending analytics and real-time transaction notifications (Futures, 2023).

This study examines a critical question: How has cash use changed over the past decade (2012–2022), particularly considering significant events such as the COVID-19 pandemic? Specifically, this thesis investigates how the pandemic has affected global cash use patterns and explores other factors that may have influenced these changes. The research places special emphasis on demographic factors, particularly age and education levels and technological infrastructure.

Key hypotheses include:

1. The COVID-19 pandemic accelerated existing trends in cash use.
2. Countries with younger populations are more likely to abandon cash as a means of payment.
3. Countries with higher education levels tend to rely less on cash.
4. Advanced technological infrastructure facilitates a faster transition away from cash.

During the pandemic, a notable shift in the level of cash held and used within economies was observed. While transactional cash use declined due to reduced consumer spending and concerns about virus transmission (Bank of England, 2020), many countries experienced an increase in banknotes in circulation as people held more cash for precautionary reasons (Reserve Bank of Australia, 2021). This dual trend highlights the complex changes in payment behaviour during crises.

To comprehensively address these questions, this study analyses panel data from 30⁶ countries over 11 years (2012–2022). These countries, spanning Europe, Asia, North America and Australia, were selected to represent a diverse range of economic development levels, demographic profiles and technological infrastructures. This approach allows for the examination of both global trends and country-specific responses.

The analysis proceeds in three phases: first, a baseline model assessing the impact of the COVID-19 pandemic on cash use; second, extended models that separately explore demographic and technological drivers of cash trends; and third, a combined model that integrates all key variables for a more complete specification.

This thesis applies a rigorous empirical framework to explore the interplay between the COVID-19 pandemic, demographic characteristics, technological development and cash use patterns across countries. The findings offer valuable insights for policymakers navigating the evolving payment landscape, with implications for digital currency initiatives, financial inclusion and monetary crisis response strategies. Following the data collection process built

⁶ Europe: Greece, Russia, Serbia, North Macedonia, Sweden, France, Italy, Norway, Poland, Spain, Germany, Austria, Slovenia, Hungary, Switzerland, Denmark, United Kingdom, Belgium, Portugal, Croatia, Slovakia, Netherlands. North America: Mexico, United States, Canada. Asia: Türkiye, Japan, United Arab Emirates, China. Australia: Australia.

on a panel dataset from 30 countries and cash use estimated via the residual method the analysis proceeds in three key stages.

3.1 Residual Method for Estimating Cash

The persistence of cash usage despite the availability of digital alternatives has been noted in prior research (Khiaonarong & Humphrey, 2019). For this purpose, household consumption data from each country covered in this thesis (for the period 2012 to 2022) is utilized.

Calculation methodology is defined as:

$$\text{CashUse} = (\text{Household consumption on country account} - \text{All credit and debt payments in the country} - \text{E-money (digital payments in the count)}) \quad (1)$$

This methodology involves several key steps to estimate the level of cash held and used across countries from 2012 to 2022. The process begins by collecting comprehensive household spending data for each country for each year from 2012 to 2022 in USD (in billions), sourced from reputable international databases such as the World Bank and national statistical offices. Household consumption represents the total spending by households on goods and services and serves as the basis for calculating cash use. From this total, all non-cash transactions are removed, including payments made by credit and debit cards, which reflect purchases completed through bank-issued cards. Additionally, e-money transactions are excluded, as they cover a wide range of digital payment methods such as mobile payments, digital wallets and online banking apps. By subtracting these components, the remaining portion reflects the estimated amount of spending carried out using physical cash.

E-money transactions in this study encompass a wide range of digital payment methods, reflecting the diverse landscape of electronic payments across different regions. While not exhaustive, these include mobile payments (such as Apple Pay, Google Pay and Samsung Pay), stored value card payments, online payment platforms (such as PayPal and Stripe), bank-specific digital wallets, peer-to-peer payment apps and even cryptocurrency transactions where applicable and significant. The composition of e-money transactions can vary significantly across countries due to differences in technology adoption, regulatory environments and consumer preferences. For example, services like Revolut and N26 are prevalent in Europe, offering convenient digital banking features such as fee-free foreign transactions and intuitive mobile apps (N26, n.d.).

Meanwhile, platforms like Venmo and Cash App are widely used in the United States, a 2022 Pew Research Center survey found that 38% of U.S. adults use Venmo and 26% use Cash App (Pew Research Center, 2022).

In Asia, Alipay and WeChat Pay dominate in China, accounting for over 90% of the mobile payments market, although their use may be limited in other regions due to regulatory constraints (Chave, 2021).

This diversity in e-money ecosystems presents some limitations in data comparability. By aggregating these different forms of electronic payments, we aim to capture a comprehensive picture of non-cash transactions across markets. The amount remaining after deducting these electronic and card-based transactions from total household consumption is considered cash use. While this approach is not perfect, it provides a reasonable estimate of cash transactions in the economy, taking into account the heterogeneous nature of e-payment adoption across regions.

After calculating the circulation of cash in each country (expressed in USD billions), the percentage of cash use as a share of each country's GDP is determined using the following formula:

$$\text{Cash Use (\% of GDP)} = \left(\frac{\text{CashUse(in USD billions)}}{\text{GDP (in USD billions)}} \right) \times 100 \quad (2)$$

Cash Use was expressed as a percentage of GDP rather than in absolute terms (USD billions), as this approach offers several analytical advantages. Firstly, it normalizes the data across countries of different economic sizes, allowing for more meaningful comparisons and providing context for the scale of cash reliance relative to the overall economy. Additionally, this approach helps control for economic growth and inflation effects over time, while also aligning with common practices in economic literature, making the results more comparable with other research in the field.

3.2 Baseline Model

After assembling the dataset and calculating the key metrics outlined in the Data section, the analysis begins with the estimation of a baseline panel regression model. This model serves as the foundation for assessing the impact of the COVID-19 pandemic on patterns of cash use across 30 countries over the period from 2012 to 2022. It also facilitates the identification of key influencing factors prior to the introduction of additional explanatory variables in the extended models.

To address the core research question regarding the effect of the pandemic on cash use, two standard panel data estimation techniques are considered: the fixed effects model and the random effects model.

Following the guidance of Wooldridge (2010) and the framework outlined in Gujarati and Porter's *Basic Econometrics* (2009), a systematic evaluation was conducted to identify the most appropriate model specification. This approach ensures that model selection is grounded in

statistical evidence, allowing for robust conclusions regarding the impact of COVID-19 on cash use across countries and over time.

3.2.1 Fixed Effects Model

The fixed effects model allows for arbitrary correlation between the explanatory variables in the model and the unobserved country-specific effect. As outlined by Baltagi (2021), the fixed effects model can be specified as:

$$Cash\ Use_{it} = \beta_0 + \beta_1 Covid_t + X_{it} \beta + \alpha_i + \varepsilon_{it} \quad (3)$$

In the fixed model (3), $Cash\ Use_{it}$ represents the level of cash reliance for country i at time t , while $Covid_t$ serves as a dummy variable indicating the COVID-19 period. A vector of control variables, denoted by X_{it} , accounts for other factors that may influence cash use. The model also incorporates α_i to capture country-specific effects that remain constant over time and ε_{it} represents the idiosyncratic error term.

A key feature of the fixed effects model is its treatment of α_i as a parameter to be estimated for each country. This approach effectively creates a country-specific intercept, capturing all unobserved, time-invariant factors unique to each nation. As Gujarati and Porter (2009) note, this method is equivalent to including a dummy variable for each country, which is why it is often referred to as the least squares dummy variable approach. The fixed effects estimator utilizes only the within-country variation in the data, effectively controlling for all time-invariant country characteristics, whether observed or unobserved. This makes it particularly robust against omitted variable bias from time-invariant factors, enhancing the reliability of my analysis.

3.2.2 Random Effects Model

In contrast, the random effects model treats the country-specific effects as random variables that are uncorrelated with the explanatory variables. Following Baltagi (2021), the random effects model can be specified as:

$$CashUse_{it} = \beta_0 + \beta_1 Covid_t + X_{it}\beta + u_i + \varepsilon_{it} \quad (4)$$

where u_i represents a random country-specific effect, assumed to be independently and identically distributed with $u_i \sim IID(0, \sigma_u^2)$. All other variables are defined as in the fixed effects model. The random effects model assumes that:

$$E(u_i | Covid_t, X_{it}) = 0 \quad (5)$$

This crucial assumption implies that the unobserved country-specific heterogeneity is uncorrelated with the included explanatory variables. When this assumption holds, the random effects estimator is more efficient than the fixed effects estimator because it captures both within-country and between-country variation in the dataset.

The choice between fixed and random effects models involves several important trade-offs, as highlighted by both Baltagi (2021) and Gujarati and Porter (2009). Fixed effects allow for correlation between the unobserved country-specific effects (α_i) and explanatory variables, while random effects assume no such correlation. Random effects models are generally more efficient when their assumptions are met. In contrast, fixed effects models are more robust and consistently provide unbiased estimates. Another key distinction is that fixed effects cannot estimate coefficients on time-invariant variables, as these are absorbed by the country-specific effects, whereas random effects can incorporate such variables. In terms of identification, fixed effects models rely solely on within-country variation, while random effects utilize both within and between-country variation. Lastly, fixed effects models consume more degrees of freedom due to the estimation of individual country effects, which can be a consideration in smaller samples. These differences underscore the importance of carefully evaluating model choice in the context of the specific research question and data structure at hand.

3.2.3 Hausman Test

To determine the most appropriate model specification, the Hausman specification test was applied, following the recommendations of Baltagi (2021) and Wooldridge (2010). This test assesses whether systematic differences exist between the coefficient estimates produced by the fixed effects and random effects models.

The null hypothesis of the Hausman test is that the random effects estimator is consistent and efficient:

$$H_0: E(u_i | Covid_t) = 0 \quad (6)$$

The alternative hypothesis is that the random effects estimator is inconsistent, while the fixed effects estimator remains consistent:

$$H_A: E(u_i | Covid_t) \neq 0 \quad (7)$$

The test statistic, as detailed in Gujarati and Porter (2009, p. 606), is calculated as:

$$H = (\beta_{FE} - \beta_{RE})^T [Var(\beta_{FE}) - Var(\beta_{RE})]^{-1} (\beta_{FE} - \beta_{RE}) \quad (8)$$

where β_{FE} represents the coefficient estimates from the fixed effects model and β_{RE} represents the coefficient estimates from the random effects model. This respective variance–covariance matrix is $Var(\beta_{FE}) - Var(\beta_{RE})$. Under the null hypothesis, this statistic follows a chi-squared distribution with degrees of freedom equal to the number of time-varying regressors.

3.3 Extended Model Specifications

Based on the results of the Hausman test (see Table 7), the random effects model was identified as the more appropriate specification for the panel data. Consequently, all regression models in this section are estimated using the random effects estimator.

3.3.1 Demographic Factors and Cash Use Decline

To investigate how demographic characteristics influenced cash use from 2012 to 2022, particularly during the pandemic years, the baseline model was extended to include demographic variables and their interaction terms with the COVID-19 dummy variable. This model allows for an assessment of whether countries with younger populations experienced a greater decline in cash use compared to those with older populations. Additionally, it examines whether individuals with higher education levels used less or more cash during the COVID-19 pandemic years. The extended model is specified as follows:

$$\begin{aligned} Cash Use_{it} = & \beta_0 + \beta_1 Young Population_{it} + \beta_2 Tertiary Education_{it} + \beta_3 Covid_t + \\ & \beta_4 (Covid_t \times Young Population_{it}) + \beta_5 (Covid_t \times Tertiary Education_{it}) + X_{it}\beta + \\ & u_i + \varepsilon_{it} \end{aligned} \quad (9)$$

As was mentioned earlier $YoungPopulation_{it}$ represents the percentage of the population aged 18-35 in country i at time t . $Tertiary Education_{it}$ denotes the percentage of the population with tertiary education. The interaction terms $Covid_t \times YoungPopulation_{it}$ and $Covid_t \times Tertiary Education_{it}$ capture how the impact of COVID-19 on cash reliance varies depending on demographic characteristics. Specifically, $Covid_t \times YoungPopulation_{it}$ examines whether countries with a higher proportion of young people experienced a greater decline in cash use during the pandemic.

Similarly, $Covid_t \times Tertiary Education_{it}$ assesses whether higher education levels amplified the pandemic's effect on cash use. This approach aligns with research indicating that demographic factors significantly influence payment preferences, especially during the pandemic. Such findings support the inclusion of age and education-related variables in analyzing cash related behaviour (Auer et al., 2021).

3.3.2 Technology and Cash Use Decline Model

To examine the role of technological factors in the decline in the use of cash, the following model is estimated, incorporating two independent variables that reflect key dimensions of technological development across countries. These factors include the High and Medium Tech Output and Digital Payments⁷, which collectively measure a country's level of innovation, technological production and digital financial adoption.

$$\begin{aligned} \text{Cash Use}_{it} = & \beta_0 + \beta_1 \text{DigitalPayments}_{it} + \beta_2 \text{High and Medium Tech Output}_{it} \\ & + \beta_3 \text{Covid}_t + \beta_4 (\text{Covid}_t \times \text{Digital Payments}_{it}) + \\ & \beta_5 (\text{Covid}_t \times \text{High and Medium Tech Output}_{it}) + X_{it} + u_i + \varepsilon_{it} \end{aligned} \quad (10)$$

DigitalPayments_{it} reflects the total value of digital payment transactions in each country, focusing on Digital Commerce and Mobile POS Payments as defined by Statista. This variable serves as an indicator of technological advancement in the payment system and reflects the level of digital adoption within the economy. Importantly, *DigitalPayments_{it}* does not capture the total volume of all non-cash transactions in the country, nor is it intended as the mathematical opposite of cash use. Traditional non-cash payment instruments such as credit and debit card payments at physical points of sale (when not executed via mobile wallets), bank transfers, direct debits and cheques are not included in this measure. Instead, *DigitalPayments_{it}* focuses exclusively on technology-driven payment innovations, such as online shopping and mobile wallet payments at physical retail locations. By using this variable, the analysis aims to capture the degree of digitalization in consumer payment behaviour and to assess its potential role in influencing cash payment patterns before and during the COVID-19 pandemic.

High and Medium Tech Output_{it} measures the share of high-technology exports as a percentage of total manufactured exports, providing an additional indicator of a country's broader innovation and production capacity in high-tech sectors. By incorporating both variables, the analysis aims to examine how technological factors relate to cash payment patterns across countries before and during the COVID-19 pandemic. Specifically, the model assesses whether higher levels of digital adoption and technological output contributed to a more pronounced decline in the use of cash during the crisis period.

3.4 Combined Model

In the final stage of the analysis, a combined model is estimated, integrating both demographic and technological factors. This approach enables a direct comparison of the relative influence

⁷ Digital Payments represent the sum of Digital Commerce (DC) and Mobile Point-of-Sale Payments (MPOS), as defined by Statista. DC refers to online payment transactions made via desktop and mobile devices, while MPOS captures mobile wallet payments conducted at physical retail locations (Worldpay, 2024).

of demographic characteristics and technological advancements on the decline in cash use during the COVID-19 pandemic. Incorporating both sets of variables within a single specification also enhances the accuracy of the estimates by controlling for potential omitted variable bias and capturing interaction effects between demographic and technological influences.

$$\begin{aligned} \text{Cash Use}_{it} = & \beta_0 + \beta_1 \text{YoungPopulation}_{it} + \beta_2 \text{TertiaryEducation}_{it} + \\ & \beta_3 \text{DigitalPayments}_{it} + \beta_4 \text{High and Medium Tech Output}_{it} + \beta_5 \text{Covid}_t + \\ & \beta_6 (\text{Covid}_t \times \text{YoungPopulation}_{it}) + \beta_7 (\text{Covid}_t \times \text{Tertiary Education}_{it}) + \\ & \beta_8 (\text{Covid}_t \times \text{DigitalPayments}_{it}) + \beta_9 (\text{Covid}_t \times \text{High and Medium Tech Output}_{it}) + \\ & X_{it}\beta + u_i + \varepsilon_{it} \end{aligned} \quad (11)$$

Additionally, this comprehensive model provides deeper insights into how digitalization and population dynamics have jointly shaped consumer payment behaviour during the pandemic. By analysing the interaction effects, the model enables an assessment of whether younger, more educated populations in highly digitalized countries experienced a more rapid transition from cash to digital payments.

3.5 Total Payments

To further address the relationship between overall payment activity and cash use, an additional model was estimated incorporating Total Payments as a percentage of GDP. This variable includes both cash and non-cash payments, thus reflecting the total volume of consumer payment transactions within the economy.

The inclusion of Total Payments aims to capture the overall payment intensity in each country, thereby addressing potential bias present when analysing non-cash payments in isolation. By considering total payment volume, the model ensures that countries with generally low payment activity are not misrepresented.

To investigate whether the impact of Total Payments on cash use changed during the pandemic, an interaction term between Total Payments and the Covid-19 dummy was included. The following panel regression model with random effects was specified:

$$\begin{aligned} \text{CashUse}_{it} = & \beta_0 + \beta_1 \text{Covid}_t + \beta_2 \text{TotalPayments}_{it} + \beta_3 (\text{Covid}_t \times \text{TotalPayments}_{it}) \\ & + \beta_4 \text{YoungPop}_{it} + \beta_5 \text{TertiaryEducation}_{it} \\ & + \beta_6 \text{High and Medium TechOutput}_{it} + u_i + \epsilon_{it} \end{aligned} \quad (12)$$

The variable Total Payments (% of GDP) represents the total value of consumer payment transactions in relation to GDP, including both cash and non-cash payments.

This comprehensive measure captures the overall payment activity within an economy. The calculation was based on household consumption data, following the assumption that consumer spending closely reflects the total volume of payments.

4 DATA

This study employs a comprehensive panel dataset spanning 30 countries across 4 continents, providing a global perspective on cash use patterns. The sample includes 22 European countries (17 of which are European Union member states), 4 Asian countries, 3 North American countries and Australia. By selecting this diverse geographical representation, the research aims to capture variations in economic structures, technological development and demographic compositions that might influence the use of cash.

The dataset covers the critical period from 2012 to 2022, strategically encompassing both pre-COVID-19 years and the pandemic period. This timeframe allows for a nuanced analysis of how extraordinary global events might impact payment behaviours. While the World Health Organization officially declared the end of the pandemic in 2023, this study's data concludes in 2022, providing a comprehensive view of the pandemic's potential effects on cash reliance.

4.1 Data Sources and Variables

The dataset for this study integrates information from multiple sources, categorizing variables into dependent and independent groups.

Dependent variable

The primary dependent variable is Cash Use, as defined in equation (1) a, expressed as a percentage of each country's GDP and calculated using the residual method. This calculation requires household consumption data from the World Bank and credit and debit card transaction data from the European Central Bank (for European countries) and the Bank for International Settlements (for non-European countries) from 2012 to 2022.

Independent variables

Independent variables are divided into demographic factors and technological advancement indicators.

Independent variables were selected based on previous research linking demographic and technological factors to differences in cash use. Table 1 presents a summary of these key independent variables, including their definitions and data sources.

Table 1: Overview of independent variables

Variable	Definition	Source
Young Population	Share of population aged 18-35 in country i at time t (%)	World Bank: UN Population Division
Tertiary Education	Share of population with tertiary education (%)	World Bank: School Enrolment
Digital Payments	Value of DC and MPOS payments expressed as a percentage of GDP ⁸ in country i at time t (2017–2022)	Statista, own calculation
High and Medium Tech Output	High-tech and medium-tech output index in country i at time t	OECD, Eurostat & World Bank
Covid	Dummy variable = 1 for years 2020–2022, 0 for 2012 to 2019	Own construction (based on WHO timeline)
Total Payments	Value of total consumer payments expressed as a % of GDP in country i at time t	World Bank - World Development Indicators

Source: Own work

Demographic factors include age, focusing on population aged 18-35 sourced from the World Bank Group's United Nations Population Division data. Education level, specifically tertiary education attainment is also considered, with data obtained from the World Bank's "School Enrolment" category. This segmentation allows for examining generational differences in payment preferences. Recent research suggests that even older generations are increasingly adopting digital payment methods, challenging traditional assumptions about age-related financial behaviours (Sveriges Riksbank, 2023).

⁸ GDP values are used for normalization purposes only and are not directly included in the regression analysis. Data sourced from the World Bank (World Development Indicators).

Another critical demographic factor considered is education level, with a specific emphasis on tertiary education attainment. This data is obtained from the World Bank's comprehensive "School Enrolment" category, covering the entire study period from 2012 to 2022. The inclusion of education data enables an investigation into whether higher levels of educational attainment correlate with a quicker adoption of alternative payment methods and consequently, reduced cash use.

In the realm of technological advancement, the study primarily uses the high and medium tech output index as a key indicator. This variable reflects a country's level of innovation and industrial technology, which is closely related to modern financial system development. The decision to focus on this index was made after careful consideration of the most appropriate way to measure technological progress in relation to cash use. High and medium tech production indicates broader technological capabilities that can support digital payment infrastructure and reduce reliance on cash. This classification follows internationally recognized standards from OECD and Eurostat, which categorize manufacturing sectors based on their technological intensity. The index broadly distinguishes between high, medium and low-tech industries, reflecting the degree of innovation and research and development embedded in national industrial output. The data for this variable were primarily sourced from OECD.Stat and Eurostat and were supplemented with values from the World Bank Group for countries not covered in the before mentioned databases.

The COVID-19 period highlighted the importance of technological readiness, as it played a major role in shaping financial behaviour during the crisis (Strohecker, 2023). To ensure the robustness of the analysis, digital payments are included as a percentage of GDP for each country from 2017 to 2022, based on data from Statista. Although not the primary focus, these figures provide important context about the actual use of modern payment tools across countries and offer a more complete picture of the relationship between technology and cash use.

An additional independent variable used in the Total Payments model is Total Payments (% of GDP). This variable reflects the total value of consumer payment transactions in relation to GDP, capturing both cash and non-cash payments within each country. The calculation of this variable was based on household consumption data, if total household consumption closely approximates the total volume of payments made by consumers.

By including Total Payments, the model accounts for overall payment activity levels, reducing the risk of biased interpretation when analysing the impact of non-cash payments in isolation. The descriptions of all other variables remain consistent with the definitions presented in the previous sections.

4.2 Descriptive Statistics and Data Overview

Table 2 presents a detailed overview of the main variables included in the analysis, along with the number of observations available for each, to provide a clearer understanding of the dataset's structure and scope. Most variables including cash use, demographic characteristics and technological indicators, have a full sample of 330 observations, ensuring broad coverage across countries and time. The variable for tertiary education includes slightly fewer entries 327 observations.

Data on digital payments, both in absolute terms and as a percentage of GDP are more limited, with 180 observations each. This is because data are only available for the period from 2017 to 2022. This reflects the difficulty in obtaining consistent digital payment data across all countries and years.

Despite certain limitations, the available data remain sufficient to support a robust analysis of digital payment trends. The inclusion of a Covid dummy variable present in all 330 observations, enables the model to account for the impact of the pandemic.

Table 2: Number of observations per variable

Variable	Observations
Cash Use (% of GDP)	330
Young Population	327
Tertiary Education	327
High and Medium Tech Index	330
Digital Payments (% of GDP)	180
Covid (dummy variable)	330
Total Payments (% of GDP)	330

Source: Own work

Data limitations

While the dataset provides substantial coverage, it is important to acknowledge several limitations that may affect the interpretation of the results. Digital payments data is available

for fewer observations (180 vs. 330), significant variations exist across countries in technological and demographic metrics, and the COVID-19 pandemic period represents approximately 27.27% of observations.

5 DESCRIPTIVE STATISTICS

This section provides a detailed analysis of trends in cash use across 30 examined countries for the period 2012 to 2022, with a particular focus on the years 2020 to 2022, defined as the COVID-19 period.

The term *Cash Use* in this context refers to the dependent variable defined in Equation (2), which expresses the use of cash as a percentage of GDP and was calculated using the residual method, as outlined in the methodology chapter. The analysis first examines which countries recorded the highest and lowest levels of cash use, as well as which countries and regions experienced the most significant decline in cash use over time. In addition, the study investigates whether all countries during the COVID-19 period experienced a reduction in cash use. Finally, the section explores how other factors, such as technological advancement, demographic age structure and educational background, may have influenced changes in the use of cash during this period.

5.1 Overall Patterns of Cash Use

To analyse overall patterns in cash use, data for the 30 countries were calculated as a percentage of their annual GDP, following the approach outlined in Equation (2), to ensure more accurate and consistent comparisons across different economies. Table 3 presents detailed annual statistical data covering the period from 2012 to 2022. The average level of cash use over the entire period is 41.73%, indicating that, on average, economies conducted cash-based transactions equivalent to approximately 42% of their GDP. The lower median value of 39.06% suggests a positively skewed distribution, indicating that a subset of countries maintains significantly higher dependence on cash compared to the typical economy.

This skewness is further supported by a standard deviation of 11.57%, calculated from the entire dataset of observations, along with a wide range between the minimum value of 12.35% and the maximum of 44.14%. These variations underscore the substantial heterogeneity in payment system development and consumer payment preferences across countries.

In addition to the aggregate values, Table 4 provides a year-by-year statistical overview that highlights the global decline in reliance on cash over the past decade. Between 2012 and 2022, the mean share of cash in total payment transactions declined significantly from 44.39% to 35.72%, while the median dropped even more steeply, from 43.72% to 32.56%. This consistent downward trend suggests a gradual yet persistent global shift away from cash-based transactions and toward digital payment alternatives.

Table 3: Percentage of cash use across countries, 2012–2022

Year	Mean	Median	St. Deviation	Min	Max
2012	44.39	43.72	17.19	14.14	44.14
2013	45.01	44.20	16.95	16.97	43.86
2014	45.04	42.76	17.89	18.39	42.91
2015	46.83	42.22	21.88	21.55	42.36
2016	46.18	41.68	22.61	22.00	41.74
2017	44.03	40.61	21.10	19.82	41.20
2018	42.29	38.28	20.34	19.66	39.90
2019	41.70	39.03	21.14	20.46	39.03
2020	39.99	36.36	21.89	20.07	36.48
2021	37.00	33.32	19.89	17.55	35.67
2022	35.72	32.56	19.74	12.35	35.70
Overall	41.73	39.06	11.57	12.35	44.14

Source: Own work

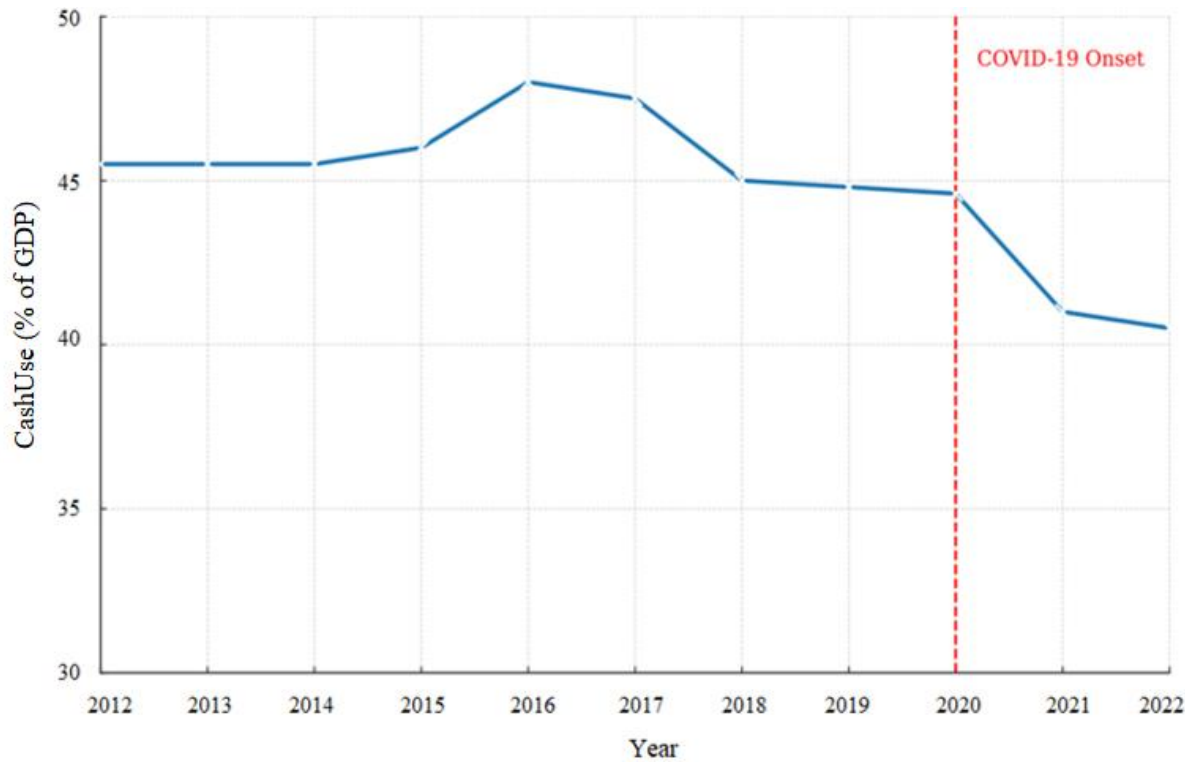
Despite the overall decline, standard deviation values remained relatively stable, ranging from 16.95% to 22.61%, indicating that the disparity between cash-reliant and digitally advanced economies has persisted. Notably, the highest variation was observed in 2016 (22.61%), which also coincides with elevated median levels, possibly reflecting regional economic uncertainties or structural differences in financial behaviour during that period.

During the COVID-19 pandemic, a sharper decline in cash use was observed, with the average share decreasing from 41.70% in 2019 to 37.00% in 2021. This reduction was driven by the increased adoption of contactless and digital payment solutions during the period from 2019 to 2021. Despite this accelerated shift towards digitalization, the persistent level of standard deviation over the decade highlights that substantial global heterogeneity in payment preferences remains a defining feature of the international financial landscape.

Figure 3 presents the trends in cash use, as defined by the dependent variable in Equation (2), expressed as a percentage of GDP for the period from 2012 to 2022. This variable was calculated using the residual method described in the methodology chapter and reflects the estimated share of cash-based transactions within the economy. The graph provides a clear visual representation of the trends discussed in the previous tables, offering additional insights

into the temporal evolution of reliance on cash at the global level. The line graph highlights three distinct phases in cash use patterns over the decade.

Figure 3: Trends in cash use across 30 Selected Countries (2012–2022)



Source: Own work

The graph provides a clear visual representation of the trends discussed in the previous tables, offering additional insights into the temporal evolution of reliance on cash at the global level. The line graph highlights three distinct phases in cash use patterns over the decade.

From 2012 to 2014, the level of cash use remained relatively stable at approximately 46% of GDP, indicating a period of balanced payment preferences. This was followed by a notable increase during 2015 and 2016, when the share of cash transactions peaked at around 48% of GDP, potentially reflecting economic uncertainties or regional policy changes that temporarily slowed the digitalization trend in certain economies.

Starting in 2017, the data reveal a consistent downward trajectory, which dramatically accelerated after the onset of the COVID-19 pandemic, visibly marked on the graph with a vertical red dashed line. This visual evidence demonstrates how the pandemic acted as a catalyst for transformation in payment behaviour. Before the pandemic, from 2017 to 2019, the use of cash gradually declined, decreasing by approximately one percentage point per year from

around 46% to 44% of GDP. The post-pandemic period shows a sharp drop, with cash use falling to approximately 41% by 2021 and continuing to decline to around 40.5% in 2022.

Examining cash use at the individual country level reveals nuanced patterns that provide deeper insights into the economic, cultural and technological factors influencing payment preferences. The bar chart in Figure 4, which compares the pre-COVID and COVID-era levels of cash use, highlights several distinct country clusters and notable outliers that warrant detailed analysis.

Greece emerges as the highest cash-dependent economy in the dataset, with pre-COVID cash use approaching 90% of GDP that declined to approximately 80% during the pandemic. This substantial cash dependency likely reflects Greece's economic structure, with its significant tourism sector, large proportion of small businesses and the lingering effects of its financial crisis during the 2010s, which may have reinforced cash preferences due to banking system concerns.

Russia represents the second-highest cash-reliant economy, with pre-COVID usage around 75% of GDP declining to approximately 70% during the pandemic. Russia's high cash dependency likely stems from multiple factors: lower banking penetration in remote regions, historical experiences with banking instability, significant natural resource-based informal economic activity and regulatory approaches that have traditionally accommodated cash transactions. The relatively small gap between pre-COVID and COVID-era usage demonstrates how structural economic factors can maintain cash resilience even amid global digitalization catalysts.

The Balkan and Eastern European nations form a distinctive cluster, maintaining pre-COVID cash use between 60-65% of GDP. Serbia experienced a particularly significant pandemic-driven decline (to approximately 55%), while North Macedonia showed more modest reduction. This regional pattern reflects the transitional state of these economies, with developing digital infrastructure but still-substantial informal sectors and cash-based commercial traditions.

Mexico stands out among Latin American representatives with pre-COVID cash use around 60% that increased slightly during the pandemic, one of the few countries to show this counter-trend pattern. This anomaly might reflect Mexico's large informal economy substantial remittance flows and potential pandemic-driven economic behaviours that reinforced rather than reduced cash dependency.

Japan occupies a unique position among developed economies, with pre-COVID levels of cash use around 55%, which remained relatively stable during the pandemic. This Japanese exception highlights how cultural preferences for cash, an aging demographic profile and deeply ingrained consumer habits can preserve high levels of cash use even in a technologically

advanced society. A middle tier of diverse economies, including Türkiye, France and Italy, clustered in the 50–55% pre-COVID cash use range, with varying impacts observed during the pandemic period.

Türkiye shows the most substantial decline in this group, potentially reflecting its recent digital payment initiatives, while France and Italy demonstrate more modest reductions, suggesting balanced payment ecosystems resistant to rapid transformation.

The United States and several Western European nations (Germany and Austria) form a moderate cash use cluster in the 40-45% range, with consistent pandemic-era reductions to the 30-35% level. This moderate position despite technological readiness reflects complex payment ecosystems with diverse regional practices, mixed consumer preferences and multifaceted retail environments.

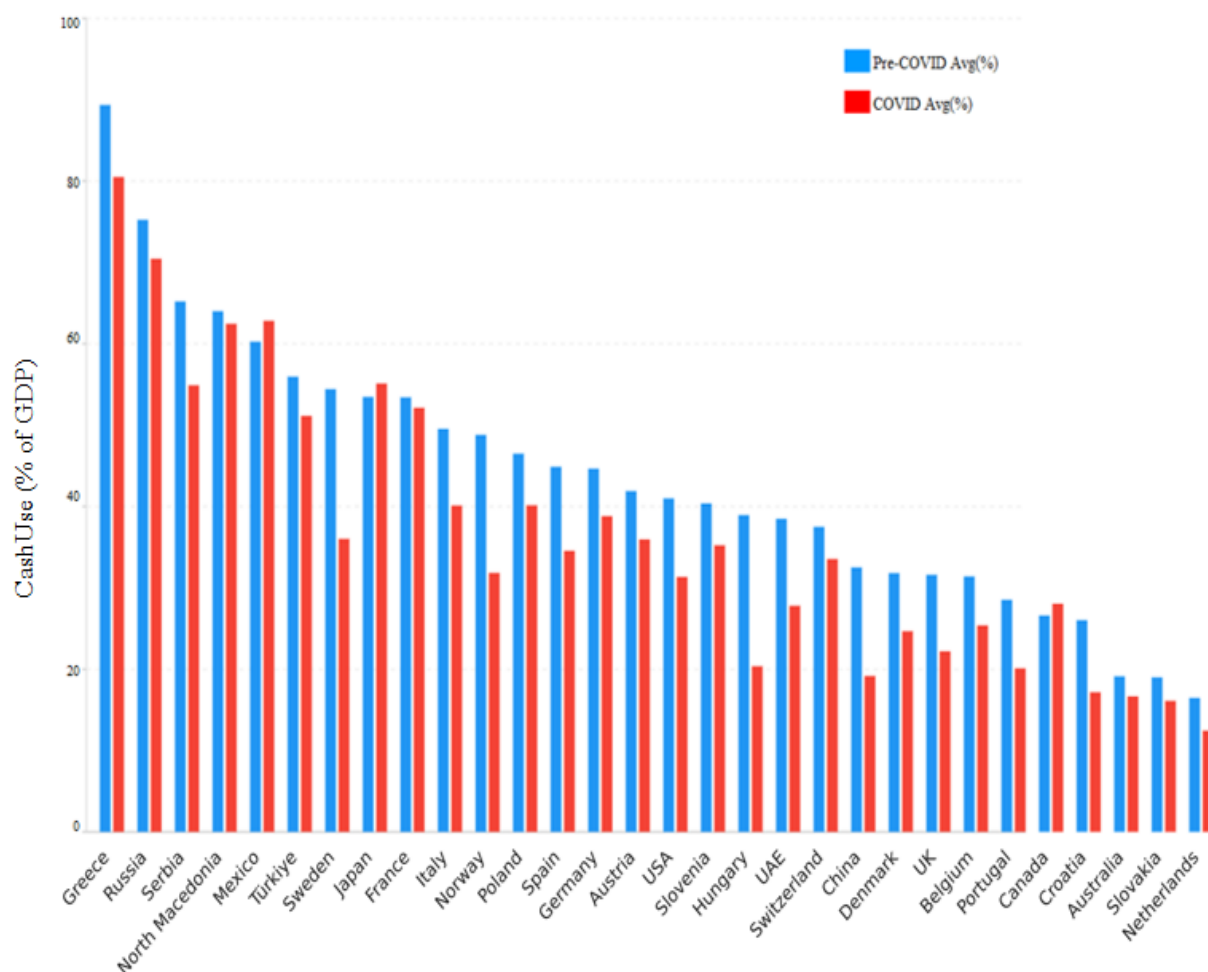
Nordic countries, including Norway, Denmark and Sweden, occupy distinctive positions toward the lower end of cash use spectrum, with pre-COVID figures ranging from approximately 35% in Sweden to around 50% in Norway. All three countries experienced significant pandemic-related declines in cash use, reinforcing the so-called “Nordic mode” of payment digitalization, which is characterized by high trust in institutions, advanced digital infrastructure and widespread cultural acceptance of electronic transactions.

The United Kingdom and Switzerland exhibit remarkably similar patterns, with pre-COVID levels of cash use around 35%. During the pandemic, the share of cash use declined to approximately 25–30%, reflecting both countries’ advanced financial sectors and early adoption of digital payment technologies. This trend highlights a strong correlation between technological infrastructure and reduced reliance on cash. Moreover, it suggests that nations with well-developed banking systems were better equipped to adapt to the shift towards contactless and remote transactions during the COVID-19 period.

At the extreme low end, the Netherlands and Australia demonstrate the most advanced levels of digitalization, with pre-COVID cash use below 20%, which further declined to 10–15% during the pandemic. These economies showcase how synchronized public-private cooperation, concentrated banking sectors, high consumer trust in digital systems and early contactless payment adoption can accelerate cash to digital transition more rapidly than technological capacity alone.

Based on the cross-country comparison presented earlier, the five countries with the lowest levels of cash use between 2012 and 2022 included the Netherlands, with only 15.37% of GDP attributed to cash, followed by Australia with 18.45%, making it one of the most cashless economies.

Figure 4: Cash use by country (as % of GDP): pre-COVID vs. COVID period



Source: Own work

Norway, known for its advanced digital payment infrastructure, also exhibited low cash use at approximately 18%. Canada ranked fourth, with around 27% of GDP reflecting the transition to digital and mobile payment systems.

These countries have successfully developed highly digitized financial ecosystems, supported by strong banking infrastructure, government incentives promoting cashless transactions and widespread adoption of contactless cards, mobile payment platforms and digital wallets. Public trust in digital finance, robust cybersecurity frameworks and active cooperation between financial institutions and fintech companies have further accelerated this transformation, making cash increasingly obsolete in daily transactions.

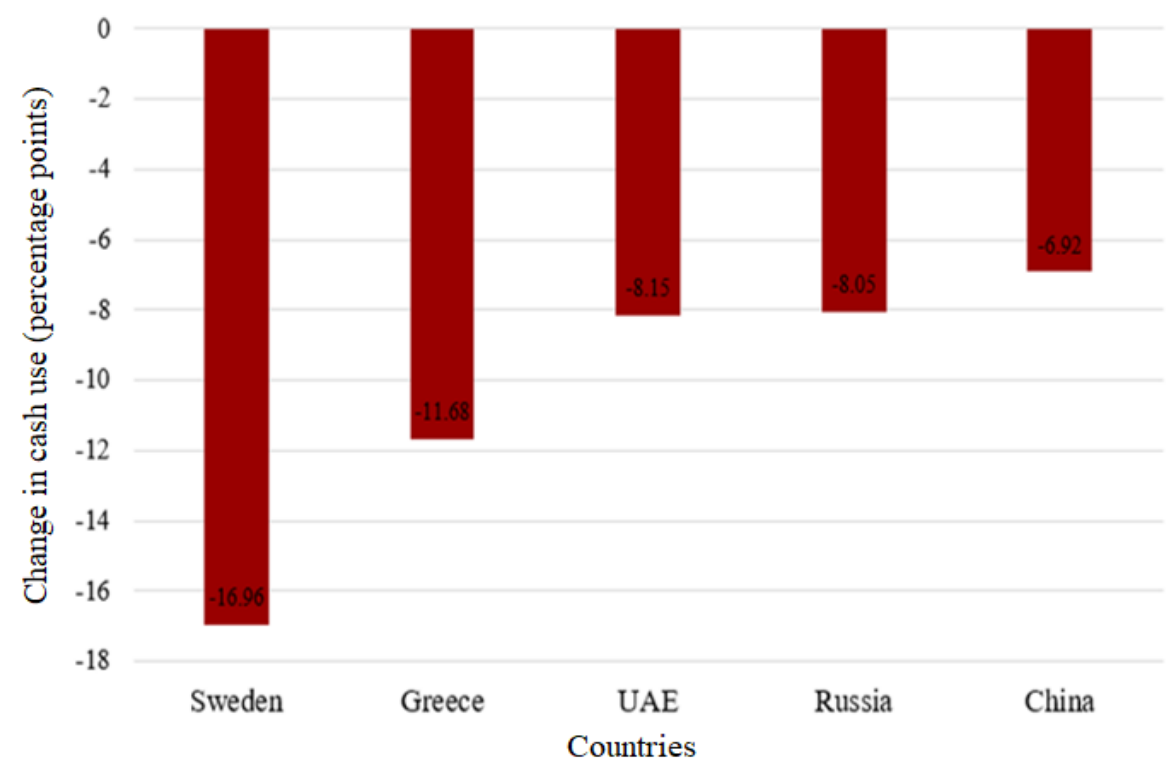
In contrast, several countries remain highly dependent on cash, where the phrase “*cash is still king*” continues to apply. Greece recorded the highest cash use, with 90.51% of GDP linked to physical currency. This was followed by Russia (73.93%), North Macedonia (63.58%) and

Serbia (62.38%), reflecting sustained reliance on cash. Mexico also ranked among the top five, with 60.95% of transactions conducted in cash. These high levels of cash use can be attributed to a combination of limited digital payment adoption, large informal economies, cultural preferences for cash and in some cases, low public trust in banking institutions.

During the COVID-19 pandemic, cash use patterns shifted significantly across countries. While many economies experienced a sharp decline in physical cash transactions due to the rising adoption of contactless methods and health-related concerns, others saw a temporary increase in cash use, driven by precautionary withdrawals and economic uncertainty.

Based on Figure 5, the five countries with the largest decrease in cash use during the pandemic were Sweden, Greece, the UAE, Russia and China. Sweden recorded the most significant decline, with a 16.96 percentage point drop in the use of cash between 2019 and the 2020–2022 period.

Figure 5: Top 5 countries with the most significant reduction in cash use during COVID-19



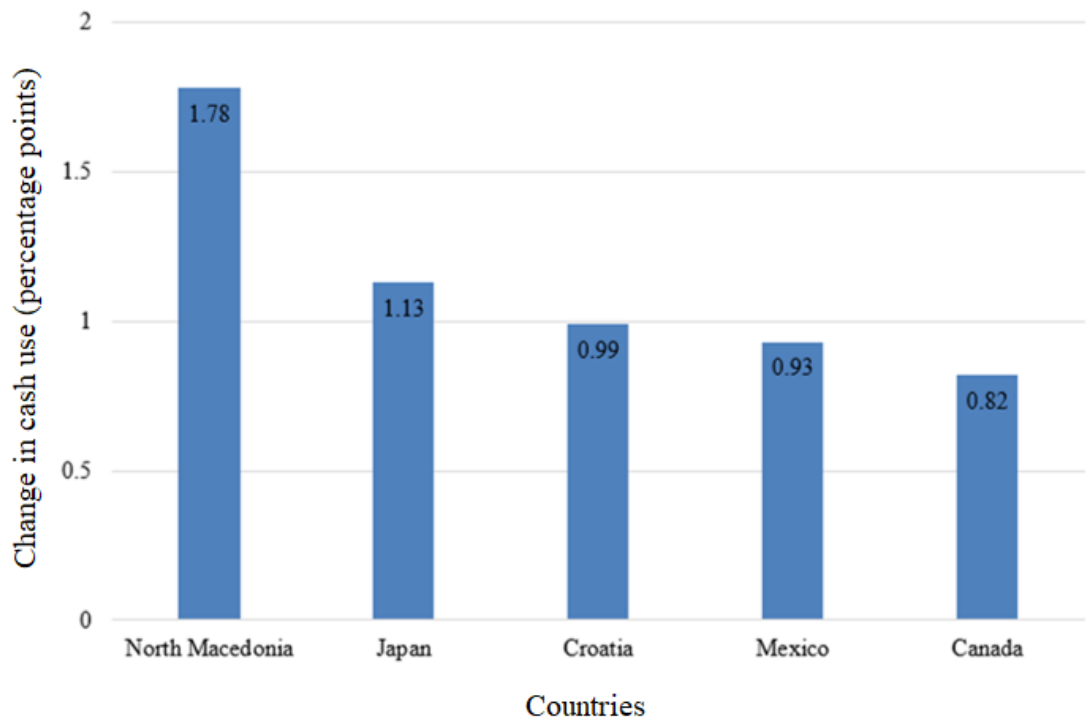
Source: Own work

This reflects Sweden’s ongoing transition toward a nearly cashless society, further accelerated by the pandemic. Greece followed, with an 11.68 percentage point decrease, likely driven by increased digital payment adoption and government incentives promoting cashless transactions.

The United Arab Emirates also experienced a notable reduction of 8.05 percentage points, emphasizing the rapid adoption of contactless and mobile payments in the region. Meanwhile, China saw a 6.92 percentage point decrease, continuing its well-established trend toward digital payment dominance.

These patterns illustrate notable cross-country variation in the response to the COVID-19 pandemic, with some economies exhibiting accelerated declines in cash use, while others experienced more moderate or temporary changes. The extent of change appears to vary in line with pre-existing levels of digital infrastructure and institutional readiness.

Figure 6: Top 5 countries with lowest reduction in cash use during the COVID-19 period



Source: Own work

Certain countries experienced an increase in cash use during the COVID-19 period, likely due to panic withdrawals and financial stability concerns. Among these nations (Figure 6), North Macedonia experienced the highest rise, with a 1.78 percentage point increase in cash use from 2019 to the 2020–2022 period. Similarly, Japan saw a 1.13 percentage point increase, while Croatia and Canada recorded increases of 0.93 and 0.82 percentage points, respectively.

The increase shows that in some countries, cash remained a key form of security, as people saved physical money during uncertain times. While some turned to digital payments, others stuck with cash out of caution and trust issues with banks. These differences underscore how

economic structure, cultural norms and institutional trust continue to shape payment behaviour, even during global disruptions. The persistence of cash in these environments highlights the role of deep-rooted habits and perceived reliability of physical money. It also suggests that digital transformation in payments may require more than just technological availability it depends on public confidence and readiness to change.

5.2 Demographic Factors and Technology Levels

After analysing trends in cash use across countries from 2012 to 2022, the scope of the study was expanded to include several independent variables in order to better understand the factors that may have influenced the use of cash during this period. The analysis begins with summary statistics for these variables, offering a general overview of the sample as presented in Table 4.

The distribution of the observed values reveals considerable heterogeneity across countries. This is evident in the substantial difference between the mean and median, suggesting the presence of a positively skewed distribution. Such skewness typically arises when a small number of countries exhibit exceptionally high values, which elevates the overall average despite the majority of observations being concentrated at lower levels. This pattern highlights the structural diversity among the countries included in the analysis, particularly with regard to technological and institutional development.

In terms of demographics, the average share of the population aged between 18 and 35 years is 26.58 percent. The standard deviation of 1.65 indicates relatively low variability across countries, suggesting that the sample countries are fairly similar in terms of the size of their young population segment.

Table 4: Summary statistics (independent variables)

Variable	Mean	Median	Std. Dev.	Min	Max
Young Population	26.58	26.32	1.65	23.38	34.16
Tertiary Education	34.14	34.20	11.28	0.40	62.74
High and Medium Tech Output	518.81	51.75	18.51	16.00	10.00
Digital Payments	0.05	0.04	0.06	0.00	0.41
Covid	0.27	0.00	0.45	0.00	1.00

Source: Own work

A dummy variable was also included to account for the period affected by the COVID-19 pandemic. This variable takes the value of one for observations from the pandemic years (2020 to 2022) and zero otherwise. The mean value of 0.27 reflects the proportion of the total observations that fall within the pandemic period, indicating that approximately 27 percent of the dataset corresponds to pandemic years. This allows for an analysis of the potential impact that the COVID-19 pandemic may have had on cash use.

Tertiary education attainment averages 34.14 percent across the sample, with values varying considerably from as low as 0.40 percent to as high as 62.74 percent. This wide spread reflects substantial differences between countries in terms of access to higher education, with more developed countries generally showing higher rates.

The technological capacity of countries, represented by high and medium technology output, has an average value of 51.81. The lowest recorded value is 16 while the highest is 100, suggesting that although levels of technological development vary significantly, countries are somewhat evenly distributed in this respect.

Another important indicator is the share of digital payments as a percentage of GDP, which averages 5% and reaches up to 41% in some cases. This demonstrates the varying degrees to which countries have adopted digital financial systems. It is important to note that data on this variable was only available for 180 observations.

Table 5: Correlation analysis

Variable	Correlation with Cash Use
Young Population	-0.003
Tertiary Education	-0.291***
High and Medium Tech Output	-0.127*
Digital Payments	-0.198***
Covid	-0.174**
Total Payments	0.027

*p < 0.05, **p < 0.01, ***p < 0.001

Source: Own work

Table 5 presents the results of the correlation analysis, which was conducted using Pearson's correlation coefficient to examine the linear relationships between cash use and the selected independent variables. The analysis reveals several noteworthy patterns. A statistically significant negative correlation is observed between tertiary education and cash use ($r = -0.291$, $p < 0.001$). This finding supports the hypothesis that populations with higher levels of education tend to be more financially literate and are more likely to adopt digital payment methods, thereby reducing their reliance on cash.

The Covid variable also demonstrates a significant negative correlation with the use of cash ($r = -0.174$, $p < 0.01$), indicating that reliance on physical currency declined during the pandemic period. This trend may be attributed to increased hygiene concerns and the accelerated adoption of contactless payment technologies during this time.

Similarly, both the high and medium technology output ($r = -0.127$, $p < 0.05$) and digital payments as a percentage of GDP ($r = -0.198$, $p < 0.001$) show statistically significant negative correlations with the use of cash. These results suggest that countries with more advanced technological infrastructure and higher levels of digital transaction activity tend to rely less on cash.

In contrast, the share of the young population (aged 18 to 35) shows no statistically significant relationship with use of cash ($r = -0.003$, $p > 0.05$). This implies that demographic age structure alone does not substantially influence a country's preference for cash transactions. For example, North Macedonia, despite having a relatively young population, still exhibits high levels of cash use. This may be explained by other contextual factors, such as limited digital infrastructure, lower financial inclusion or broader economic conditions.

In addition to the already analysed variables, the correlation between Total Payments and cash use was also examined. The results show a very weak and statistically insignificant positive correlation ($r = 0.027$, $p > 0.05$), suggesting no meaningful linear relationship between the overall payment activity and cash use at the bivariate level.

Overall, the results presented in Table 6 provide preliminary insights into the bivariate relationships between cash use and the selected socio-economic and technological indicators, setting the stage for the more detailed multivariate regression analysis presented in the following section.

A more detailed look at the period of the pandemic reveals several noticeable changes in the use of cash. Between 2012 and 2019 (see Table 6), the average share of cash use was 44.06%, while the median was 42.49%. During the pandemic years (2020 to 2022), the average dropped to 37.30% and the median fell to 34.92%. This represents a decrease of approximately 7 percentage points.

To determine whether this decline is statistically significant, an independent samples t-test was conducted. The results show that the difference in mean cash use between the pre-COVID and COVID periods is statistically significant ($t = 3.16$, $p < 0.01$). This indicates that the observed decline in cash use during the pandemic period is unlikely to be due to random variation and reflects a meaningful change in consumer payment behaviour.

Additionally, both the lowest and highest recorded values for cash use also decreased during the pandemic period. The minimum value dropped from 13.58% to 11.65%, while the maximum fell from 98.59% to 91.28%. These changes demonstrate that even countries with previously high levels of cash dependence reduced their cash use. The standard deviation increased slightly, from 16.84 to 17.46 percentage points, suggesting greater variability in cash use among countries during the pandemic.

Table 6: Impact of COVID-19 on cash use patterns

Period	Mean	Median	Min	Max	Std.Dev.
Pre-COVID (2012-2019)	44.06%	42.49%	13.58%	98.59%	16.84%
During COVID (2020-2022)	37.30%	34.92%	11.65%	91.28%	17.46%
Difference	-6.76%	-7.57%	-1.93%	-7.31%	+0.62%

Source: *Own work*

These findings suggest that the COVID-19 pandemic played a significant role in changing payment habits. Health and safety concerns, along with rapid advancements in digital payment technology and wider adoption of contactless methods, likely contributed to a global shift away from physical cash during this period.

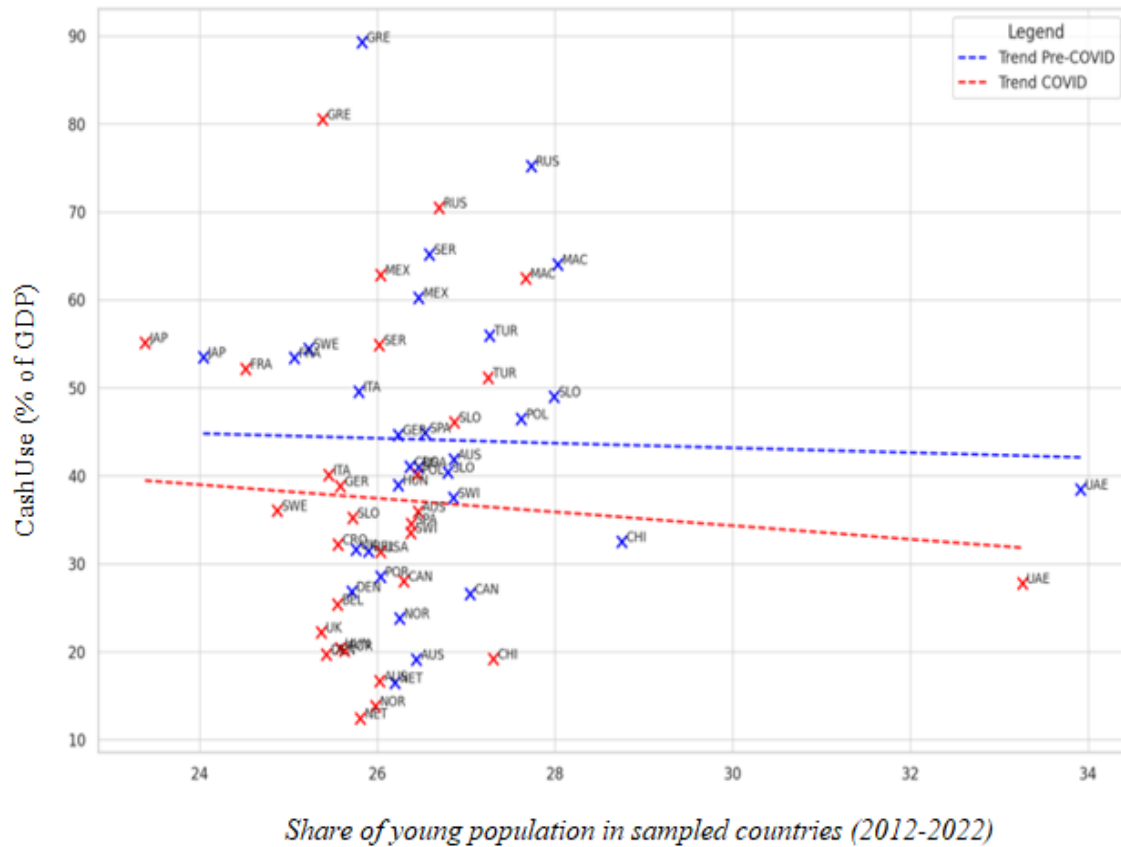
5.2.1 Demographic Factors

5.2.1.1 Young Population

This analysis examines the relationship between the proportion of younger populations (ages 18–35) and the use of cash across 30 countries, comparing pre-COVID (2012–2019) and COVID-era (2020–2022) trends. In Figure 7, titled "Relationship between young population and the use of cash (2012–2022)", the x-axis represents the percentage share of younger populations, ranging from Japan's low of 23.4% to the UAE's high of 33.2%.

The y-axis reflects the level of cash in circulation as a percentage of GDP, calculated by dividing the total physical currency in circulation by GDP and multiplying the result by 100. Greece displays the highest reliance on cash, reaching 72% of GDP, while Norway and the Netherlands represent the lower end of the scale, with values between 12% and 13%.

Figure 7: Relationship between young population and cash use (2012-2022)



Source: Own work

A weak negative correlation emerges between the youth population and the use of cash ($r = -0.04$ pre-COVID, $r = -0.07$ during COVID), suggesting that countries with smaller proportions of young people tend to rely slightly more on cash. For instance, Japan, with only 23.4% of its population aged between 18 and 35, maintains cash levels exceeding 60% of GDP, while the UAE, with 33.2% youth, shows more moderate reliance on cash. Similarly, China (27.3% youth) recorded lower levels of cash in circulation, especially during the pandemic period. Countries with youth populations below 25%, such as France (24.5%) and Greece (25.3%), also exhibit high levels of cash relative to GDP, exceeding 50%.

Middle-range countries (25–27% youth), including Germany, the United States, Spain, Italy, Canada and Russia, display considerable variation. For example, the Netherlands reports only 12.4% of GDP in cash use, while Russia stands at 58.7%. Notable exceptions challenge this general pattern: North Macedonia (27.6% youth, 63.8% cash-to-GDP ratio), Russia (26.6%

youth, 58.7%) and Mexico (27.3% youth, 57.7%) maintain high levels of cash despite having sizable younger populations. Türkiye also deviates from the trend, with a 26% youth share and 52.2% of GDP held in cash.

The COVID-19 period further accelerated digital payment adoption, particularly in countries with tech-savvy younger demographics. Many of the outliers can likely be attributed to cultural, infrastructural and structural factors. For instance, Greece's persistently high reliance on cash (72% of GDP) contrasts sharply with countries like Norway and the Netherlands, where digital transitions progressed more rapidly.

5.2.1.2 Level of Education

Another demographic factor examined in this study is education. Here, the aim is to determine whether countries with higher education levels are associated with greater cash use or if no substantial differences exist. For the indicator of education level, the coefficient of tertiary education of the countries is used which refers to all formal post-secondary education including public and private universities, colleges, technical training institutions and vocational schools (ECB, 2024; OECD, 2025).

The relationship between tertiary education level and cash use appears more pronounced than that of demographic factors alone. Figure 8 illustrates how countries with higher tertiary education levels consistently demonstrate lower levels of cash use relative to economic activity. The negative correlation between these variables is noticeable during the pandemic, shifting from -0.25 in the pre-COVID period to -0.32 during COVID-19 suggesting that education may have an increasingly important role in shaping payment preferences.

The x-axis represents the percentage of the population with tertiary education while the y-axis measures the level of cash use as a percentage of GDP. The median split analysis provides compelling evidence of this relationship as seen during the COVID period.

Countries with tertiary education levels above the median of 38.63 % used substantially less cash (with an average of 32.30 % of GDP) compared to their less-educated counterparts (average of 44.25 % of GDP) representing a substantial difference of 11.95 percentage points.

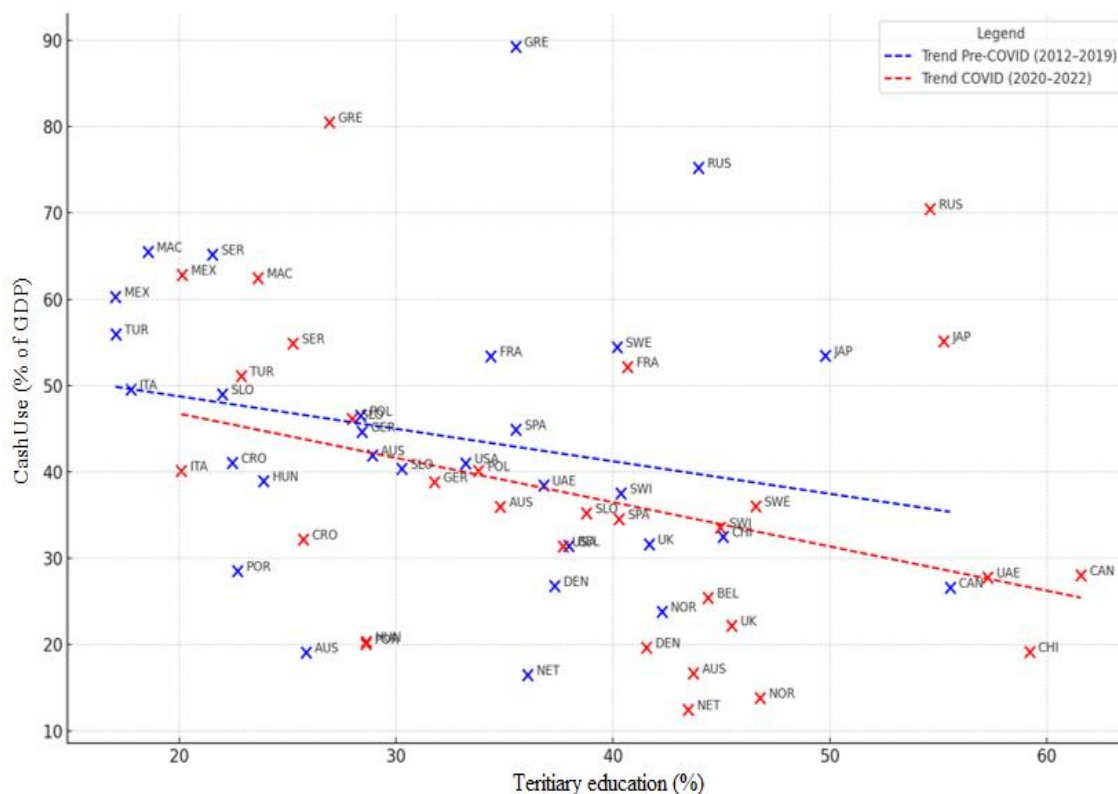
Countries such as the Netherlands demonstrate remarkably low levels of cash use (approximately 13 percent of GDP) while maintaining high tertiary education rates exemplifying the digital payment transition. Norway also shows consistently low levels of cash use remaining below 30 % alongside education rates averaging above 45%.

On the other side, Greece stands out with one of the highest levels of cash use (70–72%) despite a moderate education level (30–35%). Serbia also shows high levels of cash use ranging

between 55 and 62 % with education levels around 25–30 %. North Macedonia exhibits high levels of cash use (60–62%) with the lowest educational levels in this dataset.

Also, some countries exhibited dramatic shifts during the pandemic, as China for example shows a remarkable increase in tertiary education alongside a considerable decrease in cash use, moving significantly along both axes.

Figure 8: Relationship between the level of education and cash use



Source: Own work

China has seen a notable increase in tertiary education levels, rising from 45.1% to 58.0%, accompanied by a significant decline in reliance on cash, which dropped from 32.5% to 20.9%. Many European countries show similar, though more modest, progress toward higher education attainment alongside reduced use of cash.

Russia stands out as an exception. Despite having a comparatively high level of tertiary education, the country continues to demonstrate substantial dependence on cash. This pattern suggests that factors other than education, such as cultural habits, economic conditions, or limitations in digital infrastructure, may also play an important role in shaping payment preferences.

To provide a clearer picture of how education levels influence the use of cash across the 30 countries in the sample, a detailed quartile-based breakdown is presented below:

- Lowest Quartile (less than 25% tertiary education) shows an average cash-to-GDP ratio of 48.7%.
- Second Quartile (between 25% and 38% tertiary education) shows an average cash-to-GDP ratio of 39.8%.
- Third Quartile (between 38% and 50% tertiary education) shows an average cash-to-GDP ratio of 35.4%.
- Highest Quartile (more than 50% tertiary education) shows an average cash-to-GDP ratio of 29.2%.

Also, general regional patterns were prepared for the sampled countries to provide an overall picture of how different regions behaved during the COVID-19 pandemic and how these patterns relate to their educational structure.

- Northern European countries (NO, NL, DK): Consistently low levels of cash in circulation relative to GDP, accompanied by high education levels.
- Southern European countries (GR, IT, ES): Generally higher reliance on cash, despite varying education levels.
- Eastern European countries (RS, MK, HR): Predominantly high dependence on cash, often linked with lower education levels.
- Asian economies (CN, JP): Divergent patterns, with China rapidly transitioning away from cash-based transactions, while Japan maintains a strong preference for cash despite high education levels.

5.2.2 Technology Index

The final factor considered in relation to the use of cash across the 30 countries is the level of technological advancement. To capture this aspect, two variables were selected to represent the degree of technological development within each country.

The analysis begins by examining the relationship between the high and medium-tech output index and the use of cash. Following that, the connection between this technological index and the adoption of digital payments is explored. Lastly, the relationship between digital payments and the level of cash in circulation is assessed.

In general, countries with higher levels of high and medium-tech output tend to be more technologically advanced. These nations are also more likely to have well-developed digital payment systems, which is closely linked to lower reliance on physical currency. The next section focuses on analysing the relationship between the high and medium-tech output index and the use of cash in the selected countries.

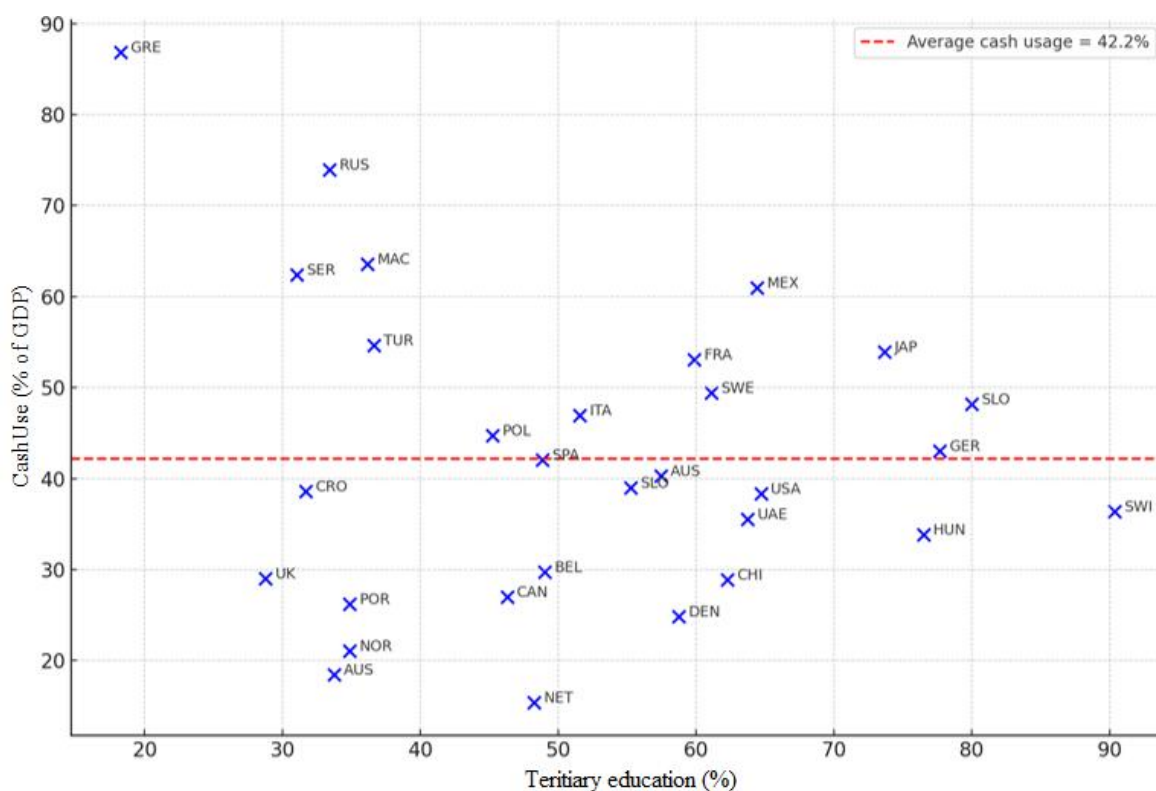
5.2.2.1 High and Medium Tech Output

The amount of high and medium tech output a country produce is a strong indicator of its developmental stage and technological capability. Generally, countries with higher high-tech and medium-tech outputs tend to have stronger economies with higher GDPs, categorizing them as advanced economies.

The descriptive analysis relies on average values from the period 2012 to 2022, offering a balanced and representative overview of cross-country patterns in technological development and the use of cash.

As illustrated in Figure 9, there is only a marginal correlation between average high-tech and medium-tech output and the average level of cash in circulation. Countries such as Austria, Germany and Japan, despite high technological capacity, continue to maintain elevated levels of cash in circulation. These findings suggest that technological advancement alone does not automatically result in lower cash reliance, as behavioural, cultural and institutional factors appear to exert a substantial influence.

Figure 9: Relationship between high and medium tech output and cash use

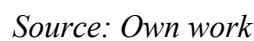


Source: Own work

On the other hand, Norway, Australia and the Netherlands stand out for combining high levels of technological development with low levels of cash use, supporting the hypothesis that

In contrast, countries like Greece and North Macedonia, with lower technological output, continue to exhibit strong reliance on cash, demonstrating that the relationship between technology and payment behaviour is not linear and may be influenced by a broader set of historical and socio-economic variables.

To gain a clearer understanding of this complex relationship, it is essential to examine the intermediary role of digital payments. Technological advancement is expected to support the infrastructure necessary for increased digital transactions, thereby theoretically reducing reliance on cash.



A notable outlier in this context is China, exhibiting significantly higher digital payment levels despite its moderate technological output level. This anomaly can be attributed to China's

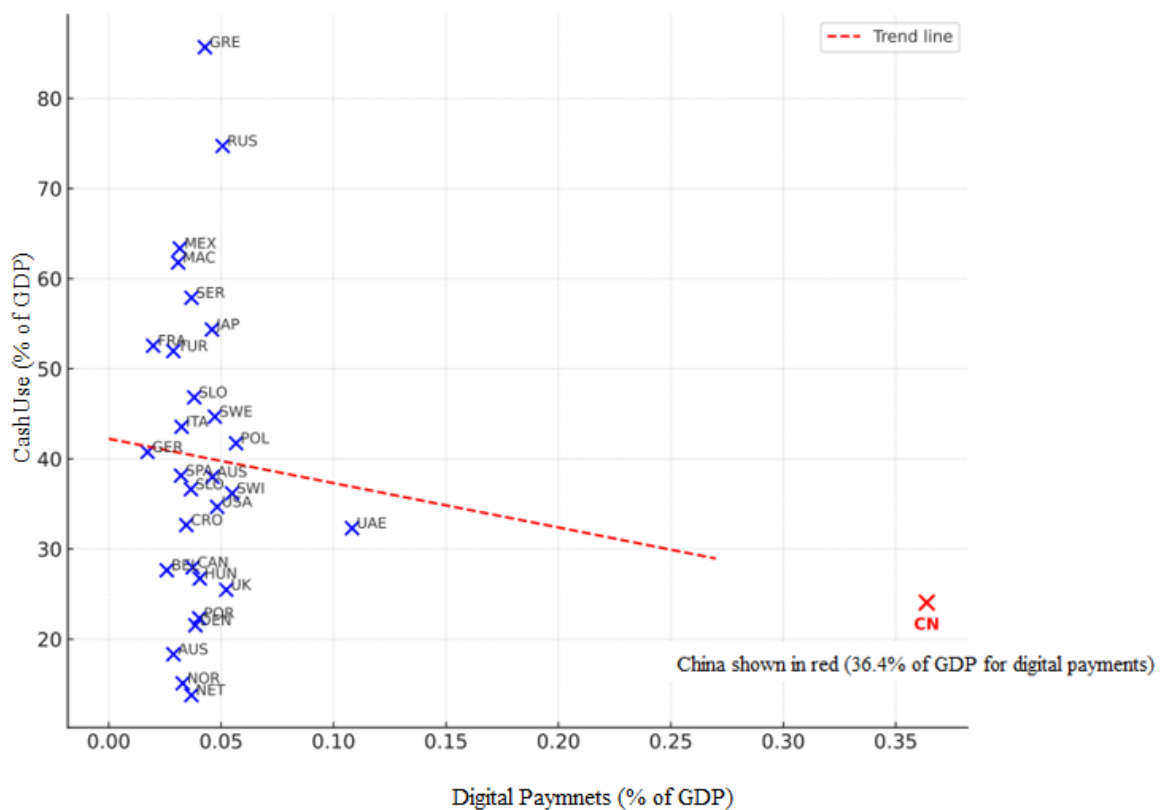
aggressive digitization policies and widespread adoption of mobile payment platforms like Alipay and WeChat Pay. Contrastingly, other technologically advanced countries like Japan or Germany show lower adoption rates, likely due to traditional consumer behaviour patterns and a conservative approach towards digital financial services.

5.2.2.3 Digital Payments vs Cash Use

The final step involves directly assessing whether higher digital payment adoption correlates negatively with cash use. The data visualization in Figure 11 clearly illustrates a stronger negative correlation, suggesting that countries with higher levels of digital payment adoption tend to exhibit significantly lower cash use.

This observation aligns closely with theoretical expectations: as consumers become more accustomed to digital transactions, the convenience and security offered by these methods gradually replace the need for traditional cash-based payments.

Figure 11: Relationship between digital payments and cash use



Source: Own work

This relationship is especially clear in countries like Sweden, Australia and Norway, where the widespread use of digital payment systems has greatly reduced the need for cash. On the other

hand, countries such as Greece, North Macedonia and Mexico where digital payment options are less common, still rely heavily on cash for everyday transactions.

Overall, the descriptive analysis shows that simply having advanced technology does not automatically lead to a significant drop in cash use. Instead, technology plays an indirect role by making digital payment systems possible. It is the broad acceptance and everyday use of these systems, often influenced by cultural habits that truly reduces the dependence on cash.

These findings highlight the importance of both strong digital payment infrastructure and cultural acceptance in helping economies move away from cash. This understanding sets the stage for the regression analysis that follows.

6 RESULTS OF THE EMPIRICAL ANALYSIS

This chapter presents the outcomes of the empirical analysis conducted in this thesis. Based on the results of the Hausman test (see Table 7), which support the use of the random effects model ($p = 0.6805$), all estimations in this chapter are conducted using random effects panel regression models, applied to data from 30 countries over the period 2012–2022.

Table 7: Hausman test results

Chi-squared Statistic (χ^2)	Degrees of Freedom (df)	p-value
2.3134	6	0.6751

Source: Own work

The analysis was performed in multiple stages, starting with a simple baseline model and gradually incorporating demographic and technological variables along with their interaction effects with the COVID-19 pandemic. Each section includes a brief explanation of the model's structure, the corresponding regression results and a factual summary of the findings. Statistical significance is reported based on conventional thresholds and model fit is assessed using R-squared values.

The dependent variable in all models reflects the level of cash use in the economy, measured as a percentage of GDP. The first model focuses on assessing the direct effect of the COVID-19 period on this variable while controlling for structural characteristics of the countries in the sample. These controls include demographic factors such as the share of young people in the population and the level of tertiary education attainment, as well as technological development indicators.

Technological development is represented by two separate variables. The first measures the value of digital payment transactions, which reflects the extent of technology-driven payment adoption, including activities such as Digital Commerce and Mobile POS payments. The second

captures the level of high and medium-tech output, expressed as the share of technology-intensive exports in total manufacturing exports. The analysis for this model is based on an unbalanced panel dataset consisting of 30 countries observed over eleven years. The regression output for this baseline model is presented in Table 8.

Table 1: Baseline model

Variable	Coefficient	Std.Error	t-value	p-value
Constant	20.560	40.414	0.5087	0.61094
Covid	-2.5968**	0.8182	-3.1987	0.0013
Young Population	0.9416	1.5138	0.6202	0.53514
Tertiary Education	-0.0272	0.0673	-0.4035	0.68655
Digital Payments	-68.809*	28.598	-2.4061	0.01612
High and Medium Tech Output	0.0497	0.05461	0.8973	0.36954

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. $R^2 = 0.4126$; Adj $R^2 = 0.3958$; Wald $\chi^2 = 120.82$ (df = 6); p-value < 0.001; N = 327 (30 countries, 2012–2022).

Source: Own work

The coefficient for Covid is negative and statistically significant at the 0.1% level ($p = 0.00138$). The variable digital payments is statistically significant at the 5% level ($p = 0.01612$), with a negative sign. The coefficients for young population, tertiary education and high and medium tech output are not statistically significant at conventional levels.

The second regression model, presented in Table 9, builds upon the baseline specification by incorporating demographic variables and testing their interaction with the COVID-19 period. This model includes the share of young people in the total population as an additional explanatory variable. To examine whether the effect of the pandemic differed across countries with varying age structures, an interaction term between the young population share and the COVID-19 dummy variable was also introduced.

The coefficient for young population is positive ($\beta = 0.9435$) but not statistically significant ($p = 0.53785$). The interaction term *Covid* $\times$ *Young Population* has a negative ($\beta = -0.0664$) coefficient and is also not statistically significant ($p = 0.84129$).

Table 2: Demographic factors: Younger population and Covid interaction

Variable	Coefficient	Std.Error	t-value	p-value
Constant	20.405	40.771	0.5005	0.61674
Covid	-0.8814	8.5911	-1.1026	0.91829
Young Population	0.9435	1.5315	0.6161	0.53785
Covid x Young Population	-0.0664	0.3165	-0.2002	0.84129
Tertiary Education	-0.0239	0.0688	-0.3475	0.72825
Digital Payments	-68.310*	28.856	-2.3673	0.01792
High and Medium Tech Output	0.0488	0.0547	0.8932	0.3717

Note: *p < 0.05; **p < 0.01; ***p < 0.001. R² = 0.417; Adj R² = 0.3935; Wald χ^2 = 120.75 (df = 7); p-value < 0.001; N = 327 (30,2012–2022).

Source: Own work

Table 3: Demographic factors: Education and Covid interaction

Variable	Coefficient	Std.Error	t-value	p-value
Constant	20.911	40.175	0.5205	0.60271
Covid	-2.6652	1.8484	-1.4419	0.14932
Tertiary Education	-0.0301	0.0821	-0.3665	0.71398
Young Population	-0.9313	1.5038	0.6194	0.53569
Digital Payments	-68.761*	28.784	-2.3889	0.01690
High and Medium Tech Output	0.0486	0.0550	0.8832	0.37712
Covid x Tertiary Education	0.0018	0.0486	0.0371	0.97342

Note: *p < 0.05; **p < 0.01; ***p < 0.001. R² = 0.413; Adj R² = 0.389; Wald χ^2 = 118.73 (df = 7); p-value < 0.001; N = 327 (30 countries, 2012–2022).

Source: Own work

Among the control variables, the digital payments variable remains statistically significant, with a coefficient of -68.3102 and a p-value of 0.01792, indicating statistical significance at the 5% or less. The coefficient for tertiary education is -0.0239, p-value of 0.7282, while the coefficient for high and medium-tech output is 0.0489, p-value of 0.3717 are not statistically significant.

Table 10 presents the results of a panel regression model that includes an interaction term between Covid and tertiary education, to examine whether the association between educational attainment and the level of cash held in the economy differed during the pandemic period. The coefficient for tertiary education is negative ($\beta = -0.0301$) but not statistically significant ($p = 0.71398$). The interaction term *Covid* $\times$ *Tertiary Education* is also not statistically significant ($\beta = 0.0018$, $p = 0.97342$).

Digital payments is statistically significant at the 5% level or less ($p = 0.01690$), with a negative coefficient, indicating a potential inverse relationship with cash use. Other variables, including Covid, tertiary education, young population and high and medium tech output, do not show statistical significance at conventional thresholds.

In Table 11, attention shifts to technological development. The analysis explores whether countries with higher levels of high-tech and medium-tech economic output exhibited different trends in cash use.

Table 4: Technology: High and medium tech output index and Covid

Variable	Coefficient	Std.Error	t-value	p-value
Constant	19.985	39.286	0.5087	0.61095
Covid	-31.896*	15.792	-20.197	0.04341
High and Medium Tech Output	0.0445	0.0558	0.7978	0.42501
Young Population	0.9749	14.787	0.6594	0.50967
Digital Payments	-69.794*	28.653	-24.358	0.01486
Tertiary Education	-0.0306	0.0681	-0.4501	0.65266
Covid x High and and Medium Tech Output	0.0123	0.0290	0.4269	0.66943

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. $R^2 = 0.410$; Adj $R^2 = 0.3863$; Wald $\chi^2 = 117.18$ (df = 7); p-value < 0.001; N = 327 (30 countries, 2012–2022).

Source: Own work

The coefficient for high and medium tech output is positive ($\beta = 0.0445$), but it is not statistically significant ($p = 0.42501$). The coefficient for Covid is negative and statistically significant at the 5% level or less ($p = 0.04341$). The interaction term *Covid* $\times$ *High and Medium Tech Output* is not statistically significant ($\beta = 0.0123$, $p = 0.66943$). Digital Payments is statistically significant at the 5% level or less ($p = 0.01486$), while the remaining control variables are not statistically significant at conventional thresholds.

The second variable under the category of technological measures is digital payments. Table 12, reports the regression results examining the relationship between digital payment adoption and cash use. The coefficient for Digital Payments is negative ($\beta = -70.051$) and statistically significant at the 5% level or less ($p = 0.029$).

The Covid variable is also statistically significant ($\beta = -2.616$, $p = 0.002$), with a negative coefficient. The interaction term *Covid* $\times$ *Digital Payments* is not statistically significant ($\beta = 0.865$, $p = 0.930$).

Table 5: Technology: Digital payments and Covid

Variable	Coefficient	Std.Error	t-value	p-value
Constant	20.288	40.645	0.499	0.618
Covid	-2.616**	0.843	-3.103	0.002
Digital Payments	-70.051*	32.115	-2.181	0.029
Covid x Digital Payments	0.865	9.898	0.087	0.93
Young Population	0.955	1.531	0.624	0.533
Tertiary Education	-0.027	0.068	-0.402	0.688
High and Medium Tech Output	0.049	0.055	0.89	0.373

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. $R^2 = 0.414$; Adj $R^2 = 0.388$; Wald $\chi^2 = 115.20$ (df = 7); p-value < 0.001; N = 327 (30 countries, 2012–2022).

Source: Own work

The final model or combined shown in Table 13 integrates all previously tested variables into one comprehensive regression. It includes both demographic (young population and tertiary education) and technological (digital payments and high and medium tech output) indicators, along with their respective interaction terms with the Covid variable.

Table 6: Combined model

Variable	Coefficient	Std.Error	t-value	p-value
Constant	14.992	39.05	0.3838	0.701
Young Population	1.1439	1.466	0.7801	0.435
Tertiary Education	-0.0415	0.088	-0.4676	0.640
Digital Payments	-83.431	31.39	-2.6579	0.007
High and Medium Tech Output	0.0329	0.057	0.5765	0.564
Covid	-2.7570	9.709	-0.2839	0.776
Covid x Young Population	-0.0036	0.363	-0.0101	0.991
Covid x Tertiary Education	0.0055	0.054	0.1027	0.918
Covid x Digital Payments	-5.9015	10.99	-0.5369	0.591
Covid x High and Medium Tech Output	0.0112	0.030	0.3734	0.708

Note: *p < 0.05; **p < 0.01; ***p < 0.001. R² = 0.3897; Adj R² = 0.3570; Wald χ^2 = 105.88 (df = 9); p-value < 0.001; N = 327 (30 countries, 2012–2022).

Source: Own work

This combined specification allows for the most robust estimation of how various country-level factors influenced trends in the level of cash held within national economies during the pandemic period. This model structure mirrors the analytical framework set out in the Methodology chapter, particularly Section 2.4, where the rationale for combining both demographic and technological dimensions was explained.

By jointly estimating all effects, the model helps assess not only their individual contributions but also their potential combined influence. The inclusion of interaction terms captures the extent to which pandemic-induced shifts in cash use may have been magnified or dampened by a country's digital infrastructure or population characteristics.

None of the explanatory variables are statistically significant at the 5% level or less. The coefficient for digital payments is negative ($\beta = -83.431$), with a t-value of -1.908 and a p-value of 0.058, which is marginally significant at the 10% level. All other coefficients, including those for young population, tertiary education, high and medium tech output, Covid and the interaction terms have p-values above 0.10 and are therefore not statistically significant at conventional thresholds in this model.

Table 14: Total Payments and Covid

Variable	Coefficient	Std.Error	t-value	p-value
Constant	41.076	25.620	1.603	0.108
Covid	-2.900*	1.2037	-2.409	0.015
Total Payments	9.1623***	2.3335	3.926	0.000
Covid x Total Payments	-2.5162*	1.2111	-2.077	0.037
Young Population	0.2053	0.9122	0.225	0.821
Tertiary Education	-0.2559***	0.0737	-3.470	0.000
High and Medium Tech Output	0.0373	0.0448	0.834	0.404

Note: *p < 0.05; **p < 0.01; ***p < 0.001. $R^2 = 0.3667$; Adj $R^2 = 0.3528$; Wald $\chi^2 = 183.75$ (df = 7); p-value < 0.001; N = 327 (30 countries, 2012–2022)

Source: Own work

Table 14 presents the results of the Total Payments model. The coefficient for Total Payments is positive ($\beta = 9.1623$), but it does not reach statistical significance ($p = 0.1379$). The coefficient for Covid-19 is negative ($\beta = -2.9001$), yet also statistically insignificant ($p = 0.4652$).

The interaction term Covid $\times$ Total Payments is statistically significant at the 5% level or less ($\beta = -2.5163$, $p = 0.0230$), indicating that the relationship between overall payment activity and cash use became more negative during the Covid-19 period.

Additionally, High-Tech Output ($p = 0.0004$) and GDP ($p = 0.0170$) remain statistically significant, while the other control variables (Young Population and Tertiary Education) do not show statistically significant effects.

7 DISCUSSION

This section reflects on the findings regarding the impact of the COVID-19 pandemic on cash use across 30 countries between 2012 and 2022, with particular attention to demographic and technological factors. The analysis focuses on four main areas: the direct effect of the pandemic, the role of age and education, the influence of digital and technological development and the combined contribution of these variables.

The results suggest that the pandemic coincided with a noticeable global decline in the relative amount of cash in circulation. On average, the share of cash relative to GDP dropped by 6.76 percentage points during the pandemic years compared to the previous period. Countries that already had strong digital payment systems, such as Sweden, experienced even sharper reductions. In Sweden's case, the level of cash held in the economy decreased by nearly 17 percentage points. This pattern reflects a broader trend observed across multiple countries, where concerns about physical contact, lockdown restrictions and an increase in online activity encouraged a shift toward digital payment options.

At the same time, not all countries followed this trajectory. North Macedonia and Japan, for example, recorded a slight increase in the level of cash held within their economies during the pandemic. In these cases, cultural preferences and precautionary behaviour likely played a role. These exceptions highlight the importance of national context, including digital readiness, economic structure and public attitudes toward financial systems.

Although the immediate shift away from cash was clear, it remains to be seen whether these changes will last. The long-term impact will depend on how strongly countries support digital access, financial inclusion and trust in digital systems in the years ahead.

When looking at demographic characteristics, the proportion of young people between 18 and 35 years of age did not show a meaningful link with the level of cash held within the economy in the regression models. Even during the pandemic, countries with large youth populations, such as Mexico or North Macedonia, continued to rely on cash. This challenges the common assumption that younger generations naturally lead the way in adopting digital payment tools.

In contrast, education showed more consistent patterns. Countries with a higher share of tertiary-educated individuals tended to use less cash. In some model versions, this effect was stronger during the pandemic period. When technological factors were included in the model, the influence of education became less clear. This suggests that the role of education might be partly shaped by how digitally prepared and inclusive a country is overall. Still, exceptions exist. For instance, Russia continues to rely heavily on cash despite its relatively well-educated population, which points to the importance of deeper structural or cultural factors.

Technological development, especially the use of digital payments, emerged as the strongest predictor of declining reliance on cash. Across most models, countries with more advanced digital payment systems experienced greater reductions in the relative amount of cash in their economies. Although broader measures of innovation, such as high-tech and medium-tech output, were included in the analysis, they did not show a strong association with cash levels. These findings suggest that it is not general innovation that plays the key role, but rather the specific type of innovation that supports digital financial tools and services.

Descriptive findings supported this. Countries such as the Netherlands, Norway and Australia, which are all known for strong digital ecosystems, saw clear drops in cash use during the pandemic. Meanwhile, others with less developed systems remained more dependent on cash for everyday transactions.

In the final model, both demographic and technological factors were combined to provide a more comprehensive perspective. Once digital payments were included, most of the other variables lost their statistical significance. Digital payments remained the only variable with a consistent and meaningful association with the level of cash held within the economy. This underlines the central role that accessible and trusted digital systems play in shaping financial behaviour, especially during periods of sudden change.

To further address potential bias from analysing only non-cash payment variables, an additional model was estimated incorporating total payments as a percentage of GDP. The results revealed that the direct effect of total payments on cash use was not statistically significant, suggesting that overall payment activity alone does not explain variations in cash demand across countries in the observed period.

However, the interaction term between COVID-19 and total payments was statistically significant and negative, indicating that in countries with higher total payment volumes, the decline in cash use was more pronounced during the COVID-19 years. This finding suggests that the pandemic intensified the relationship between overall payment activity and cash demand.

Furthermore, the continued significance of high and medium tech output and GDP across models reinforces the conclusion that both technological development and macroeconomic factors remain important determinants of cash use, even after accounting for total payment activity.

While the results are broadly consistent and informative, it is important to acknowledge certain limitations. Incomplete data on digital payments for specific countries and years may have affected some of the estimates. Additionally, measuring cash use using residual methods, although widely applied in research, may not fully capture informal transactions. Furthermore,

institutional factors such as public trust, the size of the informal economy or national regulatory attitudes are difficult to quantify but likely have a significant influence on individuals' payment choices.

Future research could look more closely at these less tangible factors. Qualitative studies, local surveys and case-specific comparisons could help deepen our understanding of what drives people's choices in how they use or stop using cash.

8 CONCLUSION

This thesis investigated trends in global cash use between 2012 and 2022, with a particular focus on the disruptive effects of the COVID-19 pandemic and the roles of demographic and technological determinants. By analyzing panel data covering over 30 countries across Europe, North America, Asia and Australia the research aimed to identify key macro-level drivers of the decline in cash use and to assess the extent to which the pandemic accelerated this shift. Regression analysis confirmed that the COVID-19 pandemic had a statistically significant and substantial impact on cash use. As shown in the baseline model, the onset of the pandemic in 2020 coincided with a significant decline in cash use, supporting the view that public health emergencies can act as exogenous shocks that intensify existing financial trends. National lockdowns, increased health concerns and shifts in consumer preferences have all contributed to a widespread shift toward digital payment methods. These effects were observed not only in traditionally digital economies, but also in countries where cash had previously maintained a stronger foothold.

The thesis further explored the impact of demographic factors. Age, measured as the share of young people in the population, did not show a statistically significant relationship with cash use, nor did it interact significantly with the effects of the pandemic. This suggests that generational factors alone do not explain differences in cash behaviour across countries. On the other hand, education, specifically the share of people with higher education, proved relevant when considered together with the COVID-19 period. Although not consistently significant in isolation, the interaction between education and the pandemic was statistically significant, indicating that a more highly educated population was more responsive to the disruption and more likely to reduce cash use during this period. These findings point to education as an indicator of digital readiness and financial literacy, rather than age per se.

Technological development emerged as the most consistent and influential factor in explaining differences in cash use across countries. Regression models found that both digital payments and high-tech products were negatively associated with cash use, especially during the COVID-19 period. Countries with well-developed digital payment systems experienced a greater decline in cash reliance. This model highlights the key role of digital ecosystems in enabling changes in payment behaviour and preferences, especially when triggered by external crises such as the pandemic. The combined model, which integrated all demographic and technological indicators

along with their interaction terms, provided the most comprehensive understanding of cash use trends. It showed that, when demographic and technological variables are considered together, the explanatory power of education and age decreases, while digital payment infrastructure remains highly significant. These findings suggest that technological capacity, rather than structural population characteristics, plays the dominant role in determining how countries respond to shocks such as the COVID-19 pandemic.

In conclusion, this thesis provides empirical evidence of a global decline in cash use, accelerated by the COVID-19 pandemic. While demographic factors, particularly education, have influenced this trend, technological infrastructure has emerged as the most decisive element. As economies increasingly shift towards digital financial systems, balancing innovation with inclusion remains essential.

REFERENCE LIST

1. Adrian, T., & Mancini-Griffoli, T. (2021). The rise of digital money. *Annual Review of Financial Economics*, 13(1), 57–77.
2. Anbugeetha, D., & Nandhini, B. (2021). Evolution of money: From barter system to digital money. In S. A. Selvan (Ed.), *The new era of digital payments* (pp. 56–65). New Chennai Publications
3. Auer, R., Cornelli, G., & Frost, J. (2021). Rise of the central bank digital currencies: Drivers, approaches and technologies. BIS Working Papers No. 880. *Bank for International Settlements*.
4. Ahnert, Hoffmann, Agnese, & Porcellacchia. (2023). CBDC and Financial Stability. *European Central Bank*.
<https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp2783~0af3ad7576.en.pdf>
5. Andolfatto, D. (2019). *Assessing the impact of central bank digital currency on private banks* (Federal Reserve Bank of St. Louis Working Paper No. 2019-003B).
<https://doi.org/10.20955/wp.2019.003>
6. Baltagi, B. H. (2021). *Econometric analysis of panel data* (6th ed.). Springer.
7. Bank for International Settlements. (2020). *COVID-19, cash and the future of payments*. Bank for International Settlements. <https://www.bis.org/publ/bisbull03.htm>
8. Baker, H. (2018, May 2). The tiny island with human-sized money. *BBC Travel*.
<https://www.bbc.com/travel/article/20180502-the-tiny-island-with-human-sized-money>
9. Bank of England. (2020). *Cash in the time of COVID*. *Bank of England Quarterly Bulletin*, 2020(Q4). <https://www.bankofengland.co.uk/quarterly-bulletin/2020/2020-q4/cash-in-the-time-of-covid>
10. Bank of England. (2018). How has money changed over time? *Bank of England*.
<https://www.bankofengland.co.uk/explainers/how-has-money-changed-over-time>

11. Bank of England. (2022). Knocked down during lockdown: *The return of cash*. Bank of England Quarterly Bulletin, 2022(Q3). <https://www.bankofengland.co.uk/quarterly-bulletin/2022/2022-q3/knocked-down-during-lockdown-the-return-of-cash>
12. Bank of England. (2023). Interest rate risk in the economy and financial system. *Bank of England*. <https://www.bankofengland.co.uk/-/media/boe/files/financial-stability-in-focus/2023/interest-rate-risk-in-the-economy-and-financial-system.pdf>
13. Cartwright, M. (2021, October 6). Trade in ancient Celtic Europe. *World History Encyclopedia*. <https://www.worldhistory.org/article/1719/trade-in-ancient-celtic-europe/>
14. Chapman, A. (1980). Barter as a universal mode of exchange. *L'Homme*, 20(3), 33-83. <https://www.jstor.org/stable/25131676>
15. Chen, H., & Hossain, T. (2021). Consumer behavior in a health crisis: What happened with cash? *Federal Reserve Bank of Atlanta, Policy Hub* (No. 2021-1). <https://www.atlantafed.org/-/media/documents/research/publications/policy-hub/2021/01/12/01-consumer-behavior-in-health-crisis-what-happened-with-cash.pdf>
16. Chave, M. (2021). The digitalization of payments and the decline of cash: An economic, social and geographical approach. *Révue d'Économie Industrielle*, 173. <https://doi.org/10.4000/rei.9471>
17. Clere, A. (2023, July 4). Central banks embrace CBDCs: Promising potential. *FinTech Magazine*. <https://fintechmagazine.com/articles/cbdcs-15-central-bank-digital-currencies-by-2030-bis-says>
18. European Central Bank. (2023). Circulation. *European Central Bank*. https://www.ecb.europa.eu/stats/policy_and_exchange_rates/banknotes+coins/circulation/html/index.en.htm
19. European Central Bank. (2022). Cash still a key payment method for Europeans, but its use is declining. *European Central Bank*. <https://www.ecb.europa.eu/press/pr/date/2022/html/ecb.pr221220~62a7c988ef.en.html>
20. European Central Bank. (2022). *Study on the payment attitudes of consumers in the euro area (SPACE)*. European Central Bank. https://www.ecb.europa.eu/stats/ecb_surveys/space/html/ecb.spacereport202212~783ffdf46e.en.html
21. European Central Bank. (2024). *Study on the payment attitudes of consumers in the euro area 2024*. European Central Bank. https://www.ecb.europa.eu/stats/ecb_surveys/space/html/ecb.space2024~19d46f0f17.en.html
22. Erh, J. (2021). Assessing digital economy policies in six Southeast Asian countries. *ISEAS – Yusof Ishak Institute, Perspective* (No. 2021/50), 1–9. <https://www.iseas.edu.sg/articles-commentaries/iseas-perspective/2021-50-assessing-digital-economy-policies-in-six-southeast-asian-countries-by-jacob-erh/>

23. Esselink, H., & Hernández, L. (2017). *The use of cash by households in the euro area* (ECB Occasional Paper Series No. 201). European Central Bank. <https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op201.en.pdf>
24. Federal Reserve Bank of Philadelphia. (2021). *The future of cash* (Discussion Paper No. DP21-03). <https://www.philadelphiafed.org/-/media/frbp/assets/consumer-finance/discussion-papers/dp21-03.pdf>
25. Federal Reserve Bank of St. Louis. (2010). *The power of money*. <https://www.stlouisfed.org/about-us/resources/why-fed-is-well-designed-central-bank/the-power-of-money>.
26. Foster, K., & Greene, C. (2021). *Survey and diary of consumer payment choice*. Federal Reserve Bank of Atlanta. https://www.atlantafed.org/-/media/documents/banking/consumer-payments/survey-diary-consumer-payment-choice/2021/sdcpc_2021_report.pdf
27. Futures, F. (2023). How digital payments are changing the world. *FinTech Futures*. <https://www.fintechfutures.com/2023/05/how-digital-payments-are-changing-the-world/>
28. Federal Reserve Bank of Boston. (2023, November 2). Cash crash: Pandemic increasing credit card use, *Diary of Consumer Payment Choice*. <https://www.bostonfed.org/news-and-events/news/2023/11/cash-crash-pandemic-increasing-credit-card-use-diary-of-consumer-payment-choice.aspx>
29. Gregory, C. A. (1996). Cowries and Conquest: Towards a Subalternate Quality Theory of Money. *Comparative Studies in Society and History*, 38(2), 195-217.
30. Gujarati, D. N., & Porter, D. C. (2009). *Basic Econometrics* (5th ed.). McGraw-Hill Education.
31. Gupta, R. (2022). How Technology Is Transforming Business Payments. *Forbes*. <https://www.forbes.com/sites/forbesfinancecouncil/2022/02/09/how-technology-is-transforming-business-payments/>
32. Hansen, M. (2011). *The Place of Coins in the Political History of Ancient Greece*. Yale University. [https://history.yale.edu/sites/default/files/files/Hansen%20Place%20of%20Coins%20\(Eng\).pdf](https://history.yale.edu/sites/default/files/files/Hansen%20Place%20of%20Coins%20(Eng).pdf)
33. Heinonen, A. (2019) The future of cash: an update. *Central Banking*. <https://www.centralbanking.com/central-banks/currency/demand/4488036/the-future-of-cash-an-update>
34. Van den Berg, H. (2016). *International finance and open economy macroeconomics* (2nd ed.). World Scientific Publishing Company.
35. Hoyrem, S. F. (2013). *Banknotes: The money of civilization (pp. 165–210)*. In *Histories of the sacred and secular, 1700–2000*. Department of History, Oxford Brookes University. <https://creativecommons.org/licenses/by/4.0/>

36. Holetić, G. (2023, March 15). Cashless trends in retail: Shaping consumer behavior. *Advanced Cashless Solutions*. <https://cashless.systems/blog/cashless-trends-in-retail-shaping-consumer-behavior/>
37. Das, M., Mancini Griffoli, T., Nakamura, F., Otten, J., Soderberg, G., Solé, J., & Tan, B. (2023). *Implications of central bank digital currencies for monetary policy transmission*. International Monetary Fund. <https://www.imf.org/en/Publications/WP/Issues/2023/02/10/Implications-of-Central-Bank-Digital-Currencies-for-Monetary-Policy-Transmission-529933>
38. Jiang, Y. (2022). *The influence of payment method: Do consumers pay more with mobile payment?* Claremont Graduate University.
39. Abi Karam, A. (2023). Central bank digital currency (CBDC) and blockchain enable the future of payments. *IBM*. <https://www.ibm.com/blog/central-bank-digital-currency-cbdc-and-blockchain-enable-the-future-of-payments/>
40. Karanikolos, M., Mladovsky, P., Cylus, J., Thomson, S., Basu, S., Stuckler, D., Mackenbach, J. P., & McKee, M. (2013). Financial crisis, austerity and health in Europe. *The Lancet*, 381(9874), 1323–1331.
41. Kauangal, J., & Paschal, M. (2023). *Determinants of cashless payment method choice among international students in their host country: Evidence from Gujarat, India*. Shree Narayana College of Commerce.
42. Khiaonarong, T., & Humphrey, D. (2019). *Cash use across countries and the demand for central bank digital currency* (IMF Working Paper No. 2019/046). International Monetary Fund. <https://www.imf.org/en/Publications/WP/Issues/2019/03/29/Cash-Use-Across-Countries-and-the-Demand-for-Central-Bank-Digital-Currency-46674>
43. Makarewicz, C. A., & Rose, K. A. (2011). Wealth in livestock, wealth in people and the pre-pottery Neolithic of Jordan. *Cambridge Archaeological Journal*, 21(3), 383-397.
44. Millman, E. (2015). The Importance of the Lydian Stater as the World's First Coin. *World History Encyclopedia*. <https://www.worldhistory.org/article/797/the-importance-of-the-lydian-stater-as-the-worlds/>
45. Mudasser, K. M. (2022). *The gold standard and fiat money system*. Bard College. https://digitalcommons.bard.edu/senproj_f2022/15/
46. Mulqueeney, J., & Livermore, T. (2023, June). Cash use and attitudes in Australia. *Reserve Bank of Australia Bulletin*. <https://www.rba.gov.au/publications/bulletin/2023/jun/pdf/cash-use-and-attitudes-in-australia.pdf>
47. National Museum of African American History and Culture. (n.d.). Cowrie shells and trade power. *Smithsonian Institution*. <https://nmaahc.si.edu/cowrie-shells-and-trade-power>
48. NatWest Group. (n.d.). Gold, banknotes and money supply in the First World War. *NatWest Group Remembers*. <https://www.natwestgroupremembers.com/banking-in->

wartime/banking-business/gold-banknotes-and-money-supply-in-the-first-world-war.html

49. NFCW. (2022, October 18). Contactless card purchases to exceed \$522bn globally by 2026. *NFCW*. <https://www.nfcw.com/whats-new-in-payments/contactless-card-purchases-to-exceed-522bn-globally-by-2026/>
50. Palma, N. (2019). *Money and modernization in early modern England* (EHES Working Paper No. 147). University of Manchester & Centre for Economic Policy Research (CEPR). <https://www.econstor.eu/bitstream/10419/247077/1/ehes-wp147.pdf>
51. N26. (n.d.). Foreign transaction fees explained. *N26*. <https://n26.com/en-eu/foreign-transaction-fee>
52. O'Neill, M. (2016). The myth of the barter economy. *The Atlantic*. <https://www.theatlantic.com/business/archive/2016/02/barter-society-myth/471051/>
53. Ohlan, M., Rani, E., & Autade, C. D. (2019). Impact of cashless transactions on purchasing behavior of respondents. *International Journal of Current Microbiology and Applied Sciences*, 8(11), 835-845.
54. Organisation for Economic Co-operation and Development. (2025). *Safeguarding consumers' access to cash in the digital economy*. https://www.oecd.org/content/dam/oecd/en/publications/reports/2025/03/safeguarding-consumers-access-to-cash-in-the-digital-economy_d6048c25/189970b4-en.pdf
55. Pacilo, L. (2024) We spend more with cashless payments. *The University of Adelaide*. <https://www.adelaide.edu.au/newsroom/news/list/2024/06/06/we-spend-more-with-cashless-payments>
56. Pew Research Center. (2022, September 8). Payment apps like Venmo and Cash App bring convenience and security concerns to some users. *Pew Research Center*. <https://www.pewresearch.org/short-reads/2022/09/08/payment-apps-like-venmo-and-cash-app-bring-convenience-and-security-concerns-to-some-users/>
57. Phillips, T. (2022). Contactless card purchases to exceed 522bn globally by 2026. *NFCW*. <https://www.nfcw.com/whats-new-in-payments/contactless-card-purchases-to-exceed-522bn-globally-by-2026/>
58. RBR (2022). *Global Payment Cards Data and Forecasts to 2027*. Datos Insights. <https://datos-insights.com/wp-content/uploads/2023/05/GC27-Brochure.pdf>
59. Reserve Bank of Australia. (2021). Cash demand during COVID-19. *Reserve Bank of Australia Bulletin*, March 2021. <https://www.rba.gov.au/publications/bulletin/2021/mar/cash-demand-during-covid-19.html>
60. Sveriges Riksbank. (2023). *The RIX payment system*. Sveriges Riksbank. <https://www.riksbank.se/en-gb/payments--cash/the-payment-system---rix/>
61. Sveriges Riksbank. (2023). *Statistics on payments*. Sveriges Riksbank. <https://www.riksbank.se/en-gb/statistics/statistics-on-payments-banknotes-and-coins/statistics-on-payments/>

62. Roberts, R. (2013). The Great Financial Crisis of 1914. *Alchemist*, (73).
<https://www.lbma.org.uk/alchemist/issue-73/the-great-financial-crisis-of-1914>
63. Rosenberg, J. (2020). The first credit card. *ThoughtCo*. <https://www.thoughtco.com/the-first-credit-card-1779328>
64. Serapioni, M., & Hespanha, P. (2019). Crisis and austerity in Southern Europe: Impact on economies and societies. *e-cadernos CES*, 31. <https://doi.org/10.4000/eces.4068>
65. Schomburgk, L., Belli, A., & Hoffmann, A. O. I. (2024). Less cash, more splash? A meta-analysis on the cashless effect. *Journal of Retailing* 100(3), 382–403.
66. Smiley, G. (2004, June 29). The U.S. economy in the 1920s. In R. Whaples (Ed.), *EH.Net Encyclopedia of Economic and Business History*.
<https://eh.net/encyclopedia/the-u-s-economy-in-the-1920s/>
67. Smith, B. (2014). From Salt to Salary: Linguists Take a Page From Science. *NPR*.
<https://www.npr.org/sections/13.7/2014/11/08/362478685/from-salt-to-salary-linguists-take-a-page-from-science>
68. Strohecker, K. (2023). Twenty-four central banks will have digital currencies by 2030, survey shows. *Reuters*. <https://www.reuters.com/markets/currencies/twenty-four-central-banks-will-have-digital-currencies-by-2030-bis-survey-2023-07-10/>
69. Szczepański, M. (2019, July). *Economic impacts of artificial intelligence (AI)* (EPRS Briefing No. PE 637.967). European Parliamentary Research Service.
https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/637967/EPRS_BRI%282019%29637967_EN.pdf
policycommons.net+7europarl.europa.eu+7journalofeconomicstructures.springeropen.com+7
70. The Metropolitan Museum of Art. (2021). *Tang dynasty (618–907)*.
http://www.metmuseum.org/toah/hd/tang/hd_tang.htm
71. Trütsch, T. (2020). The impact of contactless payment on cash usage at an early stage of diffusion. *Swiss Journal of Economics and Statistics*, 156(1), Article 5.
<https://doi.org/10.1186/s41937-020-00050-0>
72. Vodafone. (n.d.). *M-PESA: Connecting people to opportunity*.
<https://www.vodafone.com/what-we-do/services/m-pesa>
73. Worldpay. (2024). *Global payments report 2024*.
<https://worldpay.globalpaymentsreport.com/en>
74. Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data* (2nd ed.). MIT Press.
75. Zamora-Pérez, A. (2021). The paradox of banknotes: Understanding the demand for cash beyond transactional use. *European Central Bank*.
https://www.ecb.europa.eu/pub/economic-bulletin/articles/2021/html/ecb.ebart202102_03~58cc4e1b97.en.html

APPENDICES

Appendix 1: Povzetek (Summary in Slovene language)

Namen tega magistrskega dela je bil analizirati trende v uporabi gotovine med letoma 2012 in 2022, s posebnim poudarkom na obdobju pandemije COVID-19 (2020–2022). Raziskava je zajela več kot 30 držav s štirih celin: Evrope, Severne Amerike, Azije in Avstralije. V enajstletnem obdobju je bilo zaznati postopno zmanjševanje uporabe gotovine, pri čemer je bil upad najizrazitejši v zadnjih šestih do sedmih letih. Leto 2020 predstavlja prelomnico, saj je izbruh pandemije povzročil pomembne spremembe v plačilnih navadah potrošnikov. V številnih državah so bile uvedene omejitve pri uporabi gotovine zaradi skrbi glede prenosa virusa, kar je dodatno pospešilo prehod na digitalne plačilne načine.

Poleg vpliva pandemije je raziskava preučevala tudi vlogo drugih dejavnikov, kot so demografske značilnosti prebivalstva in raven izobrazbe. Čeprav številne obstoječe raziskave nakazujejo povezavo med višjo izobrazbo in manjšo uporabo gotovine, rezultati izvedenih regresijskih analiz te hipoteze niso enoznačno potrdili, kar kaže na kompleksnost odnosa med izobrazbo in plačilnimi navadami.

Tehnološki razvoj je prav tako pomembno vplival na zmanjševanje uporabe gotovine. Analiza je pokazala, da so prebivalci tehnološko bolj razvitih držav pogosteje uporabljali brezgotovinske plačilne metode. Ključni dejavniki, ki spodbujajo uporabo digitalnih plačil, vključujejo večjo dostopnost, fleksibilnost in varnost takšnih rešitev.

Zaključki raziskave kažejo na izrazit trend zmanjševanja uporabe gotovine, predvsem zaradi vse večjega razmaha digitalnih plačilnih načinov. Mnoge države že preučujejo možnosti za uvedbo digitalnih valut centralnih bank (CBDC), vendar pa bo prihodnja vloga gotovine v gospodarstvu odvisna od nadaljnjih tehnoloških, družbenih in regulatornih dejavnikov.