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Toward a Cashless Society: Cash and Non-Cash Payments in Spain, 1989-2014

Summary: This work investigates the relationships between the retail payment system, monetary aggregates and economic activity in Spain from a long-run perspective. This approach is considered from the perspective of the transformations favored by ICT in the payment system, which incorporates increasingly more and more cashless instruments. The methodology used is based on cointegration analysis and error correction models. Likewise, a new indicator of some trends in the implementation of cashless transactions in payment systems is proposed; this measure has been applied to Spain and other European countries. With respect to long-run relationships, we demonstrate the relevant (and direct) impact of changes in the monetary system and national income on the value of cashless transactions. Regarding the short-run, the most important relationships in terms of the value of cashless transactions are those related to the real estate sector. The empirical results evidence the intensive progress of the cashless society in Spain, where the banking sector, regulatory changes and ICT development have played a key role.

Keywords: Cashless payments, Money supply, Real economy, ICT.

JEL: E42, E51, G20.

Most countries are experiencing a transition to a "cashless" society. This situation has led to the development of a digital agenda by governments, policymakers and other social and economic agents (such as the recent proposals by central banks to launch digital currencies, CBDCs). This trend is accompanied by a literature particularly focused on the relationship between cashless payments and economic growth, an approach that constitutes our point of departure (Hock-Han Tee and Hway-Boon Ong 2016; Mark Zandi et al. 2016; Yanying Zhang et al. 2019; Teck-Lee Wong, Wee-Yeap Lau, and Tien-Ming Yip 2020).

A broader question cannot be dismissed in the present work: Do information and communication technologies (ICTs) foster economic growth? The authors who have addressed this topic generally evidence a positive effect, regardless of the type of country (Rudra P. Pradhan, Girijasankar Mallik, and Tapan P. Bagchi 2018; Badri Narayan Rath and Danny Hermawan 2019). This work presents a new approach, with the aim of applying a consistent analytical basis to establish the relationships between retail payment system, monetary aggregates and economic activity in Spain. Two factors underpin the interest in this contribution. First, Spain is a unique laboratory in which to conduct an empirical study on non-cash payments (see Santiago Carbó and

Francisco Rodríguez-Fernández 2014, 2017). Second, the underlying reasons for this aptitude must be established over the long-term.

Our approach includes the long-run perspectives. To this end, cointegration analysis will be used, as it will enable us to examine the long-run relationships, along with error correction models, which will focus on the short-run. On the same note, we propose a simple, yet effective quantitative measure as an indicator of some trends of cashless transactions. We apply this approach to the Spanish case, but for comparative purposes we also consider other European countries.

The paper is organized as follows. Section 1 reflects a literature survey. Section 2 briefly discusses certain idiosyncratic aspects of the Spanish payment system. Section 3 presents the data and introduces the cashless indicator. Section 4 describes the methodology. Finally, Section 5 analyzes the results and the last section draws some conclusions.

1. Analytical Background

Some of these issues have been considered in the literature. Several studies have emphasized that significant changes in payment instruments have been occurring over the last few decades, and these are for the most part the result of the technological innovation (Sheri Markose and Yiing Jia Loke 2000, 2002; Jussi S. Snellman, Jukka M. Vesala, and David B. Humphrey 2001). Other empirical approaches have been developed by combining macroeconomic and technological variables (Alessandra Guariglia and Loke 2004), and there are also cross-country approaches that highlight the role of paper-based and electronic payments and the intensive substitution of cash with cards (Snellman, Vesala, and Humphrey 2001; Humphrey 2004; Barry Scholnick et al. 2008; Peterson K. Ozili 2020); institutional indicators are also integrated into several works (Humphrey, Lawarence B. Pulley, and Vesala 1996; Snellman 2000; Sandra Deungoue 2008). Other authors suggest focusing on the problem from a microeconomic perspective; thus, Hans-Eggert Reimers, Friedrich Schneider, and Franz Seitz (2020) examine the cash holdings of private households and introduce the role of the shadow economy.

Further relevant studies show that the changes in the payment system have also had significant implications for economic activity (Mathias Drehmann et al. 2002; Daniel D. Garcia-Swartz, Robert W. Hahn, and Anne Layne-Farrar 2006; Tee and Ong 2016; Wong, Lau, and Yip 2020), and Zhang et al. (2019) confirm the fundamental relationship between retail payments and the real economy in an aggregate manner for the EU-27 countries. Recent works refer to the influence that the exogenous effects on monetary factors may have on the behavior of the retail sector (Carlos A. Arango et al. 2016), the effects that both electronic transactions at ATMs and at points of sale have on the demand for currency (Carbó and Rodríguez-Fernández 2014), and the use of low-denomination euro bank notes, associating this fact with the role of the demand for this type of denominations (Nikolaus Bartzsch and Franz Seitz 2016).

Given the empirical goals considered in our study, the demand for currency models would be of interest, in order to analyze our results (William J. Baumol 1952; James Tobin 1956; Casey B. Mulligan and Xavier Sala-i-Martin 2000). Nevertheless, our aim is particularly centered on non-cash payments. In this sense, the approaches by Orazio P. Attanasio, Luigi Guiso, and Tullio Jappelli (2002) and Carbó and

Rodríguez-Fernández (2014) constitute an adequate framework; these authors have studied the effects of using debit cards at ATMs and POS on the demand for currency with the objective of finding similarities following the standard inventory models. Likewise, the monetarist perspective establishes links between money supply and price levels; this circumstance leads us to also consider the role played by cashless payments in an economic scenario determined by the money supply and the business cycle. In addition, there is a general consensus in the literature on development economics and financial development regarding the relevance of the payment systems. Some authors, such as Kenneth N. Daniels and Neil B. Murphy (1994), Ross Levine (1997) and Asli Demirgüç-Kunt, Thorsten Beck, and Patrick Honohan (2008), note that the distribution channels of the financial system are an essential part of economic growth, precisely because of their function as payment platforms, their net structures and the externalities they create.

A relevant branch of the existing literature in this field focuses on how the transition to cashless economies impacts the real economy. Although there is mixed evidence in this regard, most authors find that, in general, the expansion of cashless instruments stimulates economic growth, regardless of the level of economic development. Thus, Wong, Lau, and Yip (2020) find a positive impact for most cashless instruments, while Nenavath Sreenu (2020) evidences a positive impact in the long-run, but not in the short-run for the Indian case. This positive effect constrained to the long-run has also been observed by Tee and Ong (2016) for five selected EU countries.

The effects on the real economy are of special interest for developing countries in terms of the policy implications that can be derived. These kinds of questions are explored, among others, by Agu Anthony Ogbonna and Agu Sunday Virtus (2020) in application to Nigeria, where the short-run impact has proven to be negative, so the authors claim, for improving the regulatory framework and the efficiency of e-payments, as well as the education of the population.

The relationship between the development of cashless instruments and the real economy has been analyzed by means of different statistical and econometric tools. Accordingly, Zandi et al. (2016) rely upon descriptive analyses to determine the effect of electronic payments on economic growth for a heterogeneous group of countries. These techniques are also used by Ozili (2020) to compare digital finance usage in four countries. When focusing on the short-run impact, Ordinary Least Squares (OLS) regressions are commonly used when only one country is being studied (Ismaila Yusuf 2016; Nino Mushkudiani 2018; Thangaraj Ravikumar et al. 2019). For the comparative analysis among different countries, most authors resort to panel data methodology (Tee and Ong 2016; Wong, Lau, and Yip 2020). If the long-run impact is considered, cointegration techniques are widely used. This is the case of the works by Ogbonna and Virtus (2020) and Sreenu (2020); ARDL specifications are also employed by Ravikumar et al. (2019). Research on the broad impact of ICTs on economic growth also uses ARDL models (Rath and Hermawan 2019) or cointegration procedures (Pradhan, Mallik, and Bagchi 2018).

Also present in the literature are qualitative procedures and techniques that measure the impact of the implementation of cashless instruments on the economy. The use of search engines, secondary data - articles, journals, survey reports, etc. - and graphs are alternatives to traditional quantitative analyses (Budheshwar P. Singhraul and Yogita S. Garwal 2018).

The major issue we address in this paper is the study of the link between the monetary system, real sector and cashless activity in Spain from a quantitative approach, as the literature has mainly focused on the qualitative side. After processing the data, we examine the fulfillment of this relationship in the long-run. In doing this, we resort to cointegration techniques; as already mentioned, the studies on the long-run impact of cashless development on economic growth use this procedure. Finally, as we focus the analysis on one country, we use cointegration from a strict univariate time series perspective.

2. Technology and Payments: Some Idiosyncratic Aspects of the Spanish Case

The implementation of electronic instruments in the payment system as a whole was neither instantaneous nor a recent event. Therefore, technological and institutional factors, along with the habits of consumers and businesses, are indispensable factors when considering the role of ICT in all its complexity in the payment system and in the financial system in general. Consequently, so as to adequately interpret the results of the analysis that will be carried out, it is helpful to know in advance about the historical development of the cashless technologies and infrastructures in Spain.

It is necessary to bear in mind that the first ATMs in Spain were introduced in the early 1980s, 15 years later than in the most advanced countries. Similarly, cards, present in the US since the inter-war period, began to be implemented in Europe throughout the 1960s and 1970s, while in Spain they were only minimally present in the 1970s and did not really take off until the 1980s. In addition to this are idiosyncratic factors, such as the force of habit with which cash was used by people and businesses, a phenomenon that is clearly reflected by the late expansion of the use of checks in Spain. It was not until 1973 that the High Banking Council (CSB, according to its Spanish acronym) even contemplated the possibility of standardizing bank checks and their mechanization by means of a magnetic strip (CSB, Standard bank check, Madrid, September 1973). In fact, check truncation did not even begin until 1982. It was initiated by “La Caixa” in Barcelona, although without reciprocity on the part of the remaining banks and savings banks; however, the idea was that they would soon follow suit (J. Charles Maixé-Altés 2013).

Table 1 summarizes the progressive evolution of both the wholesale and retail payment compensation systems in Spain. The traditional mechanics were established by the clearing houses set up in major Spanish cities after 1923. The transition from electromechanical compensation systems to systems using computer media did not occur until the mid-1980s. It was therefore throughout this decade that paperless systems began to be introduced in the national clearing house system. As we will see later, the checks that constituted 55.2% of the documents presented for compensation at the national clearing houses in 1981 only represented 5.6% of the total in 1992. Obviously, changes in the banking system and technological change had altered the payment system.

Table 1 Wholesale and Retail Payment Systems in Spain, from 1923 to Present

Length of time	Type of payment system	Description
1923-1968	Clearinghouses: Madrid, Barcelona, Bilbao, Zaragoza, Valencia and Sevilla	Retail payments. Clearing operations between associated credit institutions.
1960s-1997	Second Session of Madrid Clearing House	Clearing wholesale payment system.
1963-1985	Interbank Technical Committee - Comité técnico interbancario (CTB)	Technical cooperation among banks within the High Banking Council - Consejo Superior Bancario (CSB), a self regulating organization.
1969-1999	Provincial Clearing House System	Retail payments. The net balances of each provincial clearing house were communicated to the nearest branch office of the Bank of Spain.
1976-1999	Money Market Telephone Service - Servicio Telefónico del Mercado de Dinero (STMD)	Wholesale transfers. Interbanking clearing system of the Bank of Spain before the SLBE.
1984-	National Electronic Clearing Service - Sistema Nacional de Compensación Electrónica (SNCE)	The Spanish electronic system for clearing retail payments. Created by credit institutions and the Bank of Spain, which starting in 1988 managed the entire system. Since 2005, it became a service managed by the Spanish Society of Payment Systems (Iberpay), a company whose shareholders are the entities participating in the SNCE. Since 2011, it has been a totally centralized system.
1985-	Interbank Cooperation Center - Centro de Cooperación Interbancaria (CCI)	CCI grouped together banks, savings banks and credit cooperatives. Technical collaboration for the exchange and settlement of payment instruments.
1996-2008	Bank of Spain Settlement System - Sistema de Liquidación del Banco de España (SLBE)	Real-Time Gross Settlement' Systems (RTGS) connected to the Trans-European Automated Real-Time Gross Settlement Express Transfer System (TARGET). It was created and managed by the Bank of Spain and was discontinued on February 18, 2008 with the launch of TARGET2
1997-2004	Spanish Service of Interbanking payments - Servicio Español de Pagos Interbancario (SEPI)	Multilateral clearing system for large-value payments in euros, both domestic and international. The system was owned by its participants, through the company Interbank Payment Service (a self-regulating organization) under the supervision of the Bank of Spain. Their operation was absorbed by the SNCS and the SLBE.
2008-	TARGET2-Bank of Spain	Migration from the SLBE to the Single Shared Platform of TARGET2.

Source: European Central Bank (2018)[1]; Bank of Spain Circular 1/2008, 25 January; Antonio Sánchez Soliño (1994); Antonio Rosas Cervantes (1995); Antonio Paredes Moliner (2000); and the authors' own work.

How was such a quick transition even possible? The early introduction of computerization (third-generation computers or mainframes) and teleprocessing within the banking system promoted the development of basic infrastructures for data transfer (especially in the savings banks at the end of the 1960s, and commercial banks throughout the seventies). An example of these developments was the establishment of the RSAN protocol and the Special Data Transmission Network (RETD, according

[1] **European Central Bank.** 2018. Payment Statistics. https://www.ecb.europa.eu/press/pr/stats/paysec/html/index.en.html (accessed January 06, 2018).

to its Spanish acronym) in 1971 by Spain's National Telephone Company, CTNE, known today as Telefónica. The development of this public network and some private teleprocessing networks (point-to-point lines[2], in which "La Caixa" was a pioneer during the second half of the 1960s in Europe) propitiated access to mass banking and the rapid deployment of electronic payment systems in the 1980s (see Maixé-Altés 2013, 2019). A decade later, in the 1990s, the Spanish banking system led Europe in certain facets of the new payment systems, such as its network of ATMs and the development of clearing systems (Carbó and Rafael López del Paso 2010). From our point of view, this would be the idiosyncratic factor of the Spanish system: devotion to the use of cash, in juxtaposition to the early development of computerized banking data transfer networks that promoted a rapid transition to new systems in the 1990s.

In short, ICT and banking expansion went hand in hand in those decades in which there were also profound regulatory and institutional changes. These developments have had an important effect on payment dynamics. They affected both retail payments and national compensation systems, which quickly became National Electronic Clearing Systems (see Table 1).

3. Data and Descriptive Statistics

3.1 Data

The empirical analysis we carry out is centered on the 1989-2014 period in Spain. The selection of the starting year is subject to the data availability regarding the value of cashless transactions. We deal with three groups of variables: monetary series, the value of transactions using cashless instruments and macroeconomic variables. For monetary and macroeconomic variables, we have expanded the study period from 1952 to 2014. In all cases, we use annual data.

Monetary series correspond to the main aggregates at this point: Currency Held by Public (CHP), M1 (CHP plus Overnight Deposits), M2 (M1 plus Saving Deposits) and M3 (M2 plus Time Deposits and other components). These data are, on the one hand, the historical series of the monetary supply taken from the Bank of Spain Statistical Bulletin (BEBE, according to its Spanish acronym); and on the other hand, the contributions of Spanish MFIs to each of the aggregates of the EMU from 1999 (BEBE and ECB). In order to link the two series, we use data provided by the Bank of Spain's Statistics Information Service, which refers to the contribution by Spanish MFIs to the aggregates of the UEM from September 1997 to December 1998. With regard to the comparative study we conduct in Section 3.3. for several EU countries, the data sources are the European Central Bank - Eurosystem: Statistical Data Warehouse (2018)[3] and the Master Series Blue Book.

In order to represent the activity related to the use of cashless payment instruments and be able to measure its importance over time, we consider the aggregate value of this type of transactions (CLT). In order to calculate this aggregation, we sum up

[2] Two network nodes established a dedicated communication channel (circuit switching network), using this to connect computers that acted as the hub of the network (switching nodes).
[3] **European Central Bank.** 2018. Statistical Data Warehouse. https://sdw.ecb.europa.eu/ (accessed January 07, 2018).

the value of the transactions made in the following different manners: checks issued, payment by debit and credit card, credit transfer, direct debits, E-money purchase transactions by cards and other payment instruments. This information was obtained from the Master Series Blue Book of the European Central Bank (employing the indicator of use of various cashless payments instruments and total transaction value per year); the original series are in billions of euros.

In terms of the macroeconomic variables, we take into account the Gross Domestic Product (GDP), inflation and the GDP deflator (implicit price deflator); from the GDP values, we also calculate the *per capita* GDP and a measure of economic growth. All these variables are considered, analyzing their relation to the evolution of the cashless society within the framework of the development of monetary aggregates and economic activity in Spain. Data on the GDP come from the Spanish National Statistics Institute (INE, according to its Spanish acronym)[4]. In order to calculate the Spanish *per capita* GDP, we employ the data on the population available from the INE; so as to facilitate comparisons and interpretations, the scale of this variable is re-dimensioned (the original values are multiplied by one million). With respect to the measure of economic growth, we opted for the traditional proxy variable, based on the GDP variation rate.

Data on inflation are obtained from the INE and are transformed from a monthly into a yearly basis (annual growth rates). Regarding the implicit price deflator, the calculations have been made on the basis of the annual variation rates released by the Bank of Spain, and then transformed into index numbers with 1995 as the base year. It should be noted that all the series we use in the empirical study are constant.

Finally, it should be noted that the monetary series and GDP were originally expressed in pesetas (the former national currency) and then converted into euros. In particular, there is an overlapping period from September 1997 to December 1998 in the monetary series with time series in both pesetas and euros. The final series are expressed in billions of euros.

3.2 Descriptive Analysis

An analysis over time of the characteristics and behavior of the time series being studied is required. First of all, we concentrate on the long series, i.e. those starting in 1952. Table 2 displays the most important descriptive measures, as well as some additional information of interest.

Regarding the measures of position, the values for the mean and the median are quite similar in most series, which is the usual situation in (approximately) steady series. The only exceptions are M1 and M3, the series that experienced the greatest growth over time. The coefficient of variation reveals a reasonable degree of relative dispersion in all the series but M1; the latter exhibits a moderate variability in relative terms, as will be evident in the graphic representations.

[4] **Spanish National Statistics Institute.** 2018. https://www.ine.es/dyngs/INEbase/en/operacion.htm?c=Estadistica_C&cid=1254736164439&menu=ultiDatos&idp=1254735576581 (accessed January 07, 2018).

Table 2 Descriptive Statistics for the Spanish Series 1952-2014 (Constant Prices, in Billions of €)

Sample statistics	CHP	M1	M2	M3	GDP
Mean	28.10	130.92	174.63	312.97	304.42
Median	22.32	79.88	142.63	257.84	276.24
Standard deviation	15.89	129.17	122.95	226.83	181.89
Coefficient of variation	0.56	0.99	0.70	0.72	0.60
Skewness	0.66	1.54	1.05	0.62	0.24
Kurtosis (excess)	-0.44	1.02	0.29	-0.62	-1.24
Minimum value	7.85 at 1953	20.33 at 1953	29.52 at 1952	32.11 at 1952	55.57 at 1953
Maximum value	70.13 at 2014	455.28 at 2014	463.44 at 2009	789.62 at 2009	63.84 at 2008
Growth rate (%): 1952-2014	733.28	2119.01	1382.13	2116.42	938.79
Mean annual growth rate (%)	3.48	5.13	4.44	5.12	3.85

Source: Authors' own calculations.

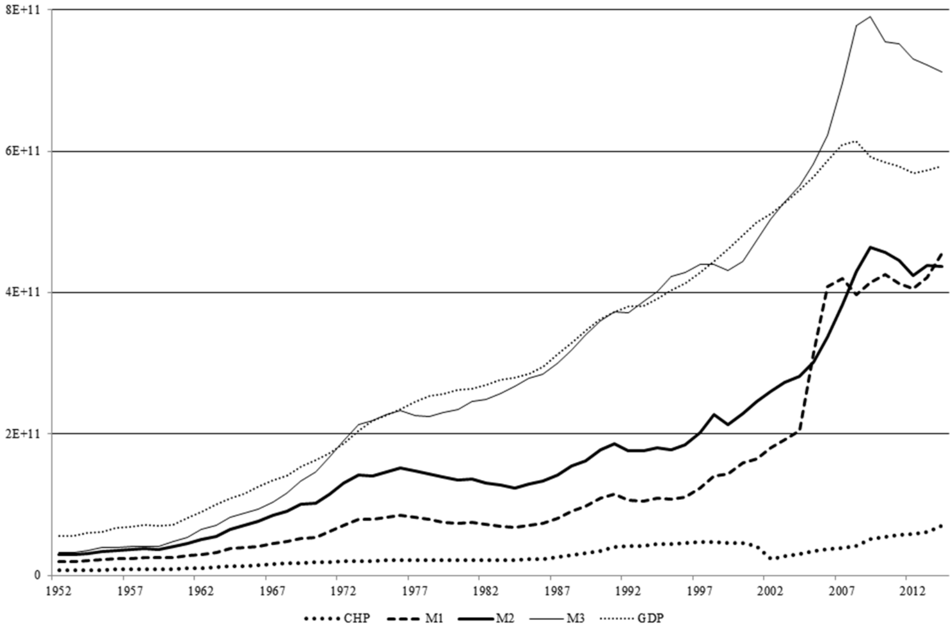
It should be noted that CHP and M1 reach their respective maximum values in 2014, the last year of the sample, while M2 and M3 do so several years earlier (with the outbreak of the 2008 crisis). We can appreciate how the less liquid aggregates experienced one or more dips in their values over time, while CHP grows almost continuously, starting at the beginning of the recent crisis; this economic crisis may have especially affected the broader aggregates. Regarding GDP, the minimum value takes place near the beginning of the sample and the maximum value is achieved near the very end; as can be observed, the latter occurs in 2008, at the same time as the outbreak of the crisis.

It is interesting to note that we also account for the variation in the rates of the variables being studied. All of them have grown exponentially from 1952 to 2014, when we directly compare both years; M1 and M3 display the largest figures, as they exceed 2000%. The huge growth experienced by these two series evidences the development of cashless payments over the last sixty years; interestingly, M1 reflects the increasing weight of banking deposits in supporting cashless transactions.

In addition to the calculation of descriptive measures, we depict the evolution of the series over time in Figure 1.

All the series display an upward trend, which is clearer for M1, M2, M3 and GDP than for CHP. The latter is the variable with the lowest rate of variation between 1952 and 2014, although it reaches 733.28%. In the majority of cases, the most remarkable increase takes place at the beginning of the 1970s and at the end of the 1980s; for some series, the relevant growths start in the sixties, as is the case of M3 and GDP. In general, the variables being studied exhibit a steady evolution (especially GDP and CHP) that is only interrupted with the outbreak of the last economic crisis. It is worth mentioning that CHP is the only variable that does not seem to be affected by this crisis; this series depicts an abrupt decrease in 2002 that may be associated with the definitive introduction of the euro. By using the appropriate techniques, we will determine whether the sharp decreases observed in the series involve the existence of structural breaks.

Due to the fact that the series related to transactions using cashless instruments start in 1989, we have developed a new descriptive analysis for the entire set of series in the 1989-2014 period. Table 3 reports the results.



Source: Authors' own work.

Figure 1 Evolution of the Spanish Variables over Time, 1952-2014: Series at Constant Euros (in Billions of €)

Table 3 Descriptive Statistics for the Spanish Series 1989-2014 (Constant Prices - Billions of € - and %)

Sample statistics	CHP	M1	M2	M3	GDP	CLT	Infl	Growth	GDPpc
Mean	44.09	240.36	287.41	539.86	492.27	4342.37	-	-	11.58
Median	43.88	173.58	253.53	488.68	505.22	2309.40	3.39	2.94	12.20
Standard deviation	10.89	139.04	109.45	152.86	89.86	3103.21	1.80	2.19	1.44
Coefficient of variation	0.25	0.58	0.38	0.28	0.18	0.71	-	-	0.12
Skewness	0.34	0.46	0.51	0.41	-0.22	0.27	0.07	-1.17	-0.43
Kurtosis (excess)	0.32	-1.72	-1.42	-1.44	-1.56	-1.95	0.11	0.89	-1.24
Minimum value	22.76 at 2002	98.26 at 1989	162.49 at 1989	340.81 at 1989	346.67 at 1989	931.56 at 1989	-0.003 at 2009	-3.74 at 2009	8.93 at 1989
Maximum value	70.13 at 2014	455.28 at 2014	463.44 at 2009	789.62 at 2009	613.84 at 2008	8307.31 at 2007	6.80 at 1989	5.28 at 1989	13.58 at 2007
Growth rate (%): 1989-2014	120.73	363.35	169.31	108.81	67	788.79	-102.1	-78.85	39.38
Mean annual growth rate (%)	3.22	6.33	4.04	2.99	2.07	9.13	-185.6	-6.67	1.34

Source: Authors' own calculations.

One different outcome of the previous analysis has to do with the variability exhibited by the series. The relative dispersion of the variables is lower when we take into account the most recent period than when we consider the long series; in comparative terms, M1 once again displays a higher degree of variability and it is also the variable with the most growth.

Regarding the minimum and maximum values, we find the same pattern of behavior as with the long series, except for CHP; this aggregate presents a strong decrease in the middle of the period under study, which could indicate a structural change. The variable with the highest growth in 1989-2014 is M1, while it was M3 in 1952-2014; in this case, the latter may have attained most of its increase before 1989. In fact, M3 is the series with the lowest average growth rate, followed by CHP; on the contrary, M1 exhibits the strongest growth, especially in the period 2003-2006, with a similar behavior from the CLT series, evidencing the development of electronic money and banking. As in the long period, GDP shows a steady evolution over time; in fact, its behavior is more stable in 1989-2014. National income variation over time is more modest than the change experienced by the monetary aggregates; in any case, a remarkable positive growth is appreciated.

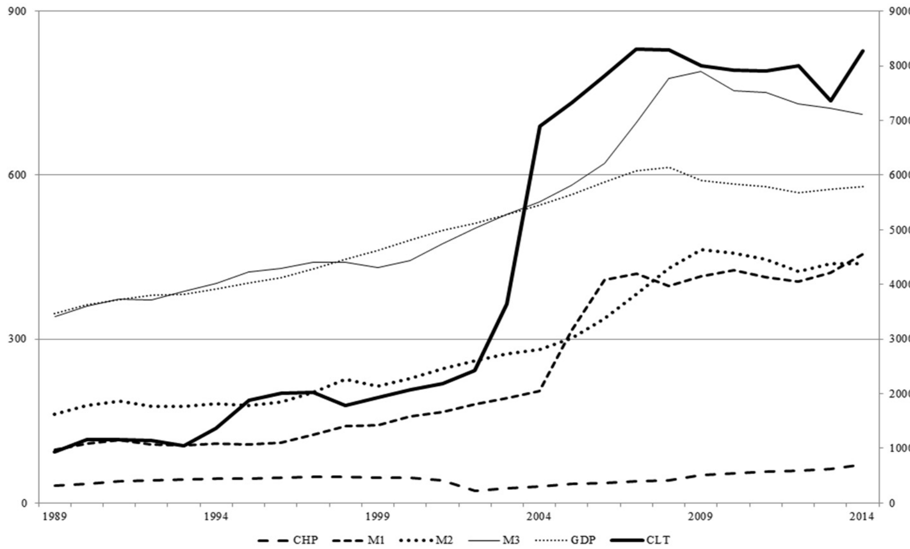
When we turn to the value of cashless transactions, we observe that the variable displays relevant oscillations over time and that its relative dispersion, in spite of being moderate, is higher than that displayed by monetary variables and GDP. Its maximum value occurs in 2007; one reason for this might be the economic crisis, which causes a decrease in the volume and magnitude of the transactions made by the individuals, and the widespread use of more liquid aggregates. From the entire set of series studied, the value of cashless transactions experiences the greatest growth from 1989 to 2014 (788.79%), and it also shows the highest average annual rate.

Finally, regarding inflation, economic growth and *per capita* GDP, we can only compare the mean and median in the last case, as the values for the first two variables are sometimes negative. Both measures show similar values for *per capita* GDP. All three variables show a reasonable or low relative dispersion, which is remarkable in the case of *per capita* GDP. Extreme values occur at the expected time moments. The average growth rate is negative for inflation and economic growth; the outstanding rate in the case of inflation is explained by the severe fluctuations experienced by this variable in 2008-2010, which affect the calculation of the average.

As the series have different measuring scales, we depict their evolution in the 1989-2014 period by means of Figures 2 and 3.

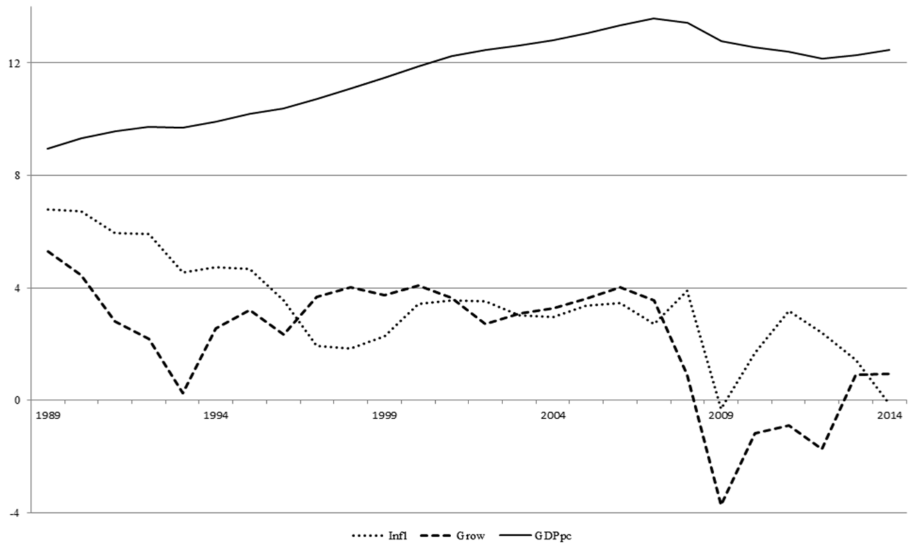
It is clearly appreciated in Figure 2 that the variable which has increased the most from 1989 until now is the value of the transactions made with cashless instruments; with a mean growth rate of 9.13%. This outstanding growth evidences how society went from being mainly based on cash instruments to being a cashless society.

In relation to Figure 3, we observe the relevant growth experienced by the Spanish *per capita* GDP in recent decades. After its drop in 1993, economic growth reached a steady state that continued throughout the 90s and the early to mid-00s. Finally, inflation displays a downward trend, with some oscillations throughout the entire period. All these series are affected by the current economic crisis, which usually leads to an abrupt decrease in their values (or even reaching minimum values).



Source: Authors' own work.

Figure 2 Evolution of the Spanish Variables over Time, 1989-2014: Series at Constant Euros (in Billions of €)

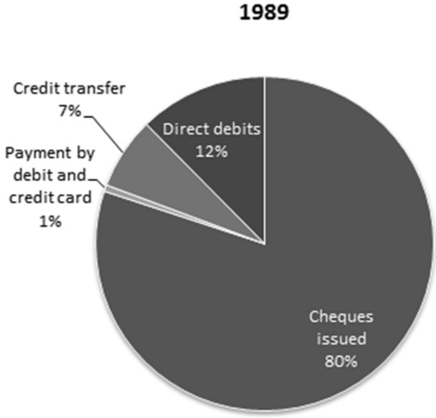


Source: Authors' own work.

Figure 3 Evolution of the Spanish Variables over Time, 1989-2014: GDPpc at Constant Euros (in Billions of €); Infl and Grow in Percentages

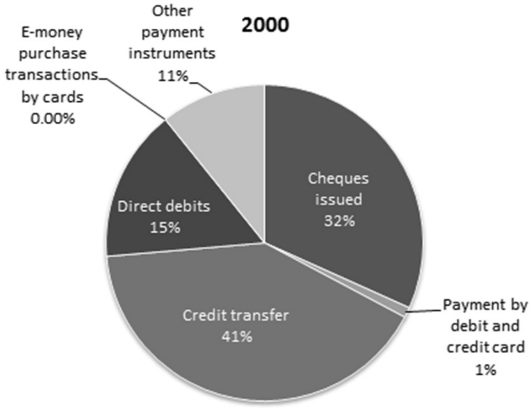
3.3 Establishing a Comprehensive Cashless Indicator

Regarding the monetary system and the value of transactions made with cashless payments instruments, we have witnessed a transformation in Spanish society. The use of cashless instruments for completing transactions is radically different as compared to the situation two decades ago and the current situation (see Figures 4-6).



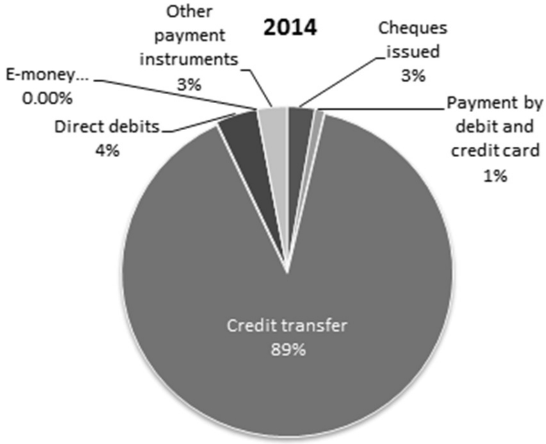
Source: Authors' own work.

Figure 4 Indicator of the Use of Various Cashless Payment Instruments in Spain, 1989: Value of Transactions (in Billions of €).



Source: Authors' own work.

Figure 5 Indicator of the Use of Various Cashless Payments Instruments in Spain, 2000: Value of Transactions (€ Billions).



Source: Authors' own work.

Figure 6 Indicator of the Use of Various Cashless Payments Instruments in Spain, 2014: Value of Transactions (in Billions of €)

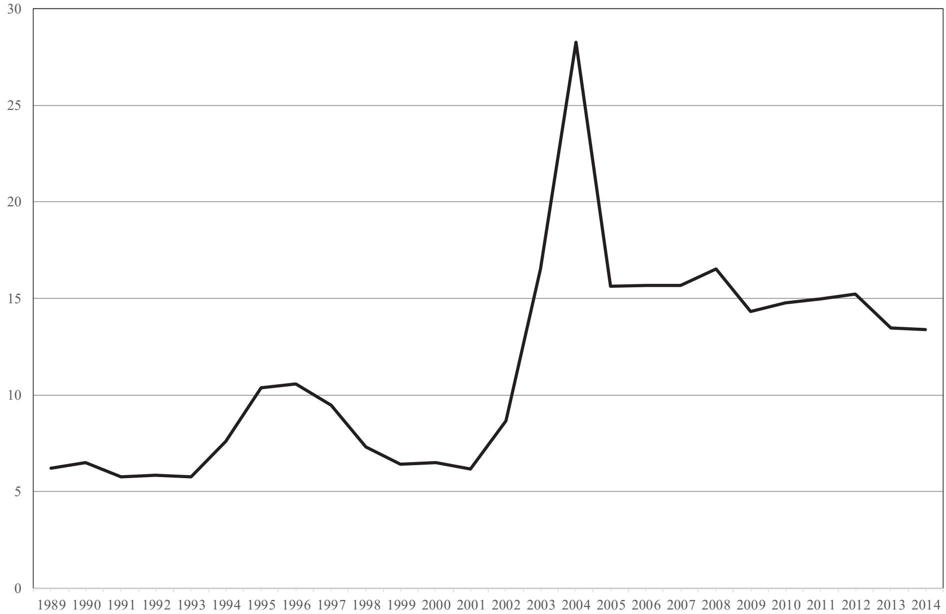
The evolution to electronic money is well appreciated in developed economies, as the literature in this field reflects. Some examples can be found in Tee and Ong (2016) and their study on EU countries, and Wong, Lau, and Yip (2020) and their analysis of selected OECD countries. The transition to cashless economies is also evidenced in cross-country studies where both developed and developing countries are analyzed; in this respect, Zandi et al. (2016) evidence the increasing use of credit and debit cards, along with their positive effect on the economic activity of developing and developed countries. Anna Oleshko, Olena Tymoshenko, and Olena Trokhymets (2018) and Sreenu (2020) are just two examples of country studies that present the status of the issue of keeping pace with the digital agenda.

In any case, we should define an indicator so as to identify this status in a particular country, i.e. an indicator that allows for confirming that a given country belongs to the so-called "cashless" society. In this sense, one of the original contributions of this current paper is the proposal of a novel measure to determine whether or not we have a cashless society. The ideal indicator should reflect the proportion of transactions made with cashless instruments out of the total value of all the transactions completed. The problem comes from the unavailability of the last aggregate value. Looking at similar works, on the one hand Deungoue (2008) calculated the use of cash by multiplying the number/value of cash withdrawals from ATMs by the velocity of money (GDP/M1). On the other hand, Zhang et al. (2019) use the number of cash withdrawals as a proxy for cash. In our case, we believe that M1 can be used as an effective proxy for cash transactions, as it represents the stock of coins and the issued banknotes put into circulation, and the overnight deposits, both with high liquidity; we then use M1 as a proxy of the volume of current liquid assets in an economic system.

The indicator we propose has the following expression:

$$\text{Cashless indicator} = \frac{\text{Value of cashless transactions}}{\text{M1}}$$

This is a clear expression of the measures that indicates the ratio between the total value of the transactions carried out using cashless instruments in a certain area and the existing M1 in that economy. This indicator allows us to measure the distance between the two series taken into consideration; the larger the divergence (in favor of cashless transactions), the stronger the evidence of a cashless society. The application of the proposed indicator to the Spanish case is represented in Figure 7.



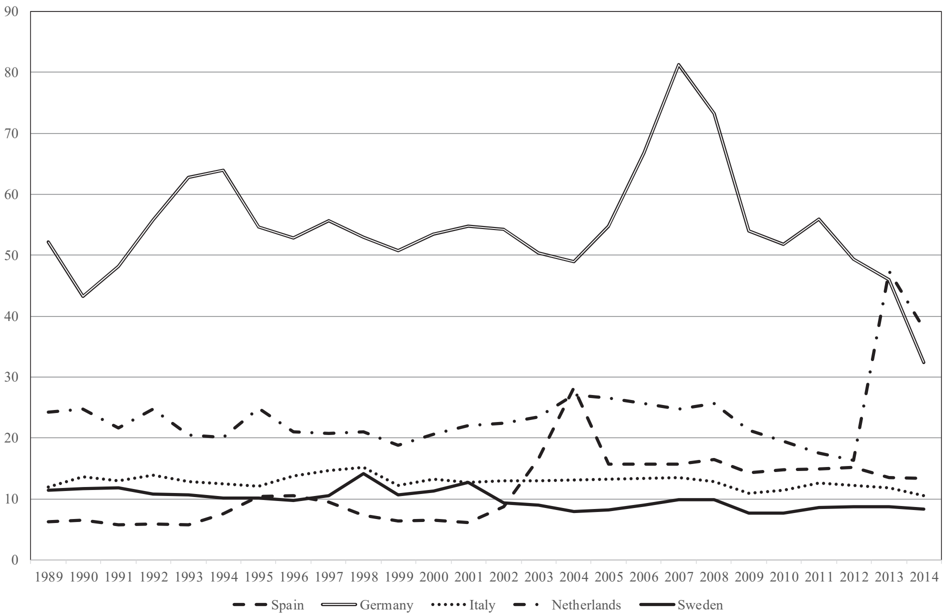
Source: Authors' own work.

Figure 7 Cashless Indicator: Evidence for Spain

The indicator also reflects crucial moments over time in a clear manner, so that we can perfectly identify them. Two phases are quite noticeable: a first phase from 1993 to 2001 and a second one, which shows a more intensive change, starting in 2002. In particular, cashless transactions experience a great leap forward between 2002 and 2004, as the consequence of the introduction of the euro; thus, from 2003 to 2004, those transactions increased by nearly 2 (1.9). As an interesting fact, 2004 represents a turning point between the first and the second phase, reflecting the maturation of the cashless environment. In the following years, there is a moderate increase until 2008, when transactions dropped following the crisis and for a certain period of time. As is clearly observed by the results of the indicator, Spanish society is accelerating its trend towards a cashless society.

As a means to check the robustness of the proposed indicator, we have applied it to countries other than Spain. In particular, we selected several European countries to make the comparison; in doing so, we pay particular attention to income levels and population size. In addition, we must account for the homogeneity of the series; the role played by the different practices developed by the national central banks (before and after joining the EU), together with the methodological changes introduced by the European Central Bank and the different dates of EU and UME accession, make it difficult to obtain long-term homogeneous series. Nevertheless, we managed to construct them for a given number of European countries.

Taking all the previous aspects into account, the selected countries for the comparison are: Germany, Italy, Netherlands and Sweden. Since our aim is the representativeness of the countries in order to enrich the comparison, we include a non-UE country (Sweden). The values of the proposed cashless indicator for these countries, together with Spain, are plotted in Figure 8.



Source: Authors' own work.

Figure 8 Cashless Indicator: Comparison of Several European Countries

The degree of ICT development in terms of monetary transactions is well appreciated in core countries like Germany and, to a lesser extent, the Netherlands. In the German case, the size and dynamism of its economy explain, to a great extent, the observed values for the ratio. Both Italy and Spain are located in an intermediate position, far from the core countries. In the list of the countries studied, Spain stands out for its progressive and notable advance towards digital payments (in particular, following the introduction of the euro), as the indicator shows an upward trend over time. The evolution of the ratio in this country illustrates very well the case of a rapid incorporation of the cashless phenomenon, as Carbó and Rodríguez-Fernández (2017) have indicated.

It is worth noting, on the one hand, the maturity of the cashless processes in most countries, which is due to the trajectory of the digitalization of their respective financial and payment systems; this is appreciated in the relative stability of the ratios. On the other hand, the ratio is sensitive to the turbulences stemming from the 2008 crisis. Therefore, the utility of the proposed measure lies in their evolution over time; in addition, certain factors, such as size or the level of economic development, influence the numerical value obtained. In this respect, it can be considered as an indicator of trends in the implementation of cashless transactions in payment systems. The robustness check through the cross-country comparison evidences this fact.

4. Methodological Framework

4.1 Structural Break Tests

As a part of data processing, we should first look for empirical evidence of structural changes; moreover, their existence usually causes distortions in the application of statistical and econometric methodologies. We also consider the historical monetary series and GDP; the value of cashless transactions is not taken into account, due to the sample size (insufficient data size for evidencing structural breaks). According to the evolution captured in Figures 3 and 4, we consider that one single structural break should be sufficient for our series. Consequently, we find the use of the Andrews-Ploberger and the Andrews-Quandt structural break tests (see Donald W. K. Andrews 1993; Andrews and Werner Ploberger 1994; Bruce E. Hansen 1997) to be relevant.

We select these procedures, as they do not require the a priori identification of the break date; in addition, the evolution of the variables studied does suggest the appropriateness of a method for detecting single structural breaks. As the timing of the break is unknown, LM-statistics are calculated for a set of potential break points. The Andrews-Ploberger test considers that the test statistic is an exponentially weighted average of the previous LM-statistics, while the Andrews-Quandt test uses the maximum value of the LM-statistics. The subsequent distributions are non-standard, and asymptotic p-values are calculated.

4.2 Correlation Analysis

As this paper aims to unveil relationships between variables related to cashless payment, we have implemented a preliminary approach with a correlation analysis. Moreover, the results may serve as a helpful tool for the cointegration exam by providing some intuition about the relationship between the variables that cannot be seen, especially in those cases where the cointegration exam involves more than two variables.

By means of correlation methodology, we are able to assess a possible linear association between two variables. One of the most common measures for correlation is the Pearson's correlation coefficient (usually denoted by "r"), which is dimensionless and ranges from -1 to +1 (these extremes indicate perfect association, either negative or positive). This will be the indicator used in this paper.

4.3 Cointegration Procedure

The present paper pays particular attention to determining whether or not the real sector of the economy and/or the monetary aggregates affect the activity based on cashless instruments. Does the value of cashless transactions increase according to the evolution of the economic activity, or is it just the opposite? What is the role played by the main monetary aggregates? In order to look for evidence of co-movement between the series being studied and with the aim of understanding how the electronic money behaves, we have resorted to cointegration methodology. By doing so, we fill a gap in the specialized empirical literature.

By means cointegration, we investigate whether there is empirical evidence of at least one long-run relationship among a group of variables. This methodology analyzes the existing relationship between non-stationary time series and is applied to numerous economic models. In a multivariate framework, there might be a linear combination of integrated (that is, non-stationary) variables that is stationary, and therefore the variables show a common trend and are said to be cointegrated.

The cointegration methodology starts with the detection of unit roots in the time series under study. The presence of unit roots indicates that the times series does not confirm the stability condition regarding its evolution over time (i.e., lack of constant mean and/or variance). Non-stationary time series are quite common in the economic sciences. As the application of the usual inference techniques requires stationarity, those series not fulfilling this condition must be transformed to meet this requirement.

We account for two widely used methodologies in the empirical literature: the Augmented Dickey-Fuller (David A. Dickey and Wayne A. Fuller - ADF 1979) test and the Denis Kwiatkowski et al. (KPSS 1992) test.

The ADF regression is represented by the following expression:

$$\Delta Y_t = \mu_t + \alpha Y_{t-1} + \sum_{i=1}^{p-1} \delta_i \Delta Y_{t-i} + \varepsilon_t, \quad (1)$$

where Y_t is the series being considered and $\mu_t = \delta_0 + \beta t$, with δ_0 a constant term and t a deterministic trend. The ADF test is based on a t-statistic for parameter α in (1); the relevant null hypothesis is $\alpha = 0$ as opposed to the alternative $\alpha < 0$. The failure to reject the null hypothesis indicates that the variable is non-stationary.

In this paper, we also perform a variant of the Dickey-Fuller test for a unit root called the ADF-GLS test (Graham Elliot, Thomas J. Rothenberg, and James H. Stock 1996). This approach offers greater power than the standard ADF procedure for the cases in which the variable being considered has a non-zero mean or exhibits a linear trend.

With respect to the KPSS test, its main characteristic is that the null hypothesis is the opposite of that of the ADF test. Unit root tests have low power in the near unit-root and the long-run trend processes, so that the KPSS test can be an appropriate complement for them. The point of departure for Kwiatkowski et al. (1992) is the following specification:

$$\begin{aligned} Y_t &= \beta t + r_t + \varepsilon_t, \\ r_t &= r_{t-1} + u_t, \end{aligned} \quad (2)$$

where Y_t is the series under consideration, t is the deterministic trend, r_t stands for a random walk process, ε_t is the error term of the first equation (by assumption, stationary) and u_t is the error term of the second one (by assumption, a series of independent and identically distributed random variables with zero mean and constant variance $\hat{\sigma}_u^2$). Kwiatkowski et al. (1992) consider a one-sided Lagrange Multiplier statistic for testing the null hypothesis $\hat{\sigma}_u^2 = 0$ as opposed to the alternative that $\hat{\sigma}_u^2 > 0$. When $\beta = 0$, the null hypothesis implies that Y_t is stationary around r_0; and if $\beta \neq 0$, Y_t would be stationary around a linear trend. In the case that $\hat{\sigma}_u^2$ is greater than zero, the conclusion is that Y_t is non-stationary.

Once the unit root tests have been completed, we must look for evidence of cointegration. The components of $Y_t = (Y_{1t}, Y_{2t}, \dots, Y_{nt})'$ are said to be cointegrated components of the order (d, b) if it is verified that all the elements of X_t are integrated components of order d and there is a vector $\beta = (\beta_1, \beta_2, \dots, \beta_n)$, so that the linear combination $\beta Y_t = \beta_1 Y_{1t} + \beta_2 Y_{2t} + \cdots + \beta_n Y_{nt}$ is integrated in the order (d-b), with b > 0.

The estimation and testing of stationary long-run relationships can be carried out using different methods. In particular, we employ the Søren Johansen (1988, 1991, 1995) and Johansen and Katarina Juselius (1990) cointegration procedure, as it is an appropriate methodology for measuring our economic relationships. Johansen's technique starts with an n-variables vector,$X_t = (X_{1t}, \dots, X_{nt})'$, generated by a VAR process of order p:

$$Y_t = \mu + A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + \varepsilon_t \qquad t = 1, \dots, T, \tag{3}$$

where Y_t is a $(n \times 1)$ vector of stochastic variables and ε_t is a n-dimensional vector with independent and identically distributed variables with a zero mean and a variance of Σ_ε. The expression in (3) in an error-correction form is:

$$\Delta Y_t = \mu + \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + \cdots + \Gamma_{p-1} \Delta Y_{t-p+1} + \Pi Y_{t-p} + \varepsilon_t \qquad t = 1,\dots,T, \tag{4}$$

where Γ and Π are coefficient matrices. Both equations may incorporate deterministic terms.

The $(n \times n)$ Π matrix contains information on the long-run relationship between the variables of the vector and its range provides the number of cointegrating relationships. When the Π rank is zero, there are n stochastic trends; subsequently, there are no long-run relationships between the variables. In the case that Π is a full rank matrix, all the variables included in Y_t are stationary. The intermediate situation takes place when the rank is lower than n $(0 < r < n)$, implying that there are r potential cointegrating vectors different from zero.

Johansen (1995) develops two tests in order to determine the number of cointegrating vectors: the trace test and the maximum eigenvalue test. The trace statistic has the following expression:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} ln\left(1 - \hat{\lambda}_i\right), \tag{5}$$

with $\hat{\lambda}_i$ being the estimated values for the eigenvalues obtained from Π and T the number of usable observations. The purpose of λ_{trace} is to test the null hypothesis that the number of cointegrating vectors is lower than r or equals r, as opposed to the alternative that it is larger than r.

Regarding the maximum eigenvalue statistic, it has the following form:

$$\lambda(r, r+1)\, ln\left(1-\hat{\lambda}_{r+1}\right)_{max}. \qquad (6)$$

The null hypothesis that the number of cointegrating vectors is r, as opposed to the alternative that $r + 1$ is successively tested. The asymptotic distribution of the tests changes depending on the deterministic components included in the VAR specification.

Finally, we should highlight the fact that the evolution of cointegrated variables over time is affected by the magnitude of any deviation from the long-run equilibrium. The long-run model is reflected in the short-run by means of the so-called Error Correction Mechanism (ECM). This specification incorporates both the variables in differences and a term that reflects the adjustment of the deviations of the endogenous variable with respect to its long-run equilibrium value.

5. Empirical Results

The methodology set out in the previous section serves to examine the link between the monetary system, real sector and cashless activity. It is worth highlighting that although this association has been extensively studied in the literature from a qualitative point of view, our aim is to employ a quantitative approach to give empirical support for the Spanish case; the aforementioned particular circumstances of this economy in the most recent decades might affect the relationship and make the theoretical relationships unclear for eventual implementation in practice. In order to demonstrate this, we have applied different techniques, with which we aim to evidence the characteristics of the relationships between the variables, in particular with regard to the signs they display, for comparison with the existing literature. The results obtained are discussed below.

As a starting point for the analysis, it is of interest to detect potential structural breaks in our historical series: CHP, M1, M2, M3 and GDP. The results of Andrews-Ploberger and Andrews-Quandt tests for these long time series are reported in Table 4.

Table 4 Structural Break Tests Results: Variables from 1952

Variable	Andrews-Ploberger		Andrews-Quandt	
	p-value	Date	p-value	Date
CHP	0.0001	2002	0.0001	2002
M1	0.0000	2004	0.0000	2004
M2	0.0003	2005	0.0001	2005
M3	0.0003	2005	0.0001	2005
GDP	0.0001	2004	0.0001	2004

Source: Authors' estimations.

Altogether, the statistics point towards the rejection of the null hypothesis of there being no structural break; there is evidence of lack of stability in the estimated coefficients for all the variables studied. According to the observed evolution of our series, the presence of a one-time break is corroborated by the test for CHP and M1. In the first case, the tests suggest 2002 as the break point; this is the year in which the euro was definitively introduced, which may affect CHP by causing a disruption in the behavior of the public with the definite use of the new currency. The break date for M1 is 2004: once the confidence in the new currency increased, people increased their demand deposits once again. This can be seen as a delayed effect of the introduction of the new currency. The support for structural breaks in the remaining variables does not have a clear correspondence when observing their behavior over time. One explanation is that the tests tend to over-identify break points throughout the sample.

Therefore, an interesting result from these tests is that they identify structural breaks for CHP and M1 in 2002-2004, the years in which cashless transactions and the cashless indicator experience their great change; thus, the evolution of CHP and M1 would be unveiling the increasing relevance of cashless activities. It turns out that the institutional change meant by the replacement of the peseta with the euro had direct implications on the behavior of the more liquid monetary aggregates.

Studying the association between the variables in question in greater depth, one tool that is useful for an initial approach is the correlation analysis. Table 5 reports the pairwise correlation coefficients for the value of cashless transactions and the remaining variables.

Table 5 Correlation Coefficients for the Value of Cashless Transactions

	CLT
CHP	0.3846
M1	0.9634
M2	0.9369
M3	0.9542
GDP	0.9325
Infl	-0.6121
Grow	-0.5439
GDPpc	0.8277

Source: Authors' calculations.

We observe that national income and the monetary system have a strong linear correlation (coefficient value close to 1) displaying a positive sign: the more the monetary aggregates increase (decrease), the larger (lower) the value of transactions made with cashless instruments. The exception is CHP. As transactions can always be completed by means of cash instruments, there would not be any place for any linkage to the value of cashless transactions; it seems reasonable that a variation in the amount of Currency Held by the Public does not necessarily affect the transactions made with non-cash instruments. This result is consistent with those empirical studies that specifically consider the transactions at ATMs and POS, and their relationship with money demand (Attanasio, Guiso, and Jappelli 2002; Carbó and Rodríguez-Fernández 2014).

Regarding non-monetary variables, we observe an important positive correlation for *per capita* GDP; accordingly, people with higher *per capita* income levels tend to make more use of cashless instruments (in terms of the value of transactions). Finally, inflation and GDP growth are negatively correlated with the value of cashless transactions, although not in a very relevant manner, as a consequence of the decline in inflation in the study period, and the trend in the GDP during two 21th century financial crises (2000-2002 dot-com bubble and 2009-2012 great depression). This behavior would therefore be associated with the monetarist perspective.

As the key point of the quantitative analysis, we performed a cointegration exam. Its first step consists of testing for unit roots; the results are reported in Table 6.

Table 6 Unit Root Tests Results (Series 1989-2014)

Variable	ADF test		ADF-GLS test		KPSS test	
	Test statistic	p-value	Test statistic	p-value	Test statistic	p-value
CHP	-0.1835	0.9287	-0.1291	0.6393	0.2619	>0.10
M1	-0.3880	0.9089	-0.4634	0.5149	0.5702	0.0320
M2	-0.5587	0.8772	-0.4855	0.5059	0.5779	0.0310
M3	-1.1239	0.7087	-0.9296	0.3140	0.5779	0.0310
GDP	-1.2088	0.6731	-0.5741	0.4689	0.5864	0.0300
CLT	-0.5951	0.8694	-0.3876	0.5448	0.5583	0.0340

Notes: KPSS p-values are calculated by interpolation.

Source: Authors' estimations.

The results obtained generally support the existence of unit roots in the study series; thus, these series behave more like a random walk than transitory deviations from a steady state. The presence of non-stationarity poses no doubt except for CHP. In the latter, the KPSS test points to a stationary process, while ADF and ADF-GLS provide evidence of non-stationarity. As already pointed out, CHP may display a structural break; however, it should be noted that ADF tests tend to over-detect non-stationarity. We should then take this result with caution.

So as to determine the number of cointegrating vectors, we consider the trace test and the λ-max test. We report two types of p-values for the trace test: the asymptotic p-values and those adjusted for the sample size. As the mean of the vast majority of the variables studied is different from zero, we consider that the only deterministic component in the model is a constant in the cointegration space; only when introducing inflation do we consider the absence of the constant. In order to facilitate the interpretation of the results, we transform the dependent variable by dividing its values by 10 (CLT10). The results are summarized in Table 7.

The Johansen procedure provides evidence of cointegration in all cases, except for CHP and the value of cashless transactions. In the remaining cases, both the trace and the largest eigenvalue tests point to a rejection of the null hypothesis that the cointegration rank is zero; later, when the rank is one, the null hypothesis of a unique cointegrating relationship is not rejected. Monetary aggregates and cashless transactions thus show a stochastic common trend; the same occurs with GDP and cashless activity.

Table 7 Johansen Tests for the Cointegration Rank

Variables\Measures	Rank	Eig. Value	Trace test	p-value (asymp.)	p-value (adjusted)	λ-max test	p-value
CLT10-CHP	0	0.2828	10.8820	0.5610	0.6186	7.9785	0.5604
	1	0.1139	2.9036	0.6067	0.6116	2.9036	0.6055
CLT10-M1	0	0.5583	21.4370	0.0325	0.0514	19.613	0.0104
	1	0.0732	1.8237	0.8064	0.8091	1.8237	0.8053
CLT10-M2	0	0.6302	27.3890	0.0035	0.0064	24.870	0.0009
	1	0.0959	2.5190	0.6776	0.6810	2.5190	0.6764
CLT10-M3	0	0.5485	22.6040	0.0215	0.0330	19.879	0.0092
	1	0.1033	2.7255	0.6392	0.6429	2.7255	0.6381
CLT10-GDP	0	0.5710	25.8570	0.0064	0.0110	21.158	0.0052
	1	0.1713	4.6991	0.3291	0.3339	4.6991	0.3284

Source: Authors' estimations.

As a novel contribution by this paper to the existing literature, we provide empirical evidence supporting long-run relationships that integrate the real sector of the economy, the monetary system and the transactions made with cashless instruments. The expressions for these estimated relationships are reported in Table 8.

Table 8 Identified Cointegrated Vectors

$CLT10_t = -118.62 + 2.1969\, M1_t$
$CLT10_t = -448.71 + 2.6817\, M2_t$
$CLT10_t = -765.79 + 2.0583\, M3_t$
$CLT10_t = -420.03 + 2.2098\, GDP_t$

Source: Authors' estimations.

The results obtained point to a direct long-run relationship between the value of cashless transactions and the main monetary aggregates, as well as the GDP; the signs are the expected ones. Likewise, the magnitude of these coefficients reveals that transactions react in an important manner to both variations in the monetary system and national income (in fact, they do so more than proportionally). As we can observe, the parameter values are quite similar in most cases, and always greater than two.

These results are consistent with the Spanish economy scenario in the period being studied, which is characterized by two main impulses: the accession to the European Economic Community in 1986 and the implementation of the euro in 2002. Both milestones enhanced certain strengths of the Spanish economy in its recent history. On the one hand is the increasing degree of openness of the economy, which is intensely reflected in exports and aggregate demand; on the other hand, we see the monetary stability provided by the European environment and, in particular, the integration into the Eurozone. The monetary consequences were very intense as a result of the European policies regarding payment systems. The first step was taken in 1996, when Spain connected to the Trans-European Automated Real-Time Gross Settlement Express Transfer System (TARGET) (see Table 1). Especially significant was the implementation of the so-called Single Euro Payment Area (SEPA) in 2008. SEPA mainly involves cashless transactions and introduced significant changes in the adoption and use of non-cash payments (Carbó, Jose Manuel Liñares, and Rodríguez-Fernández 2017).

These results are in line with the correlation analysis we have previously carried out. As displayed in Table 5, cashless transactions show an intense relationship with M1, M2 and M3 (correlation coefficients larger than 0.9), but this is not the case for CHP. Moreover, Figure 2 suggests a more similar behavior over time for transactions and M1-M3 than for CHP. Regarding GDP, our results are in line with studies on the long-run association between cashless payments and economic growth, such as the study by Tee and Ong (2016), who evidence this long-run effect for five selected EU countries in 2000-2012, or that by Sreenu (2020), who finds a positive association between the use of a cashless policy and the development of the Indian economy in the long-run. From a broader perspective, Rath and Hermawan (2019) highlight the existence of a cointegration relationship between ICT development and the economic growth in Indonesia.

It should be pointed out that M2 is the monetary variable with the highest influence on CLT10 in the long-run, together with GDP. This observation points to the role of the banking system in the development of this type of transactions; in addition, it evidences that both Spanish society and its economy have experienced an increasing banking coverage and that the regulatory changes introduced in the 1980s and 1990s were very effective for the modernization of the banking and the payment system. These results are consistent with the empirical foundation developed by Demirgüç-Kunt, Beck, and Honohan (2008) to better understand the welfare impacts of broader financial access. Our approach highlights the impact of the payment system and the cashless instruments in this scenario.

Once we establish the existence of these long-run relationships, we find it to be of interest to go into detail with regard to the connections to the economic activity. First, the cashless transactions made might be related to an individual's income. Second, there may be a link to the state of the economy: Does the use of cashless instruments vary according to the phase of the economic cycle? Finally, we should account for a wider relationship that reflects not only income, but also prices; then we must consider one of the key variables in any economy: inflation and its monetary consequences.

Once again, we must search for unit roots in these series; the usual tests are applied, using regressions that include an intercept. Table 9 reports the results.

Table 9 Unit Root Tests Results (Series 1989-2014)

Variable	ADF test		ADF-GLS test		KPSS test	
	Test statistic	p-value	Test statistic	p-value	Test statistic	p-value
GDPpc	-1.4446	0.5619	-0.7436	0.3946	0.5235	0.0400
Grow	-2.1260	0.2368	-1.8513	0.0611	0.3564	0.0990
Infl	-1.8438	0.3518	-1.3627	0.1609	0.5452	0.0360

Notes: KPSS p-values are calculated by interpolation.

Source: Authors' estimations.

The empirical evidence supports that the three series contain a unit root. Only the economic growth series shows an unclear situation. This situation resembles that of CHP; both cases are susceptible to having structural breaks, so the ADF test results could be misleading. Therefore, any empirical result that involves economic growth should be considered with caution.

Next, we carry out the cointegration analysis. So as to exploit the information, we first evidence the cointegration relationships for pairs of variables and then we consider a wider scenario with three variables. Results for the trace and λ-max tests are reported in Table 10; cointegrating equations are shown in Table 11.

Table 10 Johansen Tests for the Cointegration Rank

Variables\Measures	Rank	Eig. Value	Trace test	p-value (asymp.)	p-value (adjusted)	λ-max test	p-value
CLT10-GDPpc	0	0.5552	26.3670	0.0053	0.0092	20.2510	0.0078
	1	0.2170	6.1160	0.1882	0.1923	6.1160	0.1879
CLT10-Grow	0	0.6271	24.054	0.0127	0.0305	21.704	0.0041
	1	0.1013	2.3500	0.7092	0.7162	2.3500	0.7080
CLT10-Infl	0	0.2616	11.6130	0.4926	0.5444	7.5804	0.6067
	1	0.1489	4.0322	0.4194	0.4242	4.0322	0.4185
CLT10-GDP-Infl	0	0.6398	37.9690	0.0228	0.0556	25.528	0.0145
	1	0.2511	12.4410	0.4186	0.4750	7.2304	0.6475
	2	0.1881	5.2107	0.2706	0.2756	5.2107	0.2701
CLT10-GDPpc-Infl	0	0.6023	37.2000	0.0283	0.0662	23.054	0.0367
	1	0.2836	14.1460	0.2860	0.3401	8.3389	0.5191
	2	0.2073	5.8069	0.2135	0.2182	5.8069	0.2131
CLT10-Grow_Infl	0	0.9372	80.649	0.0000	0.0001	60.886	0.0000
	1	0.5039	19.763	0.0571	0.1432	15.420	0.0576
	2	0.1791	4.3427	0.3753	0.3934	4.3427	0.3746

Source: Authors' estimations.

Table 11 Identified Cointegrated Vectors

$CLT10_t = -480.55 + 95.85 GDPpc_t$
$CLT10_t = 783.32 - 219.19\ Grow_t$
$CLT10_t = 935.81 - 191.31\ Grow_t - 47.78\ Infl_t$
$CLT10_t = -126.82 + 70.31\ GDPpc_t - 1.48\ Infl_t$
$CLT10_t = -807.26 + 2.75\ GDP_t + 50.39\ Infl_t$

Source: Authors' estimations.

From Table 10, we derive that one of the three new variables, inflation, does not involve long-run relationships with the value of cashless transactions. Thus, the latter would not be affected by variations in the general prices of the economy; this outcome is in line with that of the correlation analysis, which pointed out a modest degree of relationship between the two variables. On the contrary, *per capita* income does have a positive effect on cashless transactions, although of a limited magnitude (see Table 11), and economic growth also influences cashless transactions in the long-run, with the expected sign. These results seem reasonable as long as a non-cash framework can only be developed under certain micro and macroeconomic circumstances, as we have stated in relation to the changes induced by the openness of the Spanish economy over the last few decades.

When we turn to a three-variable context, the intrinsic links between the economic variables seems to be crucial for finding long-run relationships with the value of transactions. As reported in Table 11, economic growth and inflation affect cashless transactions in a negative manner; the influence of the former is greater than that of the second. Inflation alters the liquidity of the system, as well as the behavior of consumers and companies with regard to their deposits and liquidities. On the contrary, the association with *per capita* GDP is positive; as occurs in the two-variable context, *per capita* income hardly influences transactions.

Finally, we find evidence of a long-run relationship between the value of transactions, GDP and inflation. According to the cointegrating equation, inflation plays a more important role than GDP, but the price variable does not show the expected sign (GDP does). The reason for this behavior may be found in the type of variables involved in the relationship; thus, we observe how CLT10 is negatively affected by inflation in a context that only considers individual characteristics (*per capita* GDP), while this effect is lost when we focus on aggregate variables (GDP). In short, these results strengthen the role of cashless developments beyond technology and financial innovation, as a consequence of their impact on the macroeconomic dynamics. The Spanish case emphasizes these aspects, precisely because of the characteristics initially outlined on the persistence of the dichotomy: strong infrastructures for cashless payments, but persistence for cash payments.

The last stage in the analysis is to look for evidence of short-run relationships in those cases where a long-run association is found. This also helps to unveil the behavior of these series in the event of any deviation from the equilibrium (or long-run) path. Unlike the long-run, where variables are expressed in levels, they are now expressed in terms of differences, so as to comply with the stationarity condition. Table 12 summarizes the estimated error correction models (ECMs) for those cases in which they apply, together with some validation statistics.

According to Table 12 and the two-variable context, empirical results evidence short-run relationships between the value of cashless transactions and M1, GDP and *per capita* GDP (in both directions). The negative and significant EC terms mean that in the short-run, we should observe an adjustment process, so that if each pair of variables is out of equilibrium in the long-run, it will adjust itself in order to reduce the equilibrium error. In addition, we observe that short-run variations in M1, GDP and *per capita* GDP influence the value of cashless transactions in a positive manner, and vice versa. A short-run relationship that goes from CLT10 to economic growth is also suggested; in this case, the latter experiences an adjustment process when both variables are not in equilibrium, so as to correct the situation. The remaining potential bivariate cases do not provide suitable error correction models, due to the sign of the EC term (which should be negative) and the validation statistics.

In the three-variable context, there are also short-run relationships for CLT10, GDP, *per capita* GDP and economic growth. For the first variable, we have significant

Table 12 Estimated Error Correction Models

	Two-variable context		
ECMs	$\Delta CLT10_t$	$\Delta M1_t$	
EC term	−0.78 (0.33)	0.30 (0.08)	
$\Delta CLT10_{t-1}$	1.13 (0.37)	−0.06 (0.09)	
$\Delta M1_{t-1}$	0.74 (0.46)	0.35 (0.11)	
Adjusted R^2	0.29	0.74	
DW-statistic	2.05	0.97	
ECMs	$\Delta CLT10_t$	$\Delta M2_t$	
EC term	0.13 (0.10)	0.10 (0.02)	
Adjusted R^2	0.03	0.60	
DW-statistic	1.43	1.27	
ECMs	$\Delta CLT10_t$	$\Delta M3_t$	
EC term	0.15 (0.12)	0.17 (0.03)	
Adjusted R^2	0.02	0.53	
DW-statistic	1.42	0.99	
ECMs	$\Delta CLT10_t$	ΔGDP_t	
EC term	−0.13 (0.05)	−0.04 (0.01)	
Adjusted R^2	0.19	0.54	
DW-statistic	1.33	0.95	
ECMs	$\Delta CLT10_t$	$\Delta Grow_t$	
EC term	0.03 (0.08)	−0.005 (0.00)	
$\Delta CLT10_{t-1}$	0.32 (0.30)	0.01 (0.00)	
$\Delta CLT10_{t-2}$	0.01 (0.325)	0.001 (0.00)	
$\Delta CLT10_{t-3}$	0.03 (0.34)	0.01 (0.00)	
$\Delta Grow_{t-1}$	3.76 (14.93)	0.51 (0.20)	
$\Delta Grow_{t-2}$	−10.93 (14.11)	0.21 (0.19)	
$\Delta Grow_{t-3}$	−6.62 (13.36)	0.46 (0.18)	
Adjusted R^2	-0.14	0.45	
DW-statistic	1.89	2.16	
ECMs	$\Delta CLT10_t$	$\Delta GDPpc_t$	
EC term	−0.13 (0.05)	−0.001 (0.00)	
Adjusted R^2	0.15	0.49	
DW-statistic	1.29	1.08	
	Three-variable context		
ECMs	$\Delta CLT10_t$	$\Delta Grow_t$	$\Delta Infl_t$
EC term	0.06 (0.12)	−0.01 (0.00)	0.001 (0.00)
$\Delta CLT10_{t-1}$	0.30 (0.33)	0.01 (0.00)	0.001 (0.00)
$\Delta CLT10_{t-2}$	0.02 (0.35)	0.01 (0.00)	−0.003 (0.01)
$\Delta CLT10_{t-3}$	−0.05 (0.39)	0.01 (0.00)	−0.01 (0.01)
$\Delta Grow_{t-1}$	13.72 (18.12)	0.67 (0.20)	0.20 (0.29)
$\Delta Grow_{t-2}$	−20.19 (25.04)	0.13 (0.28)	−0.53 (0.41)
$\Delta Grow_{t-3}$	−10.89 (21.42)	0.43 (0.24)	0.03 (0.35)
$\Delta Infl_{t-1}$	−16.60 (23.36)	−0.15 (0.26)	−0.41 (0.38)

$\Delta Infl_{t-2}$	18.13 (26.70)	0.29 (0.29)	0.23 (0.43)
$\Delta Infl_{t-3}$	−0.97 (28.43)	−0.05 (0.31)	−0.44 (0.46)
Adjusted R^2	-0.34	0.58	-0.38
DW-statistic	1.93	1.93	1.87
ECMs	$\Delta CLT10_t$	$\Delta GDPpc_t$	$\Delta Infl_t$
EC term	−0.09 (0.04)	−0.001 (0.00)	0.001 (0.00)
Adjusted R^2	0.13	0.50	-0.03
DW-statistic	1.28	1.05	2.37
ECMs	$\Delta CLT10_t$	ΔGDP_t	$\Delta Infl_t$
EC term	−0.11 (0.04)	−0.03 (0.01)	0.001 (0.001)
Adjusted R^2	0.18	0.50	0.02
DW-statistic	1.38	1.06	2.36

Notes: Standard deviation in parentheses. ECM layout: variables located at the top of each division - next to "ECMs" - are dependent variables in the model; the independent variables are arranged in rows (different columns reflect different possible combinations within each relationship).

Source: Authors' estimations.

coefficients for the error correction terms in the CLT10-GDPpc-Infl and the CLT10-GDP-Infl relationships. Accordingly, the value of cashless transactions will adjust to the equilibrium path in the case that there is a disequilibrium among the three variables in the long-run; by doing so, errors do not become larger in the long-run. In the same vein, we find evidence of a short-run relationship running from the value of cashless transactions and inflation to economic growth; the latter develops an adjustment process so as to decrease the equilibrium error when CLT10, inflation and economic growth are out of equilibrium in the long-run. Moreover, we appreciate how changes in the value of cashless transactions hardly affect economic growth, and variations in inflation exert no influence whatsoever.

The estimated error correction models suggest that the relevant short-run relationships for the value of cashless transactions are the ones with the real sector of the economy; this result is in line with the studies in the literature evidencing the thesis of a positive impact of cashless payments on economic growth (see, for example, Wong, Lau, and Yip 2020). Regarding monetary variables, only the more liquid ones show an adequate short-run response. We observe that the disequilibria in the relationships between CLT10 and some variables from the real sector, as well as that regarding M1, are corrected each year by variations in the value of cashless transactions; however, this correction takes place at a slow speed, as the EC terms show small values in most cases. This result highlights the influence of both growth and income distribution in expanding cashless transactions and allows us to assess the role of the most liquid monetary aggregates and the ability of both firms and households to access banking services (see Demirgüç-Kunt, Beck, and Honohan 2008).

6. Conclusions

The results obtained reflect the noticeable impact that variations in the monetary system and the national income have on cashless transactions in the Spanish economy. These results are in line with the vicissitudes experienced by this economy in recent decades, which are closely linked to the European economic, regulatory and monetary framework. In order to study the role played by the monetary aggregates in the transactions based on cashless instruments, we apply the cointegration methodology when focusing on the long-run. We evidence long-run relationships that integrate the real sector, the monetary system and the value of cashless transactions. Moreover, we prove the relevant (and direct) impact of changes in the monetary system and the national income on the value of cashless transactions. These results are consistent with those obtained in the correlation study.

Short-run relationships are also studied. We evidence short-run relationships between the value of cashless transactions and M1, GDP and *per capita* GDP in both directions; we also demonstrate a relationship going from transactions to economic growth. In addition, short-run relationships for CLT10, GDP, *per capita* GDP and economic growth are also found; according to the estimated ECMs, the most important short-run relationships for the value of cashless transactions are those related to the real sector of the economy; and for the monetary variables, the relevance is focused on the more liquid ones. Thus, our results point to the role of economic growth and income distribution in expanding cashless transactions.

There do not seem to be any contradictions with the results obtained in those empirical studies centered on transactions in ATMs and POS and their relation with money demand (Attanasio, Guiso, and Jappelli 2002; Carbó and Rodríguez-Fernández 2014); our results suggest similar issues to those identified in studies that stress that the distribution channels of the financial system are an essential part of the economic growth (Daniels and Murphy 1994; Levine 1997; Demirgüç-Kunt, Beck, and Honohan 2008). As already pointed out, although the results obtained are the expected ones, we consider observing the real behavior in the Spanish case to be essential, as its idiosyncrasy does not ensure that it fits into the theoretical framework; this fact is mainly caused by the already noted contradiction between the level of development of ICT infrastructures and the strong persistence of cash use in Spain.

The analysis shows that in recent times, intense progress has been made in Spain towards what is often generically referred to as a cashless society, a phenomenon that can be found in economies with different levels of development. The great leap forward occurred at the turn of the century, however our results evidence the effective role played by the banking sector (including both banks and savings banks) and the regulatory change in this process since the 1980s. The dynamization of the macroeconomic environment as a consequence of monetary stability has fostered the development of non-cash payments in Spain.

Although in general terms the degree of penetration of cashless instruments and their usage in Spain falls below the European average, this country is making progress in its digital agenda, particularly in the most recent years. According to the results of our study, policymakers should promote the acceleration of this process for two main reasons: to keep the pace with the EU leaders in cashless implementation and to impact the economic performance of the country. Given the aforementioned idiosyncrasies, it would be advisable to implement policies in the field of education, with the aim of encouraging the use of cashless instruments among citizens and companies. As we demonstrate in this paper, cashless transactions have close and direct implications with the real sector of the economy and the monetary system, both in the short- and the long-run. Accordingly, a policy recommendation would be the investment in innovation procedures and ICT infrastructures, especially for digitalization purposes, as there is margin for improvement with respect to other EU countries.

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