Cash and non-cash payments in a long run perspective, Spain 1989-2014

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Abstract

This work investigates the relationships between the retail payment system, monetary aggregates and economic activity in Spain. This approach is taken from a new perspective: that of the transformations that have been favored by ICT in the payment system. The methodology used is based on cointegration analysis and the estimation of error correction models. Likewise, an indicator of cashless transactions is proposed in order to illustrate whether a particular society can be classified as "cashless". We use the Johansen procedure to unveil long-run relationships that are integrated in the real sector, the monetary system and the value of cashless transactions. We prove the relevant (and direct) impact of changes in the monetary system and national income on the value of cashless transactions. Using error correction models, we observe that the most important short-run relationships in terms of the value of cashless transactions are those related to the real sector of the economy, while with regard to monetary variables, the relevance is focused on the more liquid sectors. The empirical results evidence the intensive progress of the cashless society in Spain, where the banking sector, the regulatory changes and ICT development have played a key role.

Keywords: Cashless payments, money supply, ICT

JEL: E42, E51, G20

1. Introduction

Not very long ago, in early 2011, the Single European Payments Area (SEPA) was fully implemented. This has meant the creation of a Euro zone in which electronic payments are considered to be domestic payments. As a result, any differentiation between national and inter-European payment areas has disappeared. Even through convergence has been achieved in terms of regulatory issues and financial oversight, differentiating factors still exist in the area of retail payments in the EMU (ECB, 2003; SEPA, 2014). This work aims to apply a consistent analytical basis to establish the relationships between the retail payment system, monetary aggregates and economic activity in Spain. This approach will be from the perspective of the transformations that have been fostered by information and communications technology (ICT), particularly the development of cashless instruments, with regard to the different payment options available to consumers and businesses. To accomplish this, cointegration analysis methodology will be used, which will enable us to examine the long-run relationships, along with the estimation of error correction models, which will focus on short-run behavior. On the same note, we propose a quantitative measure in this work that is intended to serve as an indicator of whether a particular society can be classified as "cashless".

As revealed by Carbó and López del Paso (2010) with regard to the short term, Spain is a unique laboratory in which to conduct an empirical study on non-cash payments. However, the underlying reasons for this aptness must be established in the long term. There are specific idiosyncratic factors (path dependence), such as the late incorporation of checks as compared to Anglo-Saxon countries and the devotion to cash payments, which remained strong in Spain until the 1980s. Our approach includes the historical perspective, with the aim of analyzing the development of modern payment systems and their relationship to monetary variables, with this last aspect being material in decisions affecting monetary policy. In the UK and the US, the strides toward greater efficiency made in the 1980s in different sectors (including banking and financial services) thanks to ICT would have been much less significant were it not for the infrastructures and lessons learned on a corporate level in the 1960s and 1970s (Booth, 2007).

The strong expansion of new electronic systems in the more advanced countries in the 1980s captured the attention of the specialized literature. The cross-country approach described by Humphrey et al. (1996) characterized the effects of the substitution of cash with non-cash instruments at the end of the 1980s, emphasizing the role of paper-based and electronic payments and the intensive substitution of cash with cards in the US from 1974 on (see also Scholnick et al., 2008; Humphrey, 2004). The changes in the payment system have also had significant implications for the credit activity and by extension, the economic activity (Drehmann et al., 2002). In short, the more widespread use of electronic payments, with their associated lower cost, seems to have resulted in a greater base of intermediation resources (Carbó and López del Paso, 2010). In this sense, Garcia-Swartz and Layne-Farrar (2006) established that, from a cost and benefit perspective, the change towards a cashless society generally seems to have improved economic wellbeing, although they indicate that it should not be concluded that all the parties involved benefited from this. Likewise, the substitution of cash payments with card payments and the use of electronic funds transfer at the point of sale (EFTPOS) in some countries may lead to the decline of ATMs and the hypothetical establishment of a cashless society, as long as interest rates remain above zero per cent (Markose and Loke, 2003).

Recent works refer to the influence that the exogenous effects on monetary factors may have on the behavior of the retail sector (Arango et al., 2016). Others point to phenomena such as the strong growth of low-denomination euro bank notes in circulation in Germany, associating this with the role of the demand for this type of denominations over the long term in the domestic market and outside the Eurozone (Bartzsch and Seitz, 2015). Similarly, with regard to card payments in the Spanish market, there is empirical evidence of feedback loop effects on both the cardholder and merchant sides of the payment card market (Carbó et al., 2012). The recent recession has affected consumer payment preferences (favoring the use of cash over credit cards), however, more recently there seems to be a return to the historical trend in favor of card payments (Herbst-Murphy, 2015).

In general terms, in light of the behavior of the monetary supply in the case of Spain, empirical evidence points to its endogeneity after the second half of the 1980s. The transformations experienced by the banking system and the Spanish economy generated a change in the cause-effect relationships that were contrary to what was expected under the monetary multiplier model (Palacio-Vera, 2001). It was at this time that Spain joined the trend previously noted in other developed countries, such as the US and the UK.

In summary, the approach we offer considers several new points of view with regard to the previous literature: a long-run analysis, in which several institutional aspect are assessed; the use of a simple, reliable indicator of cashless transactions; and a methodology that makes it possible to study the relationship between monetary aggregates, cashless transactions and economic activity. This paper will be organized as follows: Section 2 will briefly discuss certain idiosyncratic aspects of the evolution of the Spanish payment system. Section 3 will present the data used and introduce the cashless indicator, Section 4 will describe the methodology used and Section 5 will analyze the results and finally provide some conclusions.

2. Technology and payments: some idiosyncratic aspects of the Spanish case.

The implementation of the electronic instruments in the payment system as a whole was not instantaneous, nor was it 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.

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, known 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 '70s 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 being until 1982. It was begun 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 (Maixé-Altés, 2013).

[Table 1 around here]

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.

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 to its Spanish acronym) in 1971 by Spain's National Telephone Company, CTNE, known today as Teléfonica. The development of this public network and some private teleprocessing networks (point-to-point lines, 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). 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 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 nineties.

Viewed in these terms, it makes sent to start with the analysis of what will be discussed in this paper. 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 Compensation Systems (see Table 1).

3. Data and descriptive statistics

3.1. Data

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

Monetary series correspond to the main aggregates on 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 monetary supply from the Bank of Spain Statistical Bulletin (BEBE in its Spanish acronym); and on the other hand, the contributions of Spanish MFIs to each one of the aggregates of the EMU from 1999 (BEBE and ECB). In order to link both series we use data provided by the Bank of Spain Statistics Information Service, which refers to the Spanish MFIs contribution to the aggregates of the UEM from September 1997 to December 1998.

In order to represent the activity related to the use of cashless payment instruments and be able to measure its importance throughout time we consider the aggregate value of this type of transactions (CLT). For calculating this aggregation we sum up the value of the transactions made in the following different manners: cheques issued, payment by debit and credit card, credit transfer, direct debits, E-money purchase transactions by cards and other payment instruments. This information is obtained from the MasterSeries BlueBook of the European Central Bank (Indicator of use of various cashless payments instruments, value of total transaction per year); the original series are in billion euros.

Regarding the macroeconomic variables, we take into account Gross Domestic Product (GDP), inflation and GDP deflator (implicit price deflator); from the GDP values we also calculate the per capita GDP and a measure for the economic growth. All these variables are considered for analyzing their relation with the evolution of the cashless society, except for the GDP deflator, which is only used for deflation: all the series we use in the empirical study are in constant terms.

Data on GDP come from Prados (2003) and the Spanish National Statistics Institute (INE in its Spanish acronym). In order to calculate the Spanish per capita GDP, we employ the data on population available from the INE; so as to facilitate comparisons and interpretations, this variable is re-dimensioned in its scale (original values multiplied by one million). With respect to the measure for the economic growth, we account for the traditional proxy variable based on the GDP variation rate.

Data on inflation is obtained from the INE and is transformed from a monthly basis into a yearly one (annual growth rates). Regarding the implicit price deflator, the calculations have been done on the basis of the annual variation rates released by the Bank of Spain and then transformed into index numbers with 1995 as base year.

It should be noted that the monetary series and GDP were originally expressed in pesetas (former national currency) and then converted to 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 terms. The final series are expressed in billions euros.

3.2. Descriptive analysis

An analysis and understanding of the characteristics and behaviour of the time series under study over time 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.

[Table 2 around here]

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; thus, there would not be a priori evidence of outliers. The only exceptions are M1 and M3, but the explanation can be found in being 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 it will be proven in the graphic representations.

As expected, the monetary variables achieve their minimum values at the beginning of the sample and the maximum ones, at the end. 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 it several years earlier (with the outbreak of the crisis). We appreciate how the less liquid aggregates experienced one or several falls in their values over time, whilst CHP grows almost continuously from the beginning of the current 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 one is achieved near the very end; as it is observed, the latter occurs in 2008, at the same time as the outbreak of the crisis.

As remarkable information, we also account for the variation rates of the variables under study. All of them have undergone an outstanding growth from 1952 to 2014 when we directly compare both years; M1 and M3 display the largest figures, as they exceed 2000%. The huge growth in these two series evidence the development of the cashless payments in the last sixty years; specially, M1 shows the increasing weight of banking deposits in supporting cashless transactions.

Besides the calculation of descriptive measures, we depict the evolution of the series over time in Fig. 1.

[Figure 1 around here]

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 variation rate between 1952 and 2014, although it reaches a value of 733.28%. In the majority of cases, the most remarkable increase takes place at the beginning of the 1970s and the end of the 1980s; for some series, the relevant growths start in the sixties, as is the case of M3 and the GDP. In general, the variables under study exhibit a steady evolution (especially GDP and CHP) that is only interrupted with the outbreak of the current 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 fall in 2002 that may be associated to the definitive introduction of the euro. By using the appropriate techniques, we will determine whether the sharp falls observed in the series involve the existence of structural breaks.

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

[Table 3 around here]

With respect to the monetary variables, the values for the mean and the median are even closer than when we analyze the long period (from 1952). Even though the results for the measures of position are similar to the previous study, one different outcome 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 one; in comparative terms, M1 displays again a higher degree of variability and it is also the variable that grows the most.

Regarding the minimum and maximum values, we find the same pattern of behaviour as with the long series except for CHP; this aggregate presents a strong fall in the middle of the period under study. This fact could be pointing at a structural change for this series. The variable with the highest growth in 1989-2014 is M1, whilst it was M3 in 1952-2014; then, the latter may have reached most part 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 largest growth, evidencing the development of the electronic money.

As in the long period, GDP show a steady evolution over time; in fact, its behaviour is more stable in 1989-2014, as the relative dispersion and the proximity of mean and median proves. The minimum and the maximum values correspond to the beginning and the end of the period under consideration, as expected in a macroeconomic aggregate. 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 mean and the median are not close each other; this can be due to oscillations of the variable over time. Moreover, its relative dispersion, in spite of being moderate, is higher than that displayed by monetary variables and GDP. With respect to the extreme values, those occur in similar dates to GDP. In particular, the maximum for cashless transactions takes place 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 a widespread use of more liquid aggregates. From the whole set of series under study, the value of cashless transactions undergoes the highest growth from 1989 to 2014 (788.79%) and it also shows the largest average annual rate.

Finally, regarding inflation, economic growth and per capita GDP we can only compare 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. The three variables show a reasonable or low relative dispersion, which is remarkable in the per capita GDP case. Extreme values occur in the expected time moments. Thus, the economic crisis is responsible for the minimum values regarding inflation and economic growth; correspondingly, the maximum values for these variables take place at the beginning of the sample. Per capita GDP has a quite contrary behaviour; it reaches the maximum value during the economic expansion previous to the breakout of the crisis and its minimum takes place just before the beginning of the 90s. The average growth rate is negative for inflation and economic growth; the outstanding rate in the inflation case 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 the evolution in the 1989-2014 period by means of Figs. 2 and 3.

[Figure 2 around here]

[Figure 3 around here]

It is clearly appreciated from Fig. 2 that the value of the transactions made with cashless instruments is the variable that has increased the most from 1989 until nowadays; its mean growth rate is 9.13%. This outstanding growth evidences how the society passed from being mainly based on cash instruments to be a cashless one. As occurred with the long series, CHP and M3 are at the bottom and at the top of the graph, respectively; they do neither have values in common nor coinciding values with the other variables.

In relation to Fig. 3, we observe the relevant growth experienced by the Spanish per capita GDP in the last decades. After its fall in 1993, economic growth reached a steady state that continued along the 90s and the first mid-00s. Finally, inflation displays a downward trend with some oscillations in the whole period. All these series are affected by the current economic crisis, which usually determines an abrupt fall in their values (or even minima).

3.3. Setting a comprehensive cashless indicator

Regarding the monetary system and the value of transactions made with cashless payments instruments, we have witnessed a transformation in the Spanish society. The use of cashless instruments for completing transactions is radically different when we compare the situation two decades ago and the current one (see Fig. 4).

[Figure 4 around here]

The evolution to electronic money is well appreciated in developed economies. In any case, we should define an indicator so as to identify this status in a certain country, i.e. an indicator that allows for confirming that a given society belongs to the so-called "cashless" ones.

In the current paper we propose a clear to handle measure in order to determine if we face a cashless society. The ideal indicator should reflect the proportion of transactions made with cashless instruments from the total value of transactions completed. The problem comes from the unavailability of the last aggregate value; we believe we can use CHP as a proxy for cash transactions. Thus, the indicator we finally propose has the following expression:

$$\text{Cashless indicator} = \frac{\text{Value of cashless transactions}}{\text{CHP}} \times 100$$

This measure indicates the ratio between the total value of the transactions carried out using cashless instruments in a certain area and the existing CHP in that economy; the larger the difference, the stronger the evidence of a cashless society. One advantage of this indicator is the scale, which makes the measure easy to interpret. In this sense, the limit or critical value should be 200; exceeding this value involves a quite remarkable use of cashless instruments. The application of the proposed indicator to the Spanish case is represented in Fig. 5.

[Figure 5 around here]

This indicator allows us to measure the distance between the two series taken into consideration; the larger the divergence (in favour of cashless transactions), the larger the evidence of facing a cashless society. Moreover, it reflects crucial moments over time in a clear manner, so that we can perfectly identify them. See, for example, a first phase from 1993 to 2001 and a second one, which shows a more intensive change, from 2002. According to the numerical results, the Spanish society would be a cashless one; the value 200 is exceeded for several years and from 2002 until present the indicator is always above 100.

4. Methodological framework

4.1. Structural break tests

Based on the descriptive analysis and the graphical representations, we should look for empirical evidence of structural changes in our historical monetary series and GDP as well;

value of cashless transactions is not taken into account in this exam due to its sample size (insufficient data length for evidencing structural breaks). According to the evolution captured in Figs. 3 and 4, we consider that one single structural break should be sufficient for our series. Consequently, we find relevant the use of the Andrews-Ploberger and the Andrews-Quandt structural break tests (see Andrews, 1993; Andrews and Ploberger, 1994, and Hansen, 1997).

We select these procedures as they do not require to a priori identify the break date; in addition, the evolution of the variables under study do 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. Andrews-Ploberger test considers that the test statistic is an exponentially weighted average of the previous LM-statistics, while Andrews-Quandt test uses the maximum of the LM-statistics. The subsequent distributions are non-standard and asymptotic p-values are calculated.

4.2. Correlation analysis

As this paper aims at unveiling relationships between variables related to cashless payment, we can do a first approach with a correlation analysis; moreover, the results may serve as a helpful tool for the cointegration exam.

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, which is dimensionless and ranges from -1 to +1. This will be the indicator used in this paper.

4.3. Cointegration procedure

The present paper pays particular attention to determine whether the real sector of the economy and/or the monetary aggregates affect the activity based on cashless instruments or not. Does the value of cashless transactions increase according to the evolution of the economic activity or does it happen just the reverse?, which is the role played by the main monetary aggregates? In order to look for evidence of co-movement between the series under study and with the aim of understanding how the electronic money behaves, we resort to cointegration methodology. By means of this procedure we investigate whether there is empirical evidence of, at least, one long-run relationship between the variables.

The cointegration procedure analyzes the existing relationship between non-stationary time series and is applied to numerous economic models. In a univariate framework, the stochastic trend can be removed by differentiation and subsequent estimation. The generalization of this idea in a multivariate framework is not that easy; there might be a linear combination of integrated variables that is stationary, so that the variables show a common trend and are said to be cointegrated.

The cointegration methodolody starts with the detection of unit roots in each one of the time series under study. We account for two methodologies: the Augmented Dickey-Fuller (ADF, 1979) test and the Kwiatkowski, Phillips, Schmidt and Shin (KPSS, 1992) test. Both procedures have been widely used in the empirical literature.

The ADF regression has the following expression:

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

where Y_t is the series under consideration 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 the previous auxiliar regression; the relevant null hypothesis is $\alpha=0$ against the alternative $\alpha<0$. No rejection of the null hypothesis indicates that the variable is non-stationary, whereas the rejection points to the stationarity of the time series. The distribution of the statistic varies according to the deterministic components considered in (1): constant, trend and/or seasonal dummy variables.

In this paper we also carry out the variant of the Dickey–Fuller test for a unit root called ADF-GLS test. Elliot et al. (1996) proposed this procedure, which implies a different manner of handling the parameters of the deterministic term. First, these parameters are estimated by means of the Generalized Least Squares method; then, GLS residuals are used for determining the ADF regression. This approach offers greater power than the standard ADF procedure for the cases where the variable under study 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 to that of the ADF test. Now, the null hypothesis involves stationarity, either around a level or around a deterministic linear trend. 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:

$$Y_t = \beta t + r_t + \varepsilon_t$$

$$r_t = r_{t-1} + u_t \qquad (2)$$

where Y_t is the series under consideration, t is the deterministic trend, r_t stands for a random walk process, e_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 identically distributed random variables with mean zero and constant variance $\hat{\sigma}_u^2$). The initial value $r_0=\alpha$ serves as an intercept.

Kwiatkowski et al. (1992) consider a one-side Lagrange Multiplier statistic for testing the null hypothesis $\hat{\sigma}_u^2=0$ against the alternative that $\hat{\sigma}_u^2>0$. When $\beta=0$, the null hypothesis implies that y_t is stationary around r_0; if $\beta\neq0$, y_t would be stationary around a linear trend. In case that $\hat{\sigma}_u^2$ is greater than zero, the conclusion is that y_t is non-stationary, as there exists a unit root.

We perform unit root and stationary tests specifying a constant as the deterministic component (i.e., the assumption is stationarity around a level). In the ADF tests, the optimal lag length - number of lags so as to have white noise residuals - is determined using the Akaike Information Criterion (AIC); regarding KPSS, the lag is determined according to the sample size.

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

The evolution of cointegrated variables over time is affected by the magnitude of any deviation from the long-run equilibrium. The previous long-run model has its reflection 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.

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

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

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 zero mean and Σ_ε variance. The expression in (3) in an error-correction form is:

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

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 existing number of cointegrating relationships. When the Π rank is zero, there are n stochastic trends; subsequently, there are not long-run relationships between the variables. In case Π is a full rank matrix, all the variables included in Y_t are stationary (i.e., there is no cointegration). The intermediate situation takes place when the rank is lower than n $(0 < r < n)$, implying that there are r potential cointegrating vectors which are different from zero.

When the rank is larger than zero, Π can be decomposed in two $(n \times r)$ matrices: α and β. Thus, $\Pi = \alpha\beta'$, where β includes the coefficients for the different cointegrating vectors and is denominated cointegrating matrix; α is the weight matrix and shows the weights for each vector in the n equations of the VAR model.

Johansen (1995) carries out a maximum likelihood estimation procedure for Γ, α, β and Σ. They also develop two tests in order to determine the number of cointegrating vectors: the trace test and the maximum evigenvalue 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 $\hat{\lambda}_i$ the estimated values for the eigenvalues obtained from Π and T is 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 against the alternative of being larger than r.

Finally, the maximum eigenvalue statistic has the following form:

$$\lambda_{\max}(r, r+1) = -T \ln\left(1 - \hat{\lambda}_{r+1}\right) \tag{6}$$

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

5. Empirical results

The methodology set out in the previous section serves us for examining the linkage between monetary system, real sector and cashless activity. The application of the different techniques leads us to the following results.

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 around here]

The joint statistics point towards a rejection of the null hypothesis of no structural break; there is evidence of lack of stability in the estimated coefficients for all the variables under study. According to observed evolution of our series, the presence of a one-time break is corroborated with the test for CHP and M1. In the first case, the tests suggest 2002 as the break point; this is the year of the definitive introduction of the euro, which may affect the CHP variable by causing a disruption in the behaviour of the public with the definite use of the new currency. The break date for M1 is 2004: once the confidence on the new currency is higher, people increase their demand deposits again. This can be seen as a lagged effect of the introduction of the new currency. The support for structural breaks in the remaining variables does not have a clear correspondence when we observe their behaviour over time. An explanation is that the tests tend to over-identify break points along the sample.

Therefore, an interesting result from these tests is that they identify structural breaks for CHP and M1 in 2002-2004, the years where cashless transactions and the cashless indicator experience their great change; thus, the evolution of CHP and M1 would be detecting the increasing relevance of cashless activities.

Going in depth into the study of the association, a tool that serves as a preliminary approach is the correlation analysis. On this point, Table 5 reports the pairwise correlation coefficients for the value of cashless transactions and the remaining variables.

[Table 5 around here]

We observe that both national income and monetary system have a strong linear correlation, which displays 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 place for any linkage with the value of cashless transactions; it seems reasonable that a variation in the amount of Currency Held by Public does not necessarily affect the transactions made with non-cash instruments.

Regarding non-monetary variables, we appreciate an important positive correlation for per capita GDP; then, people with higher per capita income levels tend to make more use of cashless instruments (in terms of value of transactions). Finally, inflation and GDP growth are negatively correlated with the value of cashless transactions, even though the intensity of their relations is not very relevant.

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

[Table 6 around here]

Results generally support the existence of unit roots in the series under study, as expected according to the behaviour they display; thus, these series behave more like a random walk than like transitory deviations from a steady state. The presence of nonstationarity poses no doubt except for CHP. In the latter, the KPSS test points to a stationary process, whilst ADF and ADF-GLS provide evidence of nonstationarity. As already pointed out, CHP may display a structural break; were this case, ADF tests tend to over-detect nonstationarity. Then, we should take this result with caution.

So as to determine the number of cointegrating vectors, we consider the two Johansen tests: the trace test and the λ-max test. In addition, we report two types of p-values for the trace test: the asymptotic p-values and those adjusted for the sample size. Regarding the VAR specification, its order has been selected following AIC; taking our sample into account, we consider p=5 as an appropriate maximum lag. As the mean of the vast majority of the variables under study 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 we do consider the absence of constant option. In order to facilitate the interpretation of the results, we have transformed the dependent variable by dividing its values by 10 (CLT10). Results are summarized in Table 7.

[Table 7 around here]

The Johansen procedure provides evidence of cointegration in all cases except for the 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 of a unique cointegrating relationship is not rejected. Then, monetary aggregates and cashless transactions show a stochastic common trend; the same occurs with GDP and cashless activity.

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 around here]

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

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 it is not the case of CHP. Moreover, Fig. 2 suggests a more similar behaviour over time for transactions and M1-M3 than for CHP.

It should be pointed out that M2 is the monetary variable with the highest influence on CLT10 in the long run, together with the GDP. This ascertainment 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 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 payments system.

Once we evidence the existence of these long-run relationships, we find of interest to go into detail about the connections with the economic activity. First, the relevance of the cashless transactions made might be related to individual’s income. Second, there may be a linkage with 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 prices too; then, we consider one of the key variables in any economy: inflation. Thus, 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 around here]

Empirical evidence supports that the three series contain a unit root. The only debatable conclusion concerns the economic growth variable, which shows an unclear situation. On the one hand, the ADF test does not reject the null hypothesis of nonstationarity; on the other hand, results for ADF-GLS and the KPSS are on the edge regarding the significance level. This situation somehow resembles the one of CHP; both cases are susceptible to have structural breaks, so the ADF test results could be misleading. Then, any empirical result that involves economic growth should be handled with caution.

Next, we develop the cointegration analysis. So as to exploit the information, we first evidence cointegration relationships for pairs of variables and then we consider a wider scenario with three variables. The results for the trace test and the λ-max test are reported in Table 10 and the cointegrating equations are reflected in Table 11.

[Table 10 around here]

[Table 11 around here]

From Table 10 we derive that one of the three new variables do 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 to a modest degree of relation between both variables. On the contrary, per capita income does have a positive effect on cashless transactions, although of 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.

When we turn to a three-variable context, the intrinsic linkages between the economic variables seem to be the crucial issue 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 the second. If we substitute GDP growth by per capita income, the relationship is again significative. Inflation and transactions are negatively related; inflation alters the liquidity of the system as well as the behaviour of consumers and companies regarding their deposits and liquidities. On the contrary, the link with per capita GDP is positive; such as it occurred in the two-variable analysis, per capita income hardly influences transactions (the cointegration coefficient is extremely low).

Finally, we find evidence of a long-run relationship between value of transactions, GDP and inflation. Following 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 behaviour 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), whilst this effect is lost when we focus on aggregate variables (GDP).

In those cases where variables are cointegrated, we also look for evidence of short-run relationships. Table 12 summarizes the estimated error correction models (ECMs) for the relationships we have considered, together with some validation statistics.

[Table 12 around here]

According to Table 12, empirical results evidence short-run relationships between the value of cashless transactions and M1, GDP and per capita GDP (in both directions); we observe that an adjustment process takes place in the short run (negative and significant EC terms), so that if each pair of variables are out of equilibrium in the long run, they will adjust in order to reduce the equilibrium error. In addition, we appreciate that short-run variations in M1, GDP and per capita GDP influence the value of cashless transactions in a positive manner, and vice versa. It is also suggested a short-run relationship that goes from CLT10 to economic growth; in this case, the latter experiences an adjustment process when both variables are not in equilibrium, so as to correct the situation. The remaining bivariate cases do not involve suitable error correction models due to the sign of the EC term 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 coefficients for the error correction terms in the CLT10-GDPpc-Infl and the CLT10-GDP-Infl relationships. Then, the value of cashless transactions will adjust to the equilibrium path in case there is disequilibrium between the three variables in the long-run; by doing this, 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, while variations in inflation exert a negative but nonsignificant impact.

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; regarding the monetary variables, only the more liquid ones shows an adequate short-run response. We observe that part of the disequilibria in the relationships between CLT10 and some variables from the real sector, as well as the one regarding M1, is corrected each year by variations in the value of cashless transactions.

6. Conclusions

The empirical analysis carried out in this paper starts with an essential descriptive analysis of the variables under study (for both 1952-2014 and 1989-2014 cases). Besides interpreting the basic measures, we also carry out a correlation analysis to observe possible linear relationships between the variables and look for evidence of structural breaks in the historical series. Regarding the latter, we select Andrews-Ploberger and Andrews-Quandt structural break tests as they do not require a priori identification of the changes and are adequate for single ones. From their application we obtain clear evidence of one structural break in the CHP and M1 time series.

In order to study the role played by the monetary aggregates on the transactions based on cashless instruments, we apply the cointegration methodology when focusing on the long run. By means of Johansen procedure, we evidence long-run relationships that integrate the real sector, the monetary system and the value of cashless transactions; the only exception is the relationship between CHP and the values 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 the ones obtained in the correlation study.

Short-run relationships are also studied. Using error correction models (ECMs), we evidence short-run relationships between the value of cashless transactions and M1, GDP and per capita GDP in both directions; we also prove 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. Interestingly, we observe how the value of transactions return to their equilibrium path in case there is any disequilibrium between the variables, a fact that prevents errors from becoming larger in the long run.

Stated briefly, 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. 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 results obtained also enable us to weigh the importance that prior developments in the ICT sector had in the Spanish case (as they did in the US and the UK), especially developments in the area of computerization and teleprocessing. The interruption of the path dependence of the Spanish system, closely linked to cash payments and with little tradition of check use, and the rapid transition to new payment systems are explained to a large extent within this context.

References

Andrews, D. W. K., Ploberger, W., 1994. Optimal tests when a nuisance parameter is present only under the alternative, Econometrica 62 (6), 1383-1414.

Andrews, D., 1993. Tests for parametric instability and structural change with unknown change point. Econometrica 61 (4), 821-856.

Arango, C., Bouhdaoui, Y., Bounie, D., Eschelbach, M., Hernández, L., 2016. Cash management and payment choices: A simulation model with international comparisons. ECB Working Paper Series 1874, January.

Bartzsch, N., Seitz, F., 2015. Cash holdings in Germany and the demand for "German" banknotes: What role for cashless payments? OTH im Dialog: Weidener Diskussionspapiere 51, June.

Booth, A., 2007. The management of technical change: Automation in the UK and USA since 1950. Palgrave Macmillan, Basingstoke.

Carbó, S., López del Paso, R., 2010. Does the development of non-cash payments affect bank lending? Manchester School 78 (5), 412-436.

Carbó, S., Liñares, J.M., Rodríguez, F., 2012. Feedback loop effects in payment card markets: Empirical evidence. Review of Network Economics 11 (2), 1-22.

Dickey, D. A., Fuller, W. A., 1979. Distributions of the estimators for autoregressive time series with a unit root. Journal of American Statistical Association 74 (366), 427-481.

Drehmann, M., Goodhart, Ch., Krueger, M., Boldrin, M., Rose, A., 2002. The challenges facing currency usage: Will the traditional transaction medium be able to resist competition from the new technologies? Economic Policy 17 (34), 193-227.

ECB, 2003. Towards a Single Euro Payments Area. Progress Report, June. European Central Bank, Frankfurt.

Elliott, G., Rothenberg, T. J., Stock, J. H., 1996. Efficient tests for an autoregressive unit root. Econometrica 64, 813-836.

Garcia-Swartz, D.D.,Hahn, R.W,Layne-Farrar, A. (2006). The Move Toward a Cashless Society: A Closer Look at Payment Instrument Economics. Review of Network Economics 5 (2), 175-198.

Hansen, B. E., 1997. Approximate asymptotic p-values for structural change tests. Journal of Business and Economic Statistics 15, 60-67.

Herbst-Murphy, S., 2015. Trends and preferences in consumer payments: Updates from the visa payment panel study. FRB of Philadelphia - Payment Cards Center Discussion Paper 15-02.

Hjalmarsson, E., Österholm, P., 2007. Testing for cointegration using the Johansen methodology when variables are near-integrated. IMF Working Paper 07/141, June.

Humphrey, D.B., 2004. Replacement of cash by cards in US consumer payments. Journal of Economics and Business 56, 211-225.

Humphrey, D.B., Pulley, L.B., Vesala, J.M., 1996. Cash, paper, and electronic payments: A cross-country analysis. Journal of Money Credit and Banking 28, 914-939.

Johansen, S., 1988. Statistical analysis of cointegration vectors. Journal of Economic Dynamics and Control 12 (2–3), 231–254.

Johansen, S., 1991. Estimation and hypothesis testing of cointegration vectors in Gaussian Vector Autoregressive Models. Econometrica 59 (6), 1551–1580.

Johansen, S., 1995. Likelihood-based inference in cointegrated Vector Autoregressive Models. Oxford University Press, New York.

Johansen, S., Juselius, K., 1990. Maximum likelihood estimation and inference on cointegration with applications to the demand for money. Oxford Bulletin of Economics and Statistics 52 (2), 169–210.

Kwiatkowski, D., P.C.B, Phillips, P. Schmidt, Shin, Y., 1992. Testing the null hypothesis of stationarity against the alternative of a unit root. Journal of Econometrics 54 (1-3), 159-178.

Maixé-Altés, J.C., 2013. The technological option of Spanish savings banks before the Internet, circa 1950-1995, Investigaciones de Historia Económica - Economic History Research 9 (3), 175-186.

Markose, S.M., Loke, Y.J., 2003. Network effects on cash-card substitution in transactions and low interest rate regimes. The Economic Journal 113 (April), 456‑476.

Palacio-Vera, A., 2001. The endogenous money hypothesis: Some evidence from Spain (1987-1998). Journal of Post Keynesian Economics 23 (3), 509-526.

Prados, L., 2003. El Progreso económico de España (1850-2000). Fundacion BBVA, Bilbao

Scholnick, B., Massoud, N., Saunders, A., Carbó-Valverde, S., Rodríguez-Fernández, F., 2008. The economics of credit cards, debit cards and ATMs: A survey and some new evidence. Journal of Banking and Finance 32, 1468-1483.

SEPA, 2014. Economic analysis of SEPA: Benefits and opportunities ready to be unlocked by stakeholders. PwC Economic analysis of SEPA – European Union, January.

Wu, L., Zhang, N., Chen, Ch., Liu, J., 2009. Electronic payment instruments and endogenous money supply. Proceedings of the 3rd. International Conference on Management of e-Commerce and e-Government (ICMECG '09). IEEE Computer Society, Washington DC.

Zivot, E., Andrews, D.W.K., 1992. Further evidence on the great crash, the oil price shock, and the unit root hypothesis. Journal of Business and Economic Statistics 10 (3), 251-70.

Table 1
Wholesale and retail payment systems in Spain from 1923

Length of time	Type of payment system	Description
1923-1968	Clearing houses: 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 payments system
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
1980-	Cooperación Técnica Bancaria, CTB and Centro de Cooperación Interbancaria, CCI	Bank Technical Cooperation (CTB), private entity for technical collaboration. From 1985 was created the Interbank Cooperation Center (CCI) which grouped to banks, savings banks and credit cooperatives. Technical collaboration for the exchange and settlement of payment instruments.
1984-	National Electronic Clearing Service: SNCE - Sistema Nacional de Compensación Electrónica	The Spanish electronic system for clearing retail payments. Created by credit institutions and the Bank of Spain, which from 1988 managed the entire system. Since 2005 became a managed service by the Spanish Society of Payment Systems (Iberpay), a company whose shareholders are the entities participating in the SNCE. Since 2011 is a totally centralized system.
1996-2008	SLBE - Sistema de Liquidación del Banco de España (Bank of Spain Settlement System)	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 became extinct on 18 February 2008 with the launch of TARGET2.
1997-2004	SEPI - Servicio Español de Pagos Interbancario (Spanish Service of Interbanking payments)	Multilateral clearing system for large-value payments in euros, national and cross-border. The system was owned by its participants by 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

Sources: ECB (2007). Bank of Spain Circular 1/2008, 25 January. Sánchez Soliño, A. La transformación de los sistemas de grandes pagos españoles en la perspectiva de la Unión Europea. Bank of Spain- Economic Bulletin, June-1994. Rosas Cervantes, A. El sistema nacional de compensación electrónica (2ª edición). Bank of Spain, Economic Studies 44 (1995). Paredes Moliner, A. Los sistemas de pagos en España. V Reunión Anual de Asesores Legales de Banca Central, 23-25 agosto 2000, La Paz, Bolivia; and authors.

Table 2
Descriptive statistics for the series 1952-2014 (constant prices, € billions)

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

Table 3
Descriptive statistics for the series 1989-2014 (constant prices - € billions - 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	-185.68	-6.67	1.34

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

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

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

Note. KPSS' p-values are calculated by interpolation.

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

Table 8
Identified cointegrated vectors

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

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

Note. KPSS' p-values are calculated by interpolation.

Table 10
Johansen tests for the cointegration rank

	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

Table 11
Identified cointegrated vectors

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

Table 12
Estimated error correction models

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	
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

Note. Standard deviation in parentheses.

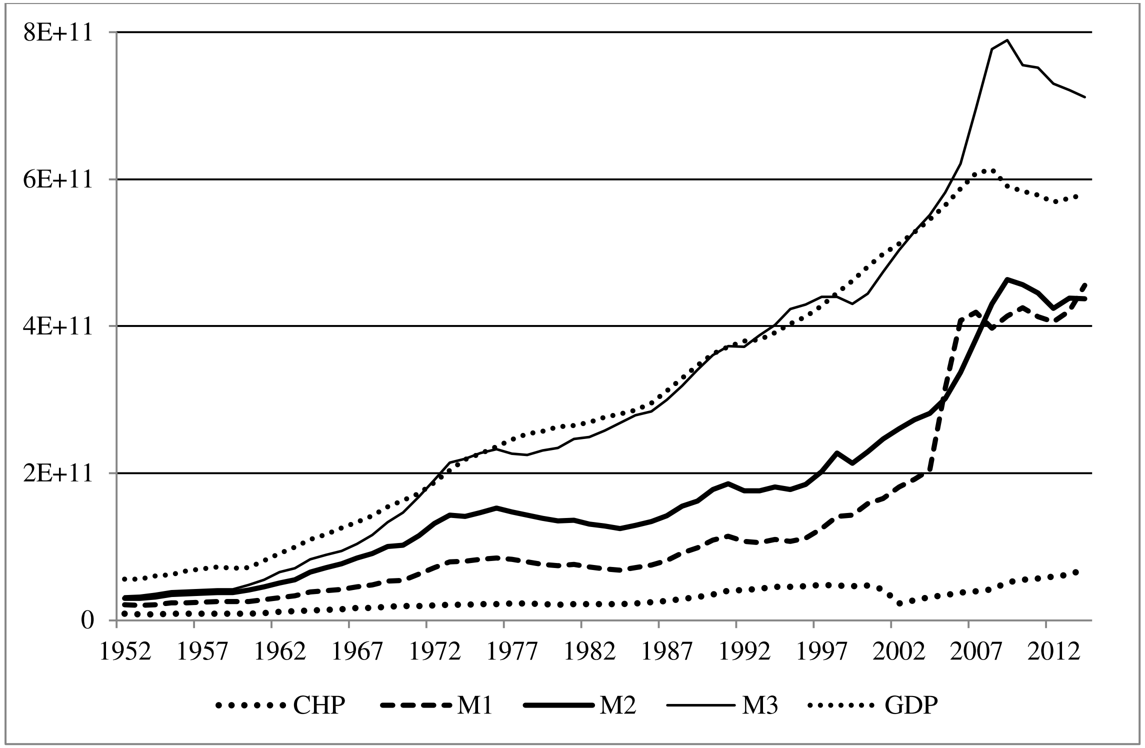


Fig. 1. Evolution of the variables over time: 1952-2014. Series at constant euros (€ billions).

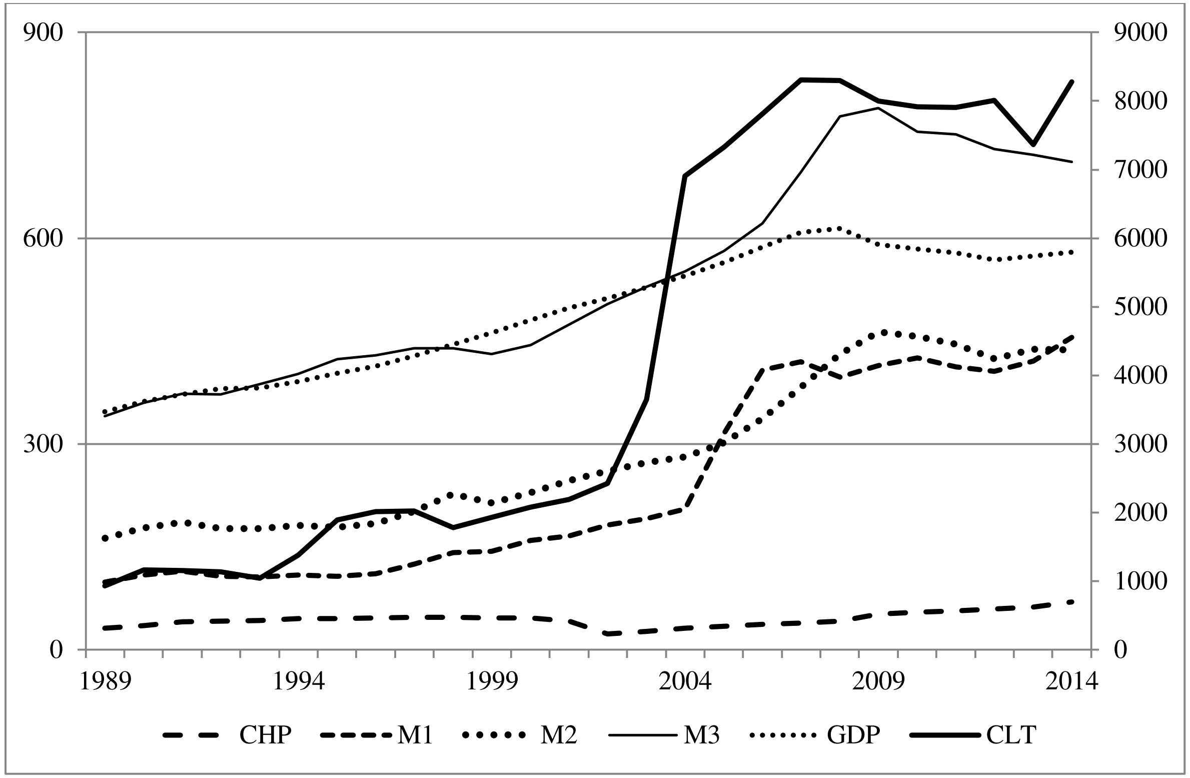


Fig. 2. Evolution of the variables over time: 1989-2014. Series at constant euros (€ billions).

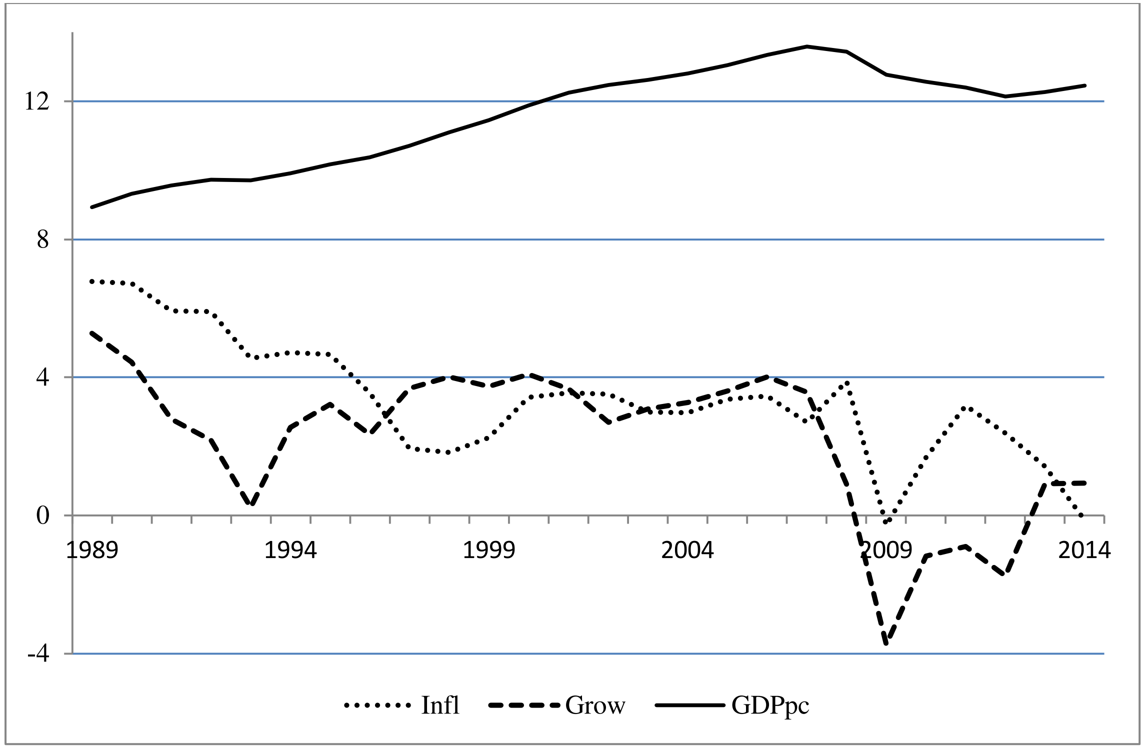
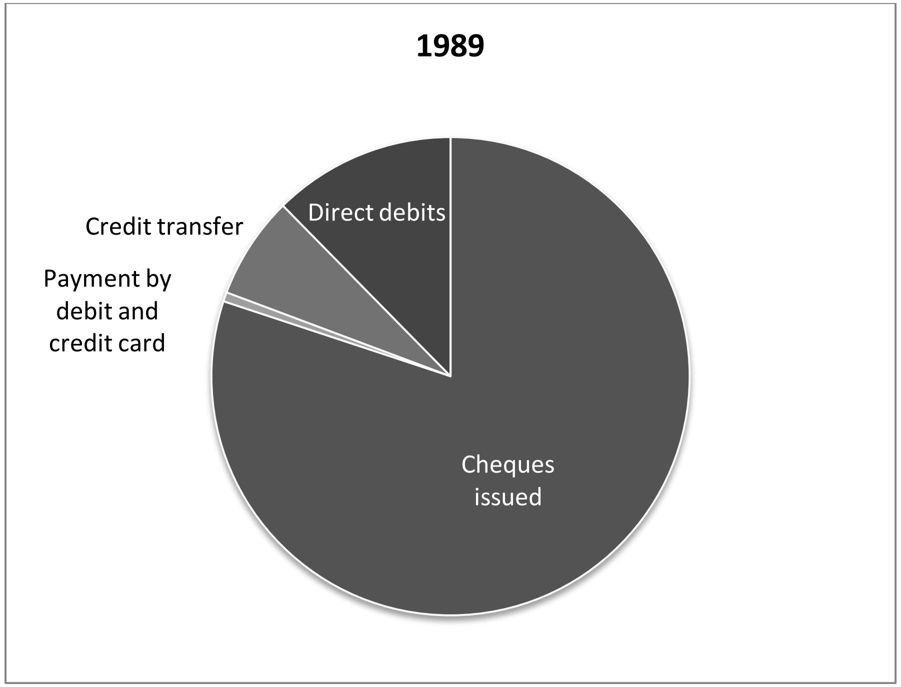
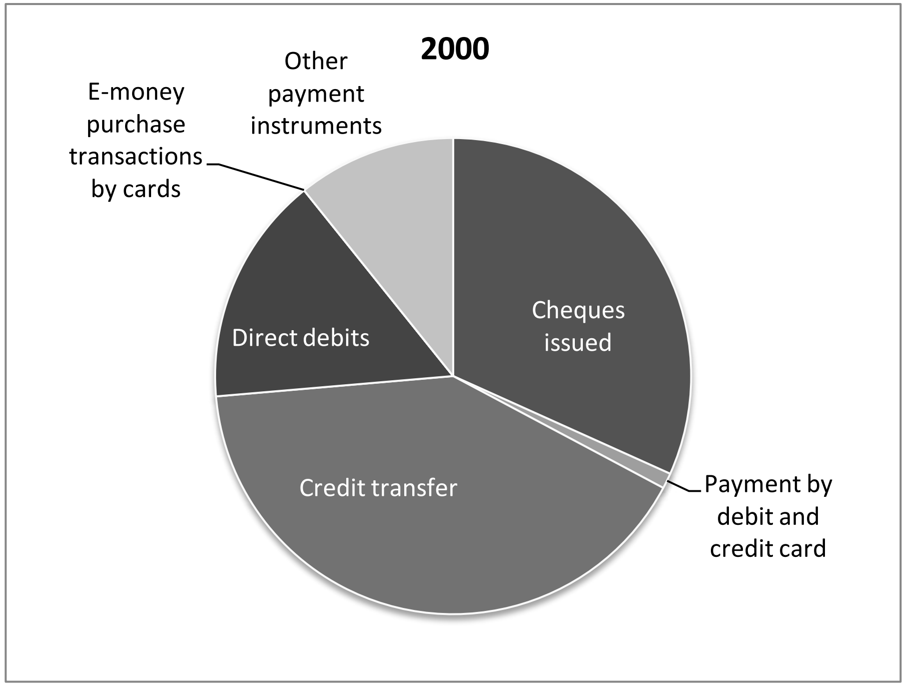


Fig. 3. Evolution of the variables over time: 1989-2014. GDPpc at constant euros (€ billions); Infl and Grow in percentage.


1989
Direct debits
Credit transfer
Payment by debit and credit card
Cheques issued


2000
Other payment instruments
E-money purchase transactions by cards
Cheques issued
Direct debits
Credit transfer
Payment by debit and credit card

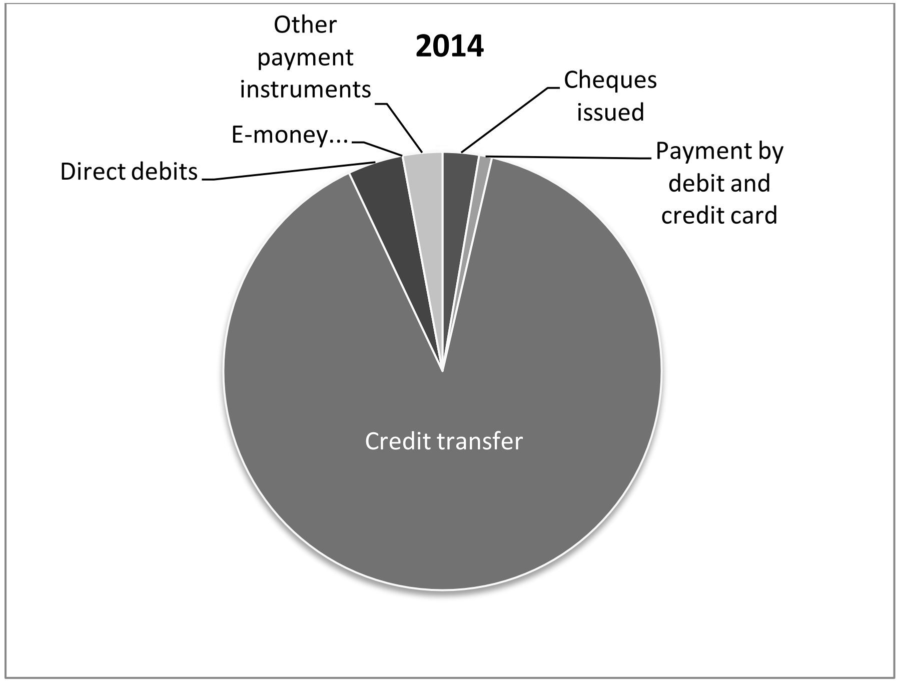


Fig.4. Indicator of use of various cashless payments instruments. Value of transactions (€ billions).

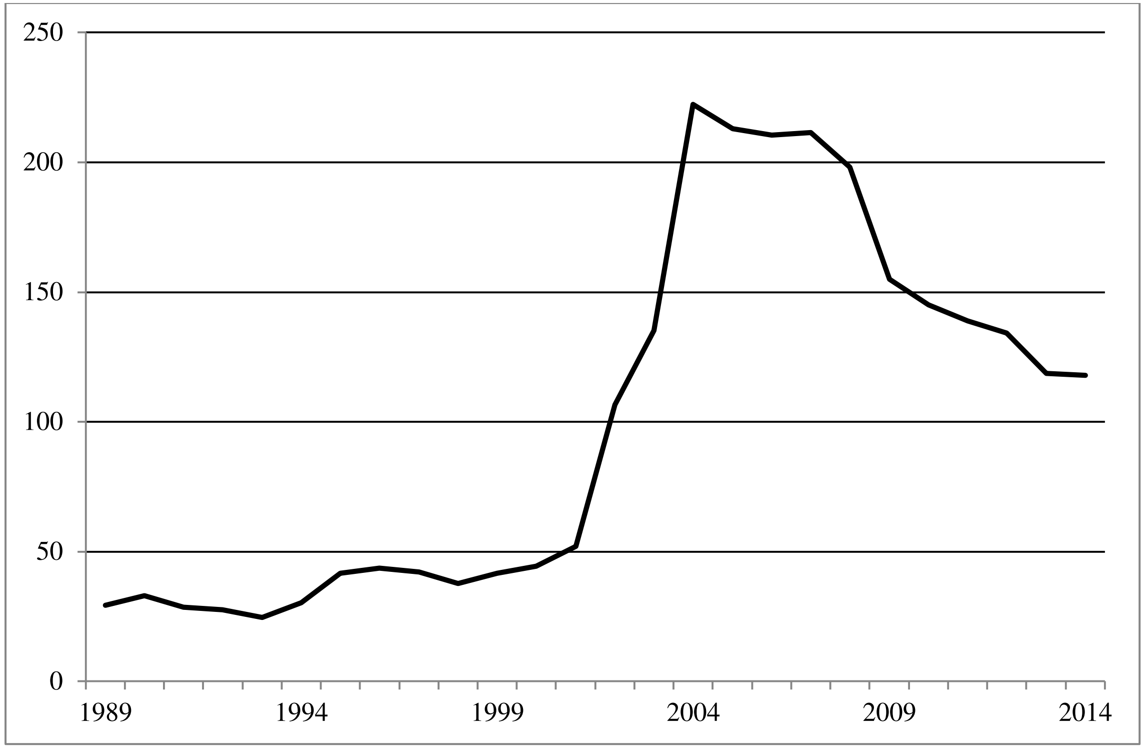


Fig. 5. Cashless indicator: evidence for Spain.