KATHOLIEKE UNIVERSITEIT
LEUVEN

Faculty of Economics and
Applied Economics

Department of Economics

Payment Cards and Money Demand in Belgium.

by

Laura RINALDI

International Economics

Center for Economic Studies
Discussions Paper Series (DPS) 01.16
http://www.econ.kuleuven.be/ces/discussionpapers/default.htm

July 2001

DISCUSSION
PAPER

Payment Cards and Money Demand in Belgium

Laura Rinaldi*

University of Leuven

July 2001

Contents

* E-mail: Laura.rinaldi@econ.kuleuven.ac.be, CES, Naamsestraat 69, 3000 Leuven (B).

1. Introduction

Everywhere in Europe the payments' patterns are changing: card-based payments are becoming more and more diffused for everyday purchases, at the detriment of notes and coins. A substitution effect between cash and the different kinds of cards is taking place. This is a tendency towards a more efficient and less expensive payments system[1]. Nevertheless, cash is still the preferred and more used payment instrument, in particular for low-value expenses.

In this paper we analyse the use of alternative payment media in Belgium and the effect of such changes in the financial system. With cash employed still in about 75 percent of purchases, Belgium is among the countries with the most intensive use of cards in Europe. As a result, the amount of outstanding currency continues to decrease. A previous study estimating currency demand in Belgium for the period 1981 and 1988 showed that the use of checks and credit cards had slowed down currency demand growth (Boeschoten, 1992). In this paper we extend such a study by analysing the evolution of bankcards, i.e. of electronic retail payments. In particular, we estimate an equation of demand for currency and approximate the substitution effect of cash with cards. We do this using annual data spanning the period 1960-1999 in order to cover the period from a pure cash-society towards a system were more instruments are used. Note that only retail payments at the point of sale are considered in this study and not all kind of transactions. In other words, we focus on non-cash instruments that can replace cash and accordingly, we define money in a quite restrictive way.

In view of the fast changing external factors in the payment systems, we focus on the most recent developments. That is, in the movement away from cash, we do not investigate the impact of cheques. We believe that, although cheques might be relevant, they actually constituted an intermediate step between cash and cards.

Instead, we consider data concerning the three types of cards present in Belgium, i.e. Bancontact/MisterCash debit cards, credit cards and electronic purses (Proton), as well as, the number of points of sale that accept them and the number of automated teller machines (ATMs). By means of these card variables and other more traditional variables, we estimate a money demand through cointegration analysis.

The paper is organised as follows. In Section 2 an overview of bankcard history in Europe and more particularly in Belgium is given, together with some considerations about their actual use. Section 3 offers a review of the literature on money demand in relation with alternative means of payment. Then, we investigate money demand function where the substitution effect is accounted for by means of card variables.

[1] De Grauwe, Buyst and Rinaldi (2000) found that the average cost of card payment is 1.3 percent of the transaction value versus 9 percent for a cash one.

Thus Section 4 deals with economic theory of money demand and Section 5 analyses the processes in levels within the Johansen cointegrating framework, with the aim of establishing stable cointegrating relationships that can be interpreted as long run-money demand functions. Then, in Section 6, the long run analysis is integrated in an Error-Correction Model (ECM) to account for the short- and long-run behaviour of the model at the same time. Finally we look at the dynamics of the model by simulating impulse response functions and vector error variance decomposition and we conclude with an economic interpretation.

2. Evolution of Payment Cards

Payment cards constitute a relatively new phenomenon. They showed up about half a century ago, but while at the beginning their use was quite limited, they became widespread during the Nineties. The first type of card offered to the consumers was the credit card, born in the late Sixties in the US. The credit cards system developed thanks to the need to find a substitute to cheques, which had an important redeemability problem in such a large payments area as the United States. People who travelled a lot had only the alternative to choose between cash, with the risk of loss, and Traveler's checks, with high time costs. During the 1950s a first commercial response to this problem was given with Travel and Entertainment (T&E) cards, notably American Express and Diner's Club card. T&E cards were a three-party instrument where the issuing organisation signed up merchants across the country of the type often frequented by travellers. A four-party[2] bank credit card was introduced in the US in 1966 in order to obtain a wider bank-card payment system, that could not be obtained by any single banking enterprise in its deposit acceptance activities, because of the geographical restrictions on banking laws. Thus the Bank of America licensed its "BankAmericard" for the first time in 1958 in California. Later its structure changed in a membership company, i.e. an association formed by all banks issuing BankAmericards with the objective to expand abroad and, in 1977 the name of the national organisation changed into Visa. MasterCard started issuing cards at the same time as Visa, and is its closest competitor. Nowadays, Visa and MasterCard are the two most diffused bankcard brands in the world with something like 1 billion cards worldwide.

Cards arrived in Europe a few years later than in the US, the evolution of cards is similar in some respects. In both Europe and the US cards' diffusion has been slow at the beginning, mainly based on T&E cards. Similarly, cards have taken off as a

[2] The issuer, the acquirer, merchants and cardholders, compose the four-party system.

payment instrument for everyday expenses in the Nineties. But, while in Europe debit cards are by far more diffused and used than credit cards, in the US credit cards dominate,[3] while several electronic money projects are attempted with limited success (Van Hove, 2000).

As far as payment habits are concerned, traditionally there were two groups of countries in Europe. On one side, Germany and the Netherlands characterised by large use of cash in retail payments and transfers for remote transactions, and France and the UK on the other side, where typically less retail payments were in cash, but cheques were also largely used. Currently this division is no longer so sharp and the importance of payment cards - debit and credit - is increasing at the expense of cheques in all EU countries, although to varying degrees. Nonetheless significant differences still exist across European countries. First, concerning the intensity of cash use, in particular the replacement of cash by various non-cash instruments. Secondly, concerning the intensity of the use of the different traditional and electronic non-cash payment instruments. Despite the increasing use of cards, cash always tends to be used for the majority of households' payments. Even in a country like Finland, which has a low volume of outstanding currency and is regarded as progressive with respect to the use of electronic payment instruments, 80 percent of households' payments are still made with cash, which corresponds to 40 percent of total households' payments value (Snellman, 2000). Many of these cash payments throughout Europe are of very low value, and thus costly for merchants and the banks to handle. The motive of reducing these costs for handling and dealing with cash is one of the main driving forces for the introduction of electronic money in Europe. From a publication of the European Central Bank (1999), it emerges that POS terminals are particularly widespread in Denmark, France, Luxembourg and Finland. The overall importance of payment cards (credit and debit cards outstanding and number of transactions per capita) is particularly high in Denmark, Finland, Luxembourg, France, United Kingdom, the Netherlands and Belgium. The number of ATMs and POS is increasing everywhere (see Table 1), but this does not reflect the actual use of these devices. For example, Spain is the country with the highest the number of both ATMs and POS in the European Union but is among the countries with the smallest number of transactions per capita for both devices. A similar discussion holds for the number of cards. In 1997 for every 1000 inhabitants in Germany there were 1038 cards with a credit of debit function while only 583 in Denmark. However the number of card transactions per person per year amounted to 3 in Germany against 58 transactions in Denmark.

[3] Between 1988 and 1997, the number of credit cards grew at almost three times the rate of debit cards, i.e. 8.1% versus 2.8% (Evans and Schmalensee, 1999).

In terms of electronic money at the beginning of the 1990s several countries have put in place electronic purses schemes with the ambition to substitute cash in small-value transaction. All these schemes had a slow initial adoption, and a less than expected success. Moreover, over the last two years several pilot projects have been shut down because of "a largely indifferent public" (Van Hove, 2000). The use of e-money predominantly for smallest value purchases is reflected at European level in the average value per purchase, which, at end –1997 was much lower in the case of e-money (Euro 4.0) than transactions via POS terminals (Euro 62) (ECB, 1999).

Table 1: Number of ATMs and POS

	1987		1990		1993		1996	
	POS	**ATMs**	**POS**	**ATMs**	**POS**	**ATMs**	**POS**	**ATMs**
Belgium	15388	802	28253	939	52984	2819	81331	4207
Finland	4995	1557	26500	2838	42000	4201	51000	4661
France	70000	11500	180000	14428	429000	18735	546000	24531
Germany	6044	4033	23152	8775	51806	25000	115000	37600
Italy	392	3705	22185	9770	77206	15227	216093	24161
Netherlands	926	457	2223	2700	24549	4461	96044	5793
Switzerland	903	1234	22765	2262	26630	3062	67000	4160
UK	13006	12507	110000	17000	270000	19100	550000	22100

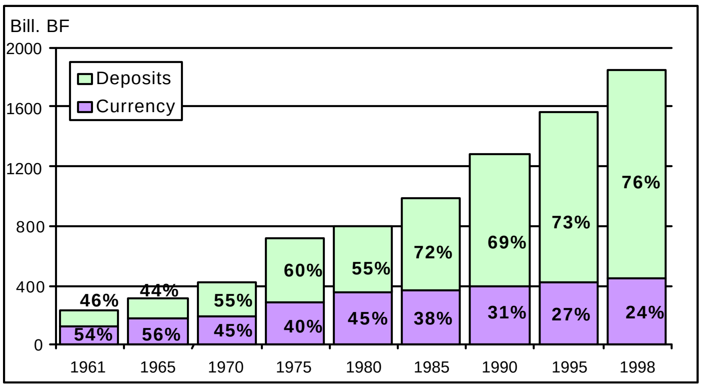
Source: BIS, EMI.

2.1 Bank Cards in Belgium

The first card appeared in Europe was the Diners club which arrived in Belgium in 1957, followed by American Express. However credit cards remain for a long time a marginal phenomenon. These cards are payment instruments reserved to a restricted circle of people, like travellers and businessmen. Only with the introduction of Visa and Mastercard, credit cards take off. Even though we have to wait for the development of the debit card network in the Nineties to see payment cards as a payment instrument for everyday expenses. Similarly to what happened in other countries, the story of debit cards in Belgium, goes hand in hand with the economic growth and the easier availability of cash.

The current Belgian payment system has been achieved mainly in two waves, a first one in the 1960s and a second in the 1980s. During the Sixties the fast economic growth boosted important changes in the banking sector mainly based on notes and coins. Two main innovations were introduced in the banking sector: the wide availability of current accounts and the promotion of easy payment instruments like cheques, transfers, direct debit, all offered free of charge to the customers. These innovations had as a result a widespread diffusion of current accounts[4] and, on the retail payment side, a large use of cheques though, without diminishing the demand for cash. Figure 1 can give an insight into this pattern: during the 1960' notes and coins constituted the majority of money supply and, starting from the 1970 the relative amount of notes and coins began progressively to decrease in favour of deposits. Moreover the new payment habits became increasingly costly for the banks[5] and induced them to provide their customers with self-service facilities that allowed the public to make use of banking services in a convenient way also outside of opening hours. Such a situation offered to financial institutions the ground to progressively introduce automation. In late Sixties, some banks installed the first cash dispensers, a prototype of the current automated teller machines (ATMs) and supplied their customers with special cards in order to use them. Only later on, the banking sector turned to add other functions to the same card, i.e. payment facility. As a result in the 1980s a second wave progressively arrived with the payment "dematerialization".

Figure 1: M1 in Belgium



Electronic retail payments were introduced first with Mister Cash in 1977 and Bancontact in 1979, whose payment terminals were installed in service stations and then in hyper- and supermarkets. The two card-based facilities, ATMs and payments at the point of sale (POS), required strong investments and co-operation, and induced

[4] In 1960 there were about 900.000 current accounts in Belgium, while in 1998 their number had increased to more than 10 million.
[5] Cheques' treatment is a labour intensive task. Moreover their relative cost have risen as the nominal value decreased constantly.

individual banks to join their forces. These are the two national debit card based systems that built two thick networks in competition. Beside the large investments required, financial institutions strongly sustained these projects because of the advantage of important cost reduction in the manual processing for routine tasks. The need for interoperability - also sustained by merchants - induced the two systems to merge in a unique nation-wide scheme. In 1989, the two former brands were brought together under a same logo: Bancontact/Mister Cash, under the control of a single company running them, Banksys. Nowadays, almost all of Belgian banks participate to Bancontact/Mister Cash.

The story of credit cards is parallel to the one of debit cards. Actually the credit card market in Belgium is divided in two brand groups: Diners Club and American Express on one side, and Visa and MasterCard and the other side. Diners Club and American Express were the first to be introduced, but their diffusion, as in other European countries has always remained marginal. Today these cards are offered mainly within company schemes and have a limited acceptance. These have a more or less constant share of about two percent of the credit card market. Differently, the penetration of MasterCard and Visa keeps on growing. Visa and MasterCard have three issuers and acquirers in Belgium, two banks and a bank' association, Bank Card Company (BCC). The latter gathers all remaining banks and handles the big majority of Visa and MasterCard's business[6]. BCC traces its history back to 1982 when the Crédit Européen Belgium issued the first Visa card and started affiliating merchants. In 1988, almost all Belgian banks enter as shareholders and the company takes the name of BCC. Four years later BCC merges with Eurocard Belgium. This is the beginning of the interoperability at a national level between Visa and Eurocard/MasterCard[7].

In 1995 Banksys launched a pilot project of electronic money, Proton, and the following year the national-wide implementation started with a phased expansion, city-by-city. This was one of the first e-money projects at a national scale.

In a recent study by Van Hove[8] it was revealed that the use of Proton cards dropped from 2.37 transactions per card, per month, in December 1996, to 1.65 in September 1999. However, at end 1999 Proton was, among the main electronic purse schemes in Europe, the one with the highest number of activated[9] cards as percentage of total population as well as the one with the highest average amount outstanding per person. It has to be noted that the total float on Proton cards if compared with cash is still

[6] BCC holds a market share for MasterCard and Visa cards of more than 80 percent.
[7] In the rest of the paper we will refer to Eurocard/MasterCard cards simply as MasterCard for sake of parsimony.
[8] Van Hove, 2000.
[9] Defined as cards activated at least once.

negligible: it corresponds to about 0.24% of the amount of outstanding currency (Van Hove, 2000).

To sum up, Belgium has a relatively high use of cards' payments if compared to the average of European countries. But currency still accounts about 75 percent of retail payments[10] - also helped by the diffusion of ATMs -, despite the fact that the share of total money stock is continuously decreasing.

Card transactions all together only account for 10 percent of total transactions. The debit card is, without any doubt, the most popular cashless instrument for domestic transactions. Since the beginning of the 1990s, the number of payments by means of debit cards almost quadrupled. The number of transactions amounted to almost 300 million in 1998[11]. Nevertheless, the popularity of the other two kinds of cards, credit and Proton, is increasing. In 1998, payments in Belgium using credit cards rose by 12.5%, while the transactions with Proton increased from 10 to 28 million. During the same period, the use of cheques decreased by 6 million (12.3%)[12], Over the period 1990 and 1998, payments by cheques have decreased by more than 56%[13]. During the last few years the banking system has applied a lot of effort to promote electronic payments. As Figure 2 shows, they may have had some success.

A few words are needed also about cheques. In the Nineties the decline in the use of cheques of small amount (less than BF 1000) accelerated considerably in Belgium. As Figure 2 shows, during the last decade the number of cheques issued has more than halved[14]. Currently cheques represent 1.25 percent of all payment in terms of number of transactions. Although we do not dispose of any statistic concerning their use, we can presume that only a small proportion of them is used for everyday payments. An explanation for such a strong reduction seems to be the substitution of cheques by electronic payments for their higher security and wide acceptability[15]. This is a reason why we do not account for their effect in our empirical estimation of cash demand.

[10] In this regard it is interesting to remark that from 1991 banks were allowed to charge a share of actual costs of the payment services they provide. This action had as a purpose not only the decrease of banks' costs but, indirectly, also to give incentives to customers to shift towards more efficient instruments, notably cards. Nevertheless this new tariff system had essentially no effect on the use of notes and coins.

[11] Source: Banksys.

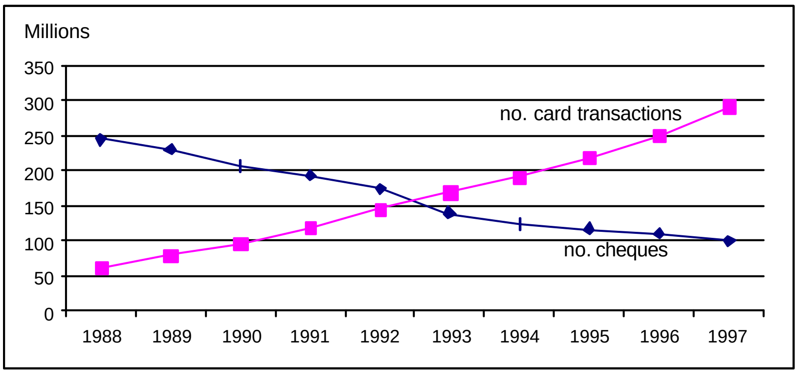
[12] This figure takes into account only inter-banking transactions and must thus be considered as an underestimation of the total.

[13] ABB, 1999.

[14] Between 1990 and 1998 cheques decreased by 56.5 percent (ABB, 1999).

[15] Humphrey *et al*., 1996.

Figure 2: Use of Cheques and Cards



3. Cash substitution in the literature

In the literature many studies focus on money demand, however, only few of them consider explicitly the demand for money in retail transactions in relation with alternative payment instruments.

One of these is by Bos (1993) who quantifies the possible influence of the introduction of prepaid electronic purses for small payments on the circulation of coins and banknotes in EU countries. He assumes that all transactions below a certain amount are carried out by means of electronic purses and also assumes a full acceptance by both consumers and merchants. He does this research approximating for all countries the Dutch payments pattern and finds large differences among the EU countries. In general the number of banknotes is more affected than their value. With regard to Belgium, the author shows that the value of currency used for transaction purposes might decrease by an amount between 1.5% and 48.4% depending on the substitution of cash by electronic purses for all transactions below respectively 2 and 20 ECU. However, this kind of approach can be criticised since it assumes a particular behaviour for consumer and merchant. Differently, Markose and Loke (2000) start from a transaction Baumol-Tobin cash balance equation and extend it with the choice between cash and cards in order to find the equilibrium where both media are used. Their model implies that for a given supply of cash, interest rates are lower with respect to an economy where only cash is used. Moreover at low interest rate regimes, for higher card network coverage the interest rate elasticity for cash-cards substitution is even bigger. Such a conclusion can have important implications for the monetary policy.

Somewhere linked even if in a microeconomic perspective is the study by Attanasio *et al.* (1998), which estimates the demand for money in Italy between 1989 and 1995 using a dataset of detailed information about households and firms. The finding for households is particularly interesting: consumption and interest rate elasticity are significant and differ among households depending on the possession of ATM cards. In Particular, the demand for money of households who holds an ATM card is much more elastic to interest rate than that of households who do not (-0.59 compared to -0.27). This difference is reflected in different transaction technologies for the two groups of households. The implication for inflation is that the welfare loss of inflation is much higher among households with a more sophisticated transaction technology as the latter raises the interest sensitivity of the demand for money.

Other empirical studies are, for instance, the one by Duca and Whitesell (1995). They study the effect of credit cards on money demand using a cross-sectional data about US households. The result is that credit card ownership is associated with lower checking and money balances and with less transaction deposits, while it has no significant effect on short time and total deposits. It is estimated that for every 10 percent increase in the probability of owing a card, current account balances are reduced by 9 percent and money fund balances by 11 percent. Blanchflower *et al.* (1998) draws similar conclusions: credit cards allow households to reduce their transactions and precautionary demand for money[16] and, again, the size of the reduction is large (about US$ 800 over the year). Boeschoten (1992) makes a micro-economic analysis of payment habits in the Netherlands in 1990. This reveals that the use of ATMs, cheques and POS terminals significantly reduces cash holdings. On the whole Boeschoten finds that the users of alternative payment media pay the same amount of cash with 20 percent lower cash balances. Humphrey, Pulley and Vesala (1996) come to similar conclusions by analysing 14 developed countries.

Less positive results concerning cash substitution are the ones of Snellman and Vesala (1999). They look at to the electronification of non-cash payment in Finland - that during the 1980s and 1990s proceeded very fast - and consider in what extent non-cash payment means are used as substitutes for cash. The process of cash substitution and electronification of payment is modelled as "S"-shaped learning curves and generate forecasts by extrapolating these curves. The result of the study suggests that the 'S'-shaped curves are steep and have short slow-growth phase at both the ends. Cash substitution seems to be saturating already. The use of cash remains quite high in retail payments and is forecasted not to fall below the 65% during next ten years. The electronification process at the moment is proceeding rapidly, but it already starting to slow down. In the same line, Snellman *et al.* (2000) estimate a money demand equation using panel data for several European countries. They find strong evidence of a substitution effect between cash and cards, ATMs and POS terminals[17].

[16] They measured demand for money by current account balance.
[17] We will comment more extensively their results in section 5 because of their close comparability with our results.

The estimated elasticity are then used to derive the S-learning curve for the 10 countries. It is showed that the nature of the substitutions of cash is similar across the countries considered, and that the development stage of each country crucially depends on the diffusion of the card payment infrastructure. The spread presence of both ATM and POS terminals (slope and speed) has a negative effect on outstanding money. Belgium, Finland, France and Denmark seem the more mature in cash substitution and close to the saturation with a 60 percent of cash rate use. The Netherlands and Switzerland have started to accelerate, while Germany, Italy and the UK go very slowly (with a cash rate use of 95 percent).

4. Economic theory

The stability of the money demand function is crucial in the conduct of the monetary policy as it enables a policy driven change in monetary aggregates to have a predictable influence on output, interest rate and prices. Because of its importance a rich theoretical and empirical research has been carried on. The most recent work is conducted through error-correction models (ECM), which provide significant emphasis on the time series characteristics of the data. This particular tool allows the economic theory to define the long run equilibrium, while the short-term dynamic is determined from the data. The theory suggests a long-run specification of the following form:

$$M^d / P = g(I,R, \bullet) \tag{1}$$

where M^d is the nominal money demanded, and P is the price level, so that the demand of money is a demand for real balances and is a function of a scale variable (I), as a measure of economic activity, and opportunity cost variables (R), to indicate the foregone earnings by not holding assets or instruments which are alternatives to money. Finally ($\bullet$) stands for other variables. Despite the wide range of different models analysing the demand for money from different angles, the implications are common. In all cases the optimal stock of real money balances is inversely related to the rate of return on earning assets, i.e., the interest rate and, positively related to real income. The empirical analysis of money demand estimation takes this conclusion as a starting point (Sriram, 1999).

The intrinsic characteristics of money led to theories based on explicit motives for holding it. This study is based on the medium of exchange function of money, where income and interest rate capture the transaction demand for money[18] and where three card variable are also included, to reflect innovation in the retail payment infrastructure. The justifications for adding payment card variables is that cards should be considered as substitutes for notes and coins, and consequently, a higher rate of card use should imply a portfolio shift away from money.

5. Empirical estimation

In order to test to what extent currency demand can be substituted by alternative means of payments, notably bankcards, we have estimated a currency demand equation. The bankcards evolution in Belgium was explicitly taken into account, from the introduction of cards up to now, including the most recent financial innovation, electronic purses.

We estimate a long-run money demand relation in (semi-) log-linear form, over a period of 40 years i.e.[19]

$$m_t = \beta_0 + \beta_1 y_t + \beta_2 R_t + \beta_3 card_t + \beta_4 accept_t + \beta_5 atm_t + \varepsilon_t \qquad (2)$$

where *m* is the real money holdings per person corrected for the share used for hoarding purposes[20], with money defined as currency (notes and coins) in circulation outside the banking sector, *y* is real GDP[21] per capita, *R* is the short term money market rate[22], [23] *card* is the number of cards with debit or credit function plus the number of activated electronic purses per 1.000 inhabitants[24], *accept* is the number of merchants accepting any cards per 1.000 inhabitants. In particular, this series is

[18] Standard economic theory puts forward that the demand for an asset depends on its opportunity cost. Although in this study we mainly consider the transaction demand of money, we try to measure the substituting potential of card payments. In that sense, the opportunity cost of holding narrow money (notes and coins) has practical meaning as long as there are alternatives to currency to make transactions.

[19] Variables in small cases are in logarithms.

[20] Transactions balances have been computed by subtracting the amount of currency in hoards derived from the estimates of Van Hove and Vuchelen (1999) from total currency in circulation. In fact, in the past, the hoarding share was quite relevant. These hoards are not used for transaction purposes for different motives. A main reason is to hold currency for precautionary purposes. This phenomenon concerns mostly higher note denominations (Boeschoten and Fase 1992, Van Hove and Vuchelen 1999). Moreover, usual circulation figures also include coins that have been lost.

[21] 1990 is the base year.

[22] Rate at which short-term borrowings are effected between financial institutions.

[23] Very often money demand equations include also the rate of inflation among explanatory variables. In this study we did not do so for sake of parsimony due to the restricted number of observations. However, according to Sriram (1999, p25) ‘nominal interest rates alone are sufficient in money demand models. […] The justification is that when moderate inflation prevails in the economy, variations in nominal interest rates can capture the variations in the expected rate of inflation.’

[24] We believe that for our purpose the number of card transactions could better reflect cards’ use then the number of cards. However such a series was not available for the period considered, that is why we use as explanatory variable the number of activated cards.

constituted by the sum of the number of points of sale accepting debit, credit and Proton cards separately, that is, it allows for double counting if the same shop accepts more than one card. This measure was chosen to put emphasis on the larger service offered by such shops, in the sense that they can satisfy more cardholders and thus increase the possibility for substituting cash with cards. *Atm* is the number of cash dispensing ATMs every 1.000 inhabitants[25]. The model is based on annual data[26] from 1960 until 1999. Because of the log linear form, all coefficients can be interpreted as long-run elasticity of money demand with respect to the different variables, except for the coefficient of *R*, which is a long-run semi-elasticity.

We expect *y* to have a positive sign and *R* negative. We also expect *accept* to be negative as it reflects the substitution effect of debit and credit cards and, more recently, electronic money. *atm* reflects the effect of a substitute cash provision method and could be positive or negative: as the number of ATMs increases, cash is easier to get, so people use it more. Given the long period considered, this latter effect could dominate. Finally, *card* incorporates the two previous effects because cards are both used to withdraw money at ATMs and to carry on transactions at the point of sales. Their sign will depend on which one of the two mentioned effects dominates.

Figure 3 plots the time series used in the empirical analysis. A visual inspection shows a trending behaviour for most of the variables, suggesting non-stationarity, while interest rate and money corrected for hoarding could give the - erroneous - impression of being stationary. In fact, the econometric tests show that all variables (included money and interest rate) are I(1) that is, they are stationary after differentiating once. We checked that none of the variables is I(2), so they all have the same order of integration[27]. Thus a cointegration study provides an analytical and statistical framework to determine the long-run relationship between non-stationary variables. The cointegration analysis of a single equation with more than two variables can result in more than one cointegrating relationship. The unknown number of cointegrating vectors and the need to allow variables to be potentially endogenous limits the usefulness of single equation models. The multivariate VAR approach developed by Johansen (1988) is an appropriate procedure to determine the correct cointegration relationships.

[25] The data for money, GDP, population, CPI and interest rates come from the International Financial Statistics (IFS) database of the IMF. The series of card variables are builds from information coming from several sources: Bank Card Company, Banksys, Belgian Bank Association, ECB (2000), KBC, National Belgian Bank (PAYSYS statistics), Van Hove (2000), Visa European Union Region.

[26] Unfortunately for card variables it was not possible to find data with higher frequency.

[27] To check for stationarity we performed the Augmented Dickey-Fuller test, the Phillips-Perron and Schmidt-Phillips test. They all gave similar results, they strongly accepted the unit root hypothesis while the I(2) hypothesis was always rejected.

Figure 3: The data

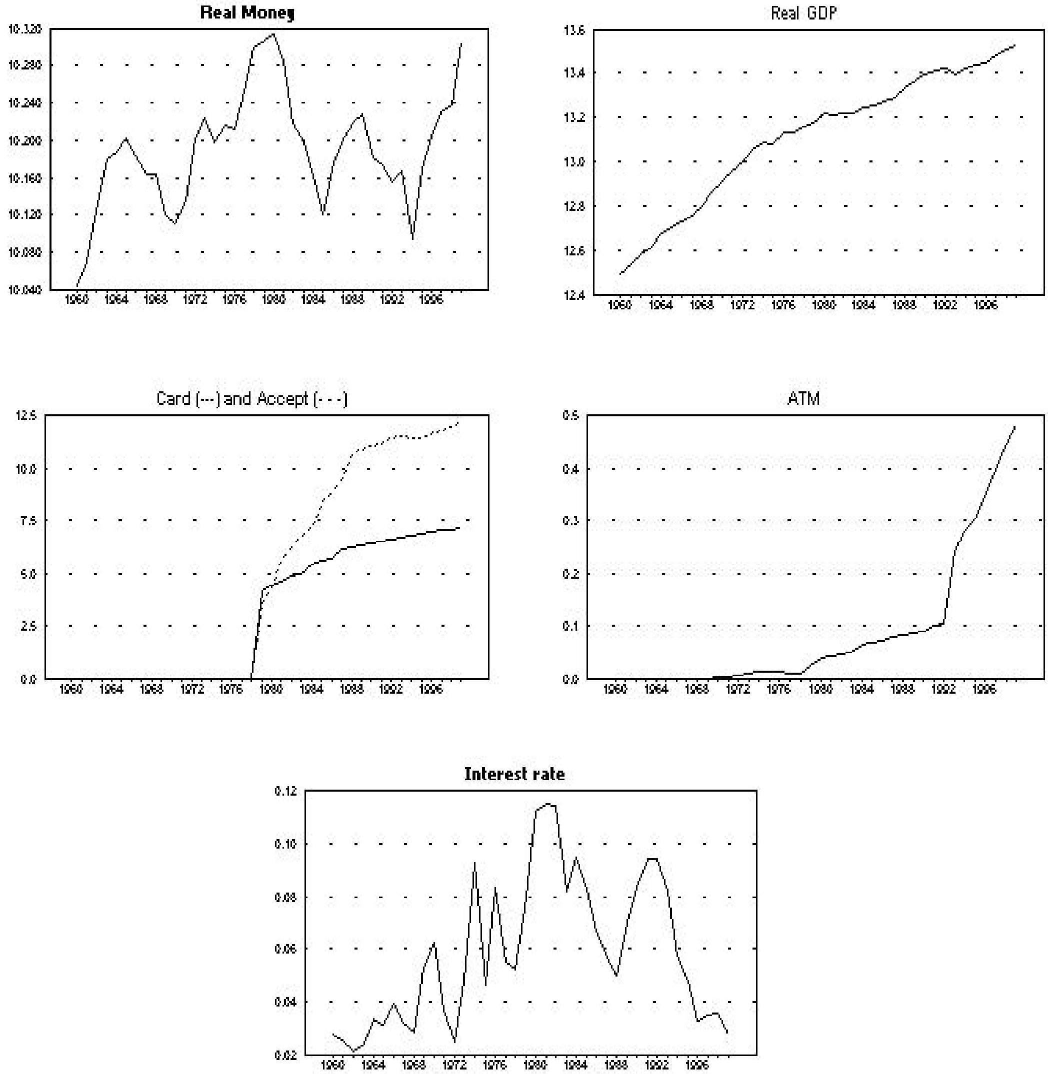


Table 2: Lag length analysis[28]

	AIC	HQ	SC	GODF2
k = 1	-36.025	-35.289	-33.957	96.299
k = 2	-36.392	-35.104	-32.772	86.009

[28] AIC, HB and SC are Akaike, Hannan-Quinn and Schwartz information criteria; GODF2 is Godfrey 'portmanteau' test for the null hypnotises of white noise residuals versus the alternative of AR(2) residuals.

We proceed with the Johansen approach by formulating a *p*-dimensional autoregressive representation for the process $X_t = (m_t, y_t, R_t, card_t, accept_t, atm_t)$ such that

$$\Delta X_t = \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-i} + m_t \ , \tag{3}$$

with

$$\Pi = \boldsymbol{ab}' \ , \tag{4}$$

where $Ã_i$ = -(I -A_1 -…- A_i), *Ð* = -(I -A_1 -…- A_k), i = 1, …, k-1 and *m* is NID(0,Σ). This specification contains information on both short- and long-run adjustment to changes in X_t thorough the estimates of *Ã* and *Ð* respectively. *á* denotes the speed of adjustment to disequilibrium, while *â* is the matrix of long run coefficients, so that $âX_{t-1}$ represents the *r* cointegrated relationships. So *á* and *â* are of dimension $k \times r$. The test for cointegration in a multivariate system corresponds to determine how many *r* (n-1) cointegration vectors exist in *â* by maximum likelihood estimation. Thus, testing for cointegration amounts to find the rank of *Ð*, i.e. the number of *r* linearly independent columns in *Ð*. If the rank of *Ð* is zero, then the variables are not cointegrated, while if *Ð* has full rank, it means that the variables in *X* are stationary.

Table 2 shows the test for the selection of the maximum lag of the VAR: a VAR with k = 2 appears well specified. A longer memory has not been tested due to lack of degrees of freedom.

According to the test for trend polinomial, the model fitting the series best is the one with a constant and linear trend in the series (the I(1) components) and only an intercept in the cointegrating equations (the I(0) components)[29]. The model was also checked according to Harris (1995) who suggests, when performing the test for cointegration rank, *r*, to compare the test statistics of the different models and choose the first one that does not reject. Indeed the trace test confirms the finding of trend polinomial test (see Table 3).

With regard to specifications tests, residuals are white noise, but we could not accept the normality hypothesis[30] for the three card variables and, as a consequence, also for the full system. This must be due to the fact that, although the estimation period starts in 1960, cards appear only in the late '70s[31]. In any case, the Johansen test is considered robust to non-normality of the data[32].

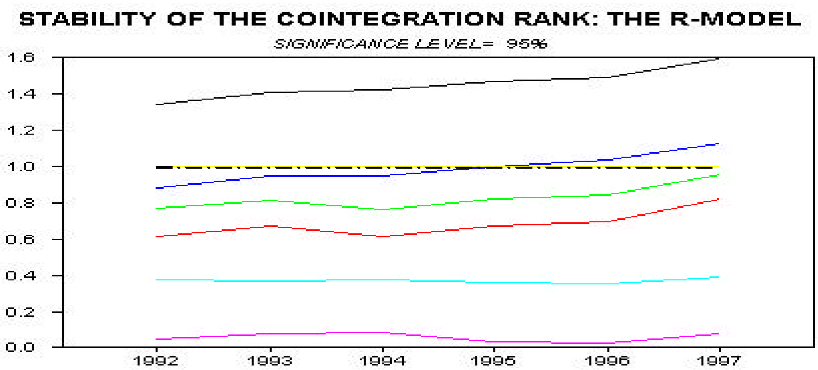
The results from the application of the Johansen procedure are summarised in Table 3[33]. From the trace test based on 95% critical value, the selected rank would be 2.

[29] Test statistic = 0.693, significance level = 0.405
[30] The performed tests are the Madia multivariate normality test and Jarque-Bera normality test.
[31] Yet the two normality tests are accepted when the starting date is shifted to the 1978.
[32] Cheung and Lai (1993).
[33] All estimates were carried out using Malcolm for Rats.

However from the plot of the stability of the cointegration rank, the rank equal to 1 could be selected in many cases; this could also be more intuitive. Even though we select $r = 2$.

Table 3: Trace tests for the cointegration rank (*r*)

	Trend	Statistic	95%	97.5%
r = **0**	0	150.01	94.15	98.33
r = **0**	restricted	173.82	114.90	119.29
r = **0**	unrestr.	150.98	104.94	109.62
r **1**	0	77.21	68.52	71.80
r **1**	restricted	100.48	87.31	91.06
r **1**	unrestr.	77.81	77.74	80.94
r **2**	0	44.90	47.21	50.35
r **2**	restricted	66.04	62.99	66.25
r **2**	unrestr.	49.54	54.64	57.79
r **3**	0	24.26	29.68	32.56
r **3**	restricted	43.21	42.44	45.42
r **3**	unrestr.	27.42	34.55	36.94
r **4**	0	5.96	15.41	17.52
r **4**	restricted	23.05	25.32	27.75
r **4**	unrestr.	8.48	18.17	20.13
r **5**	0	0.29	3.76	4.95
r **5**	restricted	5.18	12.25	14.21
r **5**	unrestr.	1.99	3.74	4.85



After restricting the rank of the long run cointegration matrix to be two, we test for long run stationarity, exclusion and weak exogeneity. The results are reported in Table 4, together with test for the identification of the cointegration vectors. We found that all variables are non-stationary and that none of them should be excluded. We also found that *card* is weekly exogenous. This means that the row of *á* corresponding to Ä*card* is equal to zero, then, the equation for Ä*card* does not contain information about the long run *â*, since the cointegration relationships do not enter this equation. In other words, this variable can enter only on the right-hand side of the VECM.

Table 4: Summary of results from Johansen procedure

Chi square test (2) for	**m**	**y**	**R**	**card**	**accept**	**atm**
stationarity	20.61**	14.40**	18.07**	14.18**	16.26**	11.79**
exclusion	6.53**	6.37**	13.02**	33.30**	27.52**	31.03**
weak exogeneity	17.83**	11.07**	6.96**	1.64	10.26**	9.16**

Chi square test (2): 3.125 Sign. Level: 0.210

Cointegrating vectors	**$â_1$**	**s. e.**	**$â_2$**	**s. e.**
m	1		1	
y	-1		-1	
R	21.63	1.80	5.83	0.91
card	-0.15	0.08	0.22	0.04
accept	0.11	0.05	-0.12	0.03
atm	3.59	0.23	0	
trend	0		0.03	2.03e-003

The loadings	**$á_1$**	**$á_2$**
m	0.15	-0.19
y	-0.04	4.56e-003
R	-0.05	0.05
card	-0.74	1.45
accept	-1.42	3.35
atm	0.07	-0.06

H_0: $á_{21}=á_{31}=á_{41}=á_{51}=á_{61}=0$ Chi square test (16): 17.21 Sign. level: 0.23

Note: * and ** indicate rejections at 10% and 5% significance level, respectively.

The Johansen procedure does not only allow to establish the number of cointegration vectors, but also to identify them, by imposing restriction in (3) for a given value of *r*. Such restrictions should be motivated by economic arguments (Harris, 1995). For the identification of the two cointegrating vectors we include a trend in the model. This allows us to identify the six variables in a unique equation by conditioning the trend equal to zero. In particular the cointegrating vectors $\hat{a}$ are estimated by restricting the trend coefficient being equal to zero and imposing unit income elasticity in the first vector and, by restricting *atm* equal to zero[34] and unit income elasticity in the second. These restrictions are accepted for any usual critical value. Once the $\hat{a}$ are identified, the loading matrix is uniquely determined. Table 4 shows the estimated coefficients and their standard errors.

The cointegration relationships which we found can be consistently interpreted as long-run money demand equations. However we give particular attention on the first vector as it included all the variables of interest. Looking at the estimated coefficients, one can see that the demand of notes and coins for transaction purposes is negatively affected by an increase in short-term interest rates, whose long-run semi-elasticity is quite strong (respectively 21.6 and 5.8 percent). In the first vector the number of cards seems to increase the demand for cash, which is quite counterintuitive. In the long run merchant acceptance has the effect of reducing cash holdings, as expected. Also ATMs have a strong negative impact on money holdings. This is explained by the fact that they have improved the ease of getting cash, suggesting that people withdraw just the amount of cash needed for small transactions in the near future, without the need to keep big amounts of money in their wallet. This is also consistent with the recent tendency observed of increasing number of monthly withdrawals of small amounts (ABB, 1999). Although, given the long period under consideration, the effect of ATMs could have been positive as well. Apparently the recent negative effect dominates the positive one.

Notice that in the second vector identified, *card* has the expected sign while *accept* does not. Arguably a multicollinear effect among the two variables cannot be excluded.

Comparing our results with the ones of Snellman et al. (2000), we note that the latter do not exibit wrong signs as we do. However their coefficient for cards is not significant at 99 percent confidence level. Besides, their elasticity for card variables is slightly smaller in magnitude, in particular the one for ATMs[35]. Of course, the

[34] This strategy was chosen according to Johansen and Juselius (1992). They propose, among other possibilities, to place the same restrictions on all cointegrating vectors spanning $\hat{a}$, to see whether a particular structure holds in all cointegration relations. In this study we follow the same methodology, but in order to identify the vectors, we are forced to impose different restrictions for at least one variable in each vector.

[35] The elasticity they find are -0.09, -0.09, -0.20, for terminals, cards and ATMs, respectively.

comparability of the two studies is limited, mainly because of the different period taken into consideration (1987-1996 for them and 1960-1999 for us). Moreover they consider several countries using panel data.

The next step consists in considering the long- and short-run at the same time through a (vector) error correction model. In doing that it would be nice to get rid of one of the two cointegrated vectors identified in order to have a single equation error correction model. However, at that stage it is not possible to select one of the two. We will be able to do that only by imposing further restriction on the speed of adjustment parameters, á. In particular, we test $á_1$ = (1 0 0 0 0 0 0) and $á_2$ = (0 * * * * * *), which means that all variables but money are exogenous in the first cointegration vector, while all other alphas are left unrestricted in the second vector. The test is accepted (see Table 4), which allows us to abandon the multivariate structure (Harris, 1995). In that way, we have started from a full model and after determining the restrictions to be placed on á and â, we now estimate the conditional model in the next section.

6. A dynamic model of money demand

For the Granger representation theorem (Engle and Granger, 1987) if a vector of variables is cointegrated, then there exists an error-correction representation of the data. Thus, we now proceed to the estimation of a parsimonious model of univariate error correction model. This formulation of the dynamic model is particularly convenient for several reasons. First, under the assumption that the variables are cointegrated, this model incorporates short and long run effects, where the coefficient for the error correction term measures with what distance the system is away from equilibrium at time t. Secondly, in an error correction model, all the terms are stationary; thus the standard regressions techniques can be used for inference, with no risk of spurious regressions.

The estimation spans again the period 1960 to 1999. The results of the model with the error correction term conditioned according to the findings of previous section are as follows:

$$\Delta m_t = 0.046 + 0.34\Delta m_{t-1} + 0.10\Delta m_{t-2} + 1.37\Delta y_{t-1} - 1.47\Delta R_{t-1} + 0.014\Delta card_{t-1} +$$

(0.14) (0.56) (0.57) (0.02) (0.03) (0.45)

$$+ 0.019\Delta card_{t-2} - 0.004\Delta accept_{t-1} - 0.037\Delta accept_{t-2} - 0.68\Delta atm_{t-1} + 0.42\Delta atm_{t-2} +$$

(0.27) (0.83) (0.05) (0.02) (0.17)

$$+ 0.05(m_{t-1} - y_{t-1} + 21.63R_{t-1} - 0.148card_{t-1} + 0.105accept_{t-1} + 3.59atm_{t-1}) + m_{1t}$$

(0.04)

T = 37	R^2 = 0.588	S.E. of regr = 0.028	
F-stat = 3.252 (0.007)	Norm = 1.31 (0.52)	ARCH(2) = 0.435 (0.65)	HET= 1.78 (0.20)
LM (1) = 1.425 (0.243)	LM (3) = 0.580 (0.63)	Chow = 0.605 (0.79)	

In parenthesis are the p-values. The Q-test could never reject the null hypothesis of zero residual autocorrelation. The same is valid for the Breusch-Godfrey Serial Correlation LM test. Overall, the results of the tests indicate that the test is well specified, the residuals seem not to suffer from autocorrelation, heteroskedasticity and non-normality. As far as the stability of the parameters is concerned, the Chow Forecast test accepts the null of no structural change in the model before and after 1990. Finally the CUSUM test (not shown here) do not signal any instability in the equation during the sample period.

The coefficient for the error correction term is significant. That confirms again that a long run relationship exists between currency in circulation and, income, interest rate, the number of ATMs, the number of cards and the merchants accepting them. With regard to the size of the coefficient, this tells something concerning the speed of adjustment of disequilibrium. The larger the coefficient, the greater the response of the variables to the previous period’s deviation from long run equilibrium. In this case, the coefficient is rather small, to indicate that the currency is unresponsive to last period’s equilibrium error, or, put differently disequilibria are corrected very slowly.

7. Simulation analysis

This section focuses on the study of the dynamic effects produced by structural shocks on the behaviour of the variables considered. To do that we come back to the multivariate system and we carry out impulse response function analysis (IRF) and forecast error variance decomposition (FEVD).

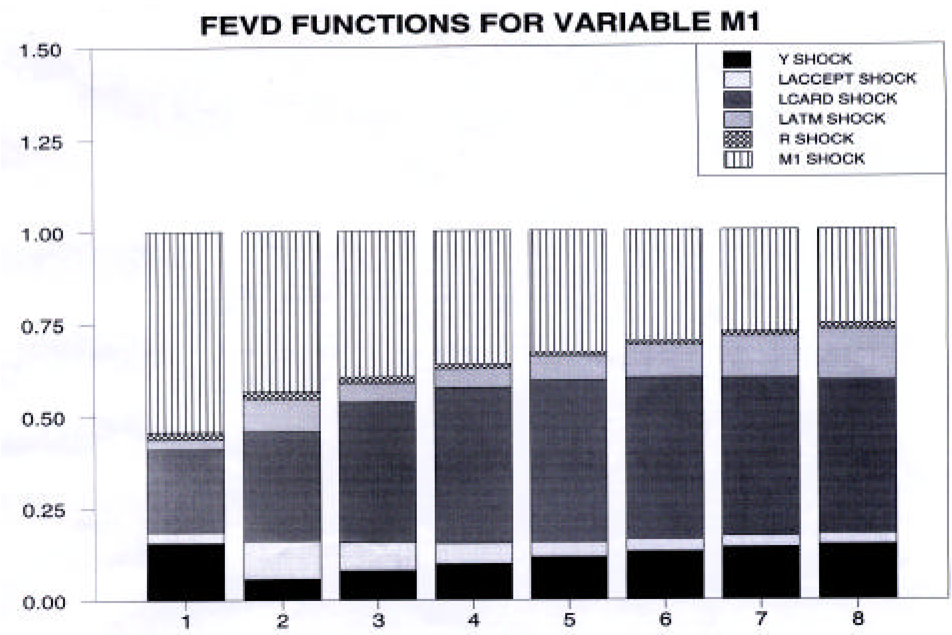
The impulse response function concerns the study of dynamic responses of the level of each variable to an innovation of one standard deviation in each identified structural disturbance. In other words, we measure the response of one variable at time *t+s* to an impulse in the same or another variable at time t, keeping constant all other variables.

We identify the structural VAR using the Cholesky decomposition of the matrix of covariance in order to give a structural interpretation to the innovations (Sims, 1980, 1992). This method is based on a contemporaneous recursive structure among the systems' variables that depend on their ordering. In particular, since the matrix of the impact multipliers is lower triangular, an asymmetry is introduced in the system implying a particular ordering of the variables. This means that, the decomposition constraints the system such that a shock in one variable has no direct effect on the variables that precede, but it does have an indirect effect, in the sense that its lagged values affect the contemporaneous value of the preceding variables. However a shock in the preceding variables has a contemporaneous effect on both the variable itself and on the ones that follow (Enders, 1995, Hamilton, 1994). We use the order: GDP, merchants, cards, ATMs, interest rates and finally money. That means, that money does not have any contemporaneous effect on the other variables but it is immediately affected by all of them.

The figures in Appendix show a selected choice of impulse response functions, together with their calculated one standard deviation asymptotic bounds. One can see that most of them are statistically significant at least for the first two to three years. Let us first have a look to the reaction of currency. A shock in GDP has a positive, permanent (and significant) effect. Such shock makes GDP to jump and then stabilises after one period to a level higher than the initial one. Shocks due to an increase in the number of cards, and in the number of merchants accepting them have, as expected, similar negative impact on currency. Money rises in the first year reacting to *accept* (maybe because of some noise), but afterwards it decreases monotonically to a level lower that the initial one. In the case of cards, money decreases right from the beginning and the effect in stronger. Interestingly, the reaction of currency to a positive shock in ATMs has a first a negative impact but that becomes positive after one year, suggesting that ATMs contribute to the easy availability of money. This finding is different from what was found in the cointegrated relations, suggesting that short- and long-run behaviour do not always correspond. Of course one might not ignore the limits of this kind of predictions as the model could very likely suffer from small sample problems. Hence, the results of these impulse responses should be taken very carefully. With regard to the behaviour of card variables, they all have a permanent (significant) reaction to their own one-period impulse. Moreover the *card* reacts positively (and permanently) to *accept* and the reverse is also true, to indicate the presence of network effect typical of card systems. At the contrary, ATMs barely react to an impulse in cards, telling maybe that in the case of ATMs the effect of network externalities is starting to slow down. Different orderings of the variables were tried, but the responses looked always very similar, which suggests that our results are not sensitive to the Cholesky ordering.

The forecast error variance decomposition completes the dynamic analysis carried out through the impulse response function, in order account for the relative importance of the different shocks. In fact, the forecast error variance decomposition provides information about the proportion of the movements in a sequence due to "its" own shock versus shocks to the other variables. Since the forecast error variance decomposition suffers from the same identification problem of the impulse response function, we identify the shocks again using the Cholesky decomposition. In the following figure the findings for cash are showed. It can be seen that the influence of card variables increases over time. This is particularly true for cards and ATMs.

Figure 4: Forecast error variance decomposition for Money



8. Conclusions

In the last decades payment instruments have seen a large evolution. As a result, cash has progressively been substituted by alternative instruments for all kinds of transactions. Accordingly, the amount of currency in circulation as a percentage of GDP has decreased in all European countries. Nevertheless, notes and coins are still the preferred and most used instrument for retails transaction with the consequence that nowadays cash use is mainly confined to low-value retail transactions.

In this paper we consider a model of money demand for retail transactions over the period 1960-1999, where we add to standard variables of the money demand theory (GDP and interest rate) the effect of bank-cards as a potential for cash substitution. We account for this by using information concerning the card payment infrastructure, i.e. the number of outstanding cards, the number of shops with card terminal and the number of ATMs in Belgium.

We focus on the long run properties of our data by means of the multivariate Johansen procedure. This allows us to identify two stable cointegration relationships. We find that over the period 1960-1999 card payments have contributed to the reduction of money demand. This is a strong finding if one thinks that cards started to be used for retail payments in Belgium only in the late Seventies. In particular we find that the elasticity of money demand to ATMs has a negative sign, meaning that ATMs contributed significantly to money reduction. Similarly the number of merchants with POS terminal also had an impact on cash substitution. The evidence for the number of cards is less clear but this could be due to a multicollinear effect between the number of cards and the number of merchants accepting them.

When cointegration holds, if there is any shocks that causes disequilibrium, there exists a well-defined short-term dynamic adjustment process such as the error-correction model mechanism that pushes back the system towards the long run equilibrium. Hence, in the light of the result of the cointegration analysis, we specify a conditional error correction model that contains information on both short- and long-run properties of the model, where disequilibrium is interpreted as a process of adjustment to the long-run model. As a confirmation we find that a long-run relation between currency and cards exists. However, since the coefficient of the error correction term is small, it can be argued that currency responds very slowly to disequilibria. Finally, we forecast future developments of money demand with respect to card payments by simulating impulse response functions. The identification problem is solved using the Cholesky decomposition, which implies an ordering of the variables. Again we find that currency decreases due to a positive shock in the number of cards and of POS terminals. Surprisingly the amount of currency increases following an ATM shock. We also find some evidence of network effects between cards and POS terminal, in the sense that cards react positively to an increase of POS terminals but the contrary is also true. Rather, ATMs barely react to an increase in the number of cards, which suggests that the ATMs infrastructure is approaching saturation in Belgium.

Given our findings one could argue that the card payments are substitutes for notes and coins and that the substitution process is already taking place. It cannot be denied that everywhere in Europe the use of electronic money, the most advanced retail payment instrument, has taken off more slowly than what was expected. An explanation could be that consumers and merchants adapt their payment habits rather slowly. Nevertheless the change towards a more efficient and convenient payment system is gradually taking place. Given the high cost of currency provision and transmission our findings are relevant also in light of the impact cards can have in the future cost reductions related to currency.

References

Amisano G. and C. Giannini, 1997, *Topics in Structural VAR Econometrics*, second edition, Springer Verlag, New York.

Association Belge des Banques, 2000, *Vade-mecum statistique du secteur bancaire 1999*, Aspects et documents 205.

Association Belge des Banques, 1999, Tendance des paiements en 1998: forte augmentation des paiements électroniques, http://www.abb-bvb/fr/press/199902.html.

Association Belge des Banques, 1998, *Vade-mecum statistique du secteur bancaire 1997*, Aspects et documents 195.

Association Belge des Banques, 1997, *Vade-mecum statistique du secteur bancaire 1996*, Aspects et documents 191.

Association Belge des Banques, 1989, *Vade-mecum statistique du secteur bancaire 1988*, Aspects et documents 93.

Association Belge des Banques, 1988, *Vade-mecum statistique du secteur bancaire 1987*, Aspects et documents 78.

Association Belge des Banques, 1987, *Vade-mecum statistique du secteur bancaire 1986*, Aspects et documents 63.

Association Belge des Banques, 1985, *Vade-mecum statistique du secteur bancaire 1984*, Aspects et documents 39.

Attanasio O., Jappelli T. and L. Guiso, 1998, The Demand for Money, Financial Innovation, and the Welfare Cost of Inflation: An Analysis With Households Data, NBER working papers 6593, June.

Bank for International Settlements, 1997, Statistics on payment systems in the Group of Ten countries: Figures for 1996, Basle, December.

Bank for International Settlements, 1995, Statistics on payment systems in the Group of Ten countries, Basle, December.

Bank for International Settlements, 1989, Payment systems in eleven developed countries, Basle.

Beyer A., 1998, European Money Demand and the role of UK for its stability: A cointegration analysis, April.

Blanchflower D.G., Evans, D.S. and A.J. Oswald, 1998, Credit cards and Consumers, NERA Working Papers, December.

Boeschoten W., 1992, *Currency Use and Payment Patterns*, Financial and Monetary Policy Studies, 23, Kluwer Academic Publishers, Norwell, MA, the US.

Boeschoten W.C. and M.M.G. Fase, 1992, The demand for large banknotes, *Journal of Money, Credit and Banking*, 24, 3, August, 317-337.

Bos J.W.D., 1993, Effects of prepaid chipcards on note and coin circulation, Research Memorandum WOE nr.9314, De Nederlandsche Bank, June.

Cheung Y.W. and K.S. Lai, 1993, Finite-sample sizes of Johansen's likelihood ratio test for cointegration, *Oxford Bulletin of Economics and Statistics*, 55, 313-28.

Coenen G. and J.-L. Vega, 1999, The demand for M3 in the euro area, Working Paper no. 6, European Central Bank, September.

De Grauwe P. and C. Costa, 2001, Monetary Policy in a Cashless Society, Discussion Paper Series 2696, CEPR, London.

De Grauwe P., Buyst E. and L. Rinaldi, 2000, The costs of cash and cards compared. The cases of Iceland and Belgium, mimeo.

Duca J. V. and W.C. Whitesell, 1995, Credit Cards and Money Demand: A Cross-sectional Study, *Journal of Money, Credit, and Banking*, 27, 2, May, 604-23.

Enders W., 1995, *Applied Econometric Time Series*, John Wiley and sons, New York.

Engle R. and C.W.J. Granger, 1987, Co-integration and error Correction: Representation, Estimation and Testing, *Econometrica*, 55, 2, 251-76.

Ericsson N. R., 1998, Empirical Modeling of Money Demand, 'Money Demand in Europe' *Empirical Economics*, 23, 3, 295-317.

European Central Bank, 1999, The effect of technology on the EU banking system, July.

European Central Bank, 2000, Payment systems in the EU, February.

European Monetary Institute, 1996, Payment Systems in the European Union, Frankfurt am Main.

Evans D. and R. Schmalensee, 1999, *Paying with Plastic*, MIT Press, England.

Favero C.A., 1998, *Econometria, modelli e applicazioni in macroeconomia*, Carocci editore, Roma.

Böhle K., Rader M. and U. Riehm, 1999, Electronic Payment Systems in European countries: Country Synthesis Report, Forschungszentrum Karlsruhe, September.

Hamilton J.D., 1994, *Time Series Analysis*, Princeton University Press, Princeton NJ.

Harris R., 1995, *Using Cointegration Analysis in Econometric Modelling*, Prentice Hall-Harvester Wheatsheaf, London.

Humphrey D., Pulley L. and J. Vesala, 1996, Cash, Paper and Electronic Payments: A Cross-Country Analysis, *Journal of Money, Credit, and Banking*, 28, 4, November.

Johansen S., 1995, *Likelihood-Based Inference in Cointegrated Vector Auto-Regressive Models*, Oxford University Press, New York.

Johansen S., 1988, Statistical Analysis for Cointegration Vectors, *Journal of Economic Dynamics and Control*, 12, 2, 231-54.

Johansen S. and K. Juselius, 1992, Testing Structural Hypothesis in a Multi-Variate Cointegration Analysis of the PPP and UIP for UK, *Journal of Econometrics*, 53, 211-44.

Krediet Bank, 1995, Le coût de la monnaie fiduciaire, *Bulletin hebdomadaire*, 1, 13 January.

Krediet Bank, 1991, Bancontact/Mister Cash, mimeo.

Markose S, and Y. Loke, 2000, Network effect on cash-card substitution in transactions and low interest rate regimes, March 2000, forthcoming, draft version.

Mosconi R., 1998, *MALCOLM: The theory and the practice of cointegration analysis in RATS*, Cafoscarina, Venezia.

Mosconi R. and C. Giannini, 1992, Non-Causality in Cointegrated Systems: Representation, Estimation and Testing, *Oxford Bulletin of Economics and Statistics*, 54, 3, 399-417.

Reimers H.-E., 1992, Comparisosn of tests for multivariate cointegration, Statistical Papers, 335-59.

Santomero A.M. and J.J. Seater, 1996, Alternative Monies and the Demand for Media of Exchange, *Journal of Money, Credit and Banking*, 28, 4, November.

Sims C., 1992, Interpreting the macroeconomic time series facts. The effects of monetary policy, *European Economic Review*, 36, 975-1011.

Sims C., 1980, Macroeconomics and reality, *Econometrica*, 48, 1-49.

Snellman J., 2000, Evolution of Retail Payments in Finland in the 1990s, Bank of Finland Discussion Papers 19/2000, Helsinki.

Snellman J., Vesala J. and D. Humphrey, 2000, Substitution of Noncash Payments Instruments for Cash in Europe, Bank of Finland Discussion Papers 01/2000, Helsinki.

Snellman J. and J. Vesala, 1999, Forecasting the Electronification of Payments with Learning Curves: The Case of Finland, Bank of Finland Discussion Paper 8/99, Helsinki.

Sriram S., 1999, Survey of Literature on Demand for Money: Theoretical and Empirical Work with Special Reference to Error-Correction Models, International Monetary Found Working Papers 99/64, May.

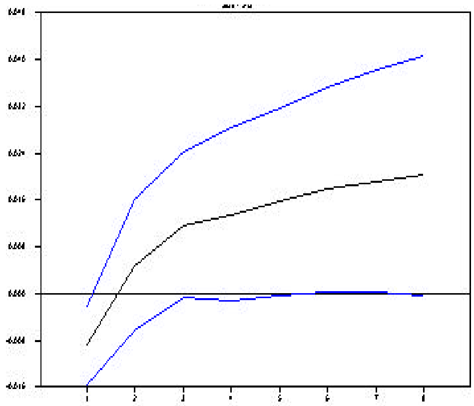
Van Hove L., 2000, Electronic purses: (which) way to go?, *First Monday* (The Peer-Reviewed Journal on the Internet), 5, 7, July.

Van Hove L. and J. Vuchelen, 1999, Currency hoarding in Belgium: an Update, *Revue de la Banque*, 7, 336-346.

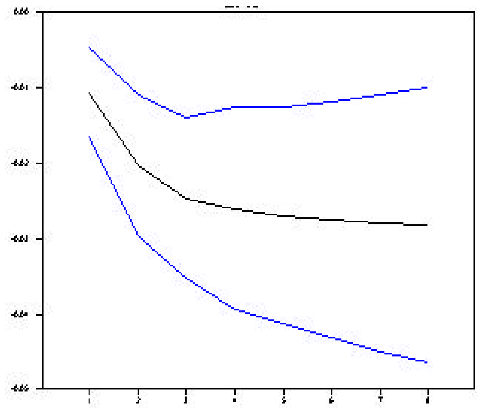
Verbeek M., 2000, *A Guide to Modern Econometrics*, John Wiley and sons, New York.

Appendix: Impulse response functions

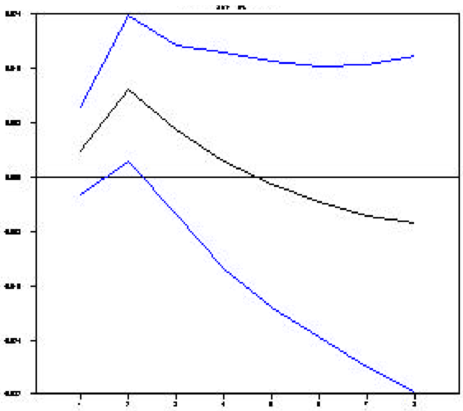
Resp. of M to Y



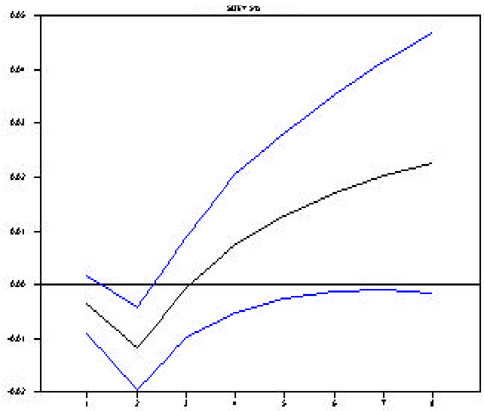
Resp. of M to CARD



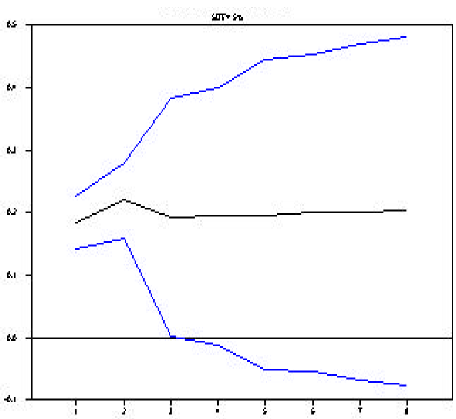
Resp. of M to ACCEPT



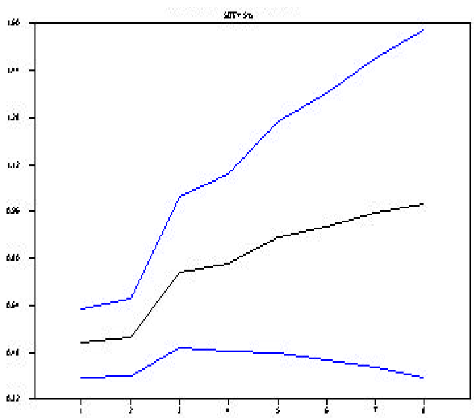
Resp. of M to ATM



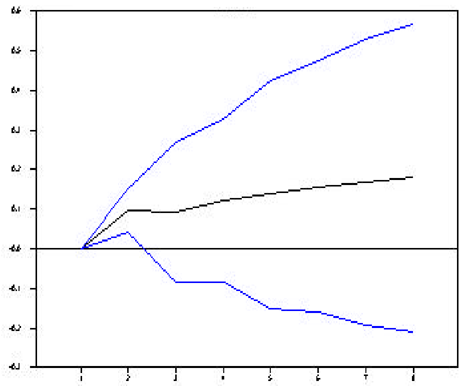
Resp. of CARD to CARD



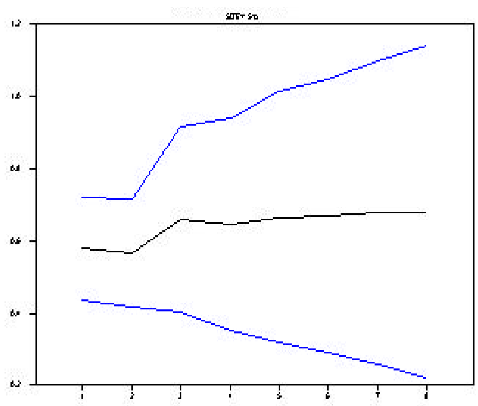
Resp. of ACCEPT to ACCEPT



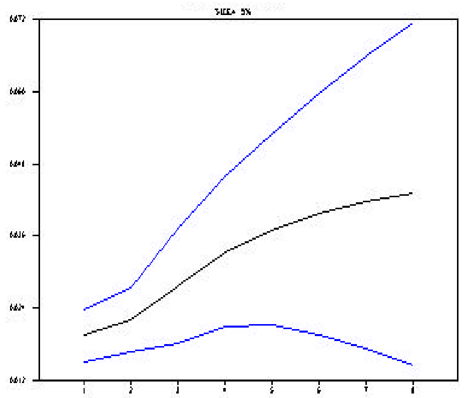
Resp. of ACCEPT to CARD



Resp. of CARD to ACCEPT



Resp. of ATM to ATM



Resp. of ATM to CARD