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Transformation of Payment Systems: The Case of European Union Enlargement*

Francisco Callado, Jana Hromcova and Natalia Utrero**

Abstract

In this paper we present a general equilibrium model on payment choice at retail level. We analyze how the accession to an economic and monetary union, and the influence of new institutions may shape the evolution of consumers' payments in newly acceded countries. The model suggests that accessing countries approach accepting group attitudes towards payment choices as a consequence of institutional pressure and technology development. We apply the results of the model to 2004 European Union enlargement process. Results confirm the relevance of institutional environment and technology development in retail payment system decisions of newly acceded countries.

Keywords: cash; payments; European Union enlargement.

JEL codes: E42, E51, G21, O52.

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1 Introduction

Following the continuous development of information technology, retail payment systems have been in clear evolution in the last years. Cash is no longer the unique possibility of making a payment and shares relevance with other instruments like cards, direct debits or some other electronic means. Accordingly, managers of financial institutions and other professionals are very interested in knowing how consumers make payments in their daily operations. This evolution has also attracted the attention of financial authorities in two respects. First, because one of their responsibilities is to promote efficiency and security in the use of payment instruments and in the payment system as a whole (European Central Bank (ECB), 2010). Second, since this development affects cash demand and therefore money supply, it could have implications for monetary policy.

The evolution of retail payments differs across countries (Humphrey et al., 1996, Humphrey et al., 2001, Humphrey, 2004, Callado and Utrero, 2004). The literature on payment systems has focused mainly on price and non-price characteristics and incentives as drivers of these differences. However, major divergences in payment composition between Western Europe, the US and Japan are not due only to price or cost, but are also the result of important disparities in these countries' technological innovations, geographical size or culture (Humphrey, 2010). These discrepancies, for instance, explain the reason why Europe has a well-established nationwide electronic payment system while the US continues to rely importantly on checks. Further, apart from Markose and Loke (2003), most money demand models only use interest rates and income to measure the consumers demand for cash and do not consider the fact that the existence of new technology could significantly reduce the demand for cash, Scholnick et al. (2006). There are some interesting contributions, however, that analyze the effect of technological innovations in banking, in particular, automatic teller machine networks in consumers' decisions (Snellman and Virén, 2006, Ferrari et al., 2007 and Yang and Ching, 2010). Together with these factors, institutional environment and national regulations shape financial market design (La Porta et al., 1997) and may as well have an influence on payment system development and usage. In fact, codes related to international bodies, such as the Committee on Payment and Settlement Systems, serve as a guide to develop sound financial systems (BIS, 1994). To the best of our knowledge institutional factors have not been included in the analysis of payment systems.

This paper tries to fill this gap by focusing on institutional and technological characteristics both from a theoretical and empirical point of view. In particular, the paper analyzes how the process of entering an economic and monetary union and the influence of new institutions could shape the evolution of consumers' payments in newly acceded countries (NAC). The conclusions of the theoretical analysis are then tested on the particular case of European Union (EU) expansion, accession of Eastern European countries. This context is particularly challenging because the enlargement process has proven to be successful in providing institution's building and structural transformation to Eastern European countries (Dabrowski and Radziwill, 2007). On May 1st, 2004 the EU welcomed 10 more countries as a part of its largest enlargement ever. The accession of the new members increased the EU population by nearly 20% but the EU's total gross domestic product (GDP) increased just 4% (Hildebrandt, 2002).[1] The NAC accession negotiations

[1] Including Romania and Bulgaria that entered in 2007.

required the implementation of the *acquis communautaire*, the set of laws that underpin the common market. As a result, NAC financial systems were expected to be transformed to such an extent that the supervisory and legal framework will reach more or less EU standards. Moreover, EU financial sector has also been experiencing a profound change - deregulation, disintermediation, technological change and single currency - representing, in fact a moving target to the NAC's authorities (Stirbu, 2004).

These countries are also expected to join the European Monetary Union (EMU) and adopt the single currency Euro, which will also affect the way payments are made, both large value and retail ones. Nowadays, the use of payment instruments in NAC differs from the uses and customs of EU15 (Callado and Utrero, 2007). In this setting, it is important to remark that security, reliability and efficiency are critical features for new payment solutions to be adopted. Therefore, the priority of NAC is to develop modern, robust and efficient market infrastructures which serve the needs of their economies and facilitate the development of safe and efficient financial markets.[2] As part of the EU, these countries must also participate and work in the adaptation of their payment systems to Single Euro Payment Area (SEPA), see ECB-SEPA (2010), and follow the guidelines of the European Central Bank with respect to both retail payment systems and instruments (BIS, 2005). The inherent changes of this process involve an economic effort on the part of the institutions and of the financial firms.

In light of the above discussion, the first objective of the paper is to develop a theoretical model that can describe the effects that the accession to an economic and monetary union can have on household payment choice and intermediation costs. We assume that consumers have two ways of acquiring consumption goods, cash and electronic payments, and that technology is crucial for the development of the payment system. Our theoretical model builds on Ireland (1994a) and Hromcová (2008). We use a learning-by-doing setup with proportional intermediation cost. Knowledge improvement leads to more sophisticated payment system and cheaper electronic transactions. That makes agents in a more developed economy use more electronic payments than in a less developed one. In the process of accession, the less developed economy (accessing country) gradually adapts to the payment system of the more developed economy (accepting country). As a consequence, agents' payment choice approaches the one of the consumers in the country with more developed payment system. The second objective of the paper is to estimate the results of the model. For that, we use data on EU payment systems for countries accessing in 2004 and those accepting the NACs. Furthermore, data availability allows us to study the joint effect of institutional environment and banking market structure on payment decisions.

The rest of the paper is organized as follows. Section 2 presents the theoretical model. Section 3 presents the empirical analysis. Finally, section 4 concludes.

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[2] These countries started the design and implementation of new payment systems in the late 90's following the objectives relating to the integration in the EU (ECB, 1999).

2 Theoretical Model

We will consider two economies which differ in the initial level of development. At the beginning they are two separated islands and can have different monetary policies. With the accession moment approaching, their monetary policies must converge and at the moment of accession a common monetary policy applies in both islands. After the unification takes place, the accessing country is gradually adopting the payment system technology of the more developed one. They maintain their own structure and other variables unchanged otherwise. Technology level is crucial for the payment system. The higher the technology achieved, the cheaper the non-cash payments. As a measure of technology, we will use the level of capital in the sense of the learning-by-doing model, Barro and Sala-i-Martin (1995). Because the learning-by-doing model can be reduced to an AK model, for simplicity of our theoretical setup, we assume that the production function has the linear form. However, we keep reminding the reader that the level of capital is the measure of achieved knowledge, and higher knowledge leads to higher technological level.

2.1 Accessing country

2.1.1 Household Problem

In the description of the model we follow closely Ireland (1994a) and Hromcová (2008). The behavior of households in both islands is analogous. Both economies consist of a large number of infinitely lived households. All households have identical preferences, production and trade opportunities. Therefore, we present the model for the island which begins with lower level of technology and at the end of the section we generalize the model for the other island.

Households inhabit the following environment: they face continuum of spatially separated markets, which are indexed by $j \in [0, 1]$. All households live in market 0, and the index j indicates the distance from home. In each market j a distinct perishable good is produced and sold in every period. Goods are thus indexed by j, which corresponds to the market of both production and trade. The representative household has the preferences given by

$$\sum_{t=0}^{\infty} \beta^t \int_0^1 u\left[c_t(j)\right] dj \tag{1}$$

where β is the discount factor, $c_t(j)$ is defined as the consumption at period t of the good produced in market j, $u(\cdot)$ is strictly increasing, strictly concave and twice continuously differentiable, with $\lim_{t\to\infty} u'\left[c_t(j)\right] = \infty$.

The production and trade is like in Lucas and Stokey (1983). Each household is composed of a worker-shopper pair. Prior to any trading, government fixes the level of the gross nominal interest rate R_{t+1} between periods t and $t+1$. We will assume that $R_{t+1} > 1$. Agents enter the period t with certain amount of monetary balances Z_t and the debt B_t, carried over from the previous period, and the capital stock k_t that represents the technology level achieved. A representative worker decides to produce on any of the markets j via the net production function

$$y_t = Ak_t \tag{2}$$

where A is the net productivity of capital.[3]

First, the goods market opens and consumption takes place. Worker stays at the market j during the whole period. Shopper visits various markets to acquire consumption goods carrying all the monetary balances of the household.

Two ways of acquiring consumption goods are allowed: using money or electronic payments. All goods purchased with government issued money will be referred to as cash goods. Goods purchased via electronic payments will be referred to as electronic goods.

Nominal monetary balances Z_t can be used to buy goods in some of the markets indexed by j. Cash purchases are subject to the liquidity constraint

$$\int_0^1 \left[1 - \xi_t(j)\right] c_t(j) dj \leq \frac{Z_t}{p_t}, \tag{3}$$

where $\xi_t(j) = 0$ if a good is purchased on market j with cash, or $\xi_t(j) = 1$ if a good is purchased on market j via an electronic payment and p_t is the price level.

As said above, agents can use an electronic payment to pay for the consumption. The financial intermediary enables electronic payments at a cost $\gamma_t(j)$ that is given for each market j and period t. The part of output that is not consumed is devoted to the investment into capital. After the goods market closes, the monetary holdings of agents are augmented by a lump sum transfer X_t from the government. The amount X_t is endogenously determined in the system according to the given nominal interest rate, so that the money demand is totally satisfied. As the next step, the securities market opens. During the securities trading session households choose their currency holdings Z_{t+1}. They also purchase (or issue) one-period nominally denominated pure discount bonds paying B_{t+1} units of money at period $t+1$ while they cost $\dfrac{B_{t+1}}{R_{t+1}}$ units of money at period t. Bonds are in zero net supply. The budget constraint agents are facing can be written

$$\int_0^1 \left[c_t(j) + \xi_t(j)\gamma_t(j)\right] dj + k_{t+1} + \frac{Z_{t+1}}{p_t} + \frac{B_{t+1}}{R_{t+1}p_t} \leq Ak_t + \frac{Z_t}{p_t} + \frac{B_t}{p_t} + \frac{X_t}{p_t}. \tag{4}$$

2.1.2 Financial Intermediation

We assume that the intermediation cost must be paid by the buyer, as motivated in Ireland (1994b). To be able to purchase without cash, some resources must be devoted to making the non-cash payment itself available such as checking the identity of the buyer or his ability to pay. When the shopper is far away from home (market zero) the communication becomes more difficult, and therefore we assume that the payment to the intermediary increases with j. The process of learning-by-doing gives a potential for the development of new technologies. It also leads to an increase in income per worker and

[3] Thanks to the AK technology, we can write the net production function as

$$y_t = (A' + 1 - \delta)\, k_t.$$

It corresponds to the one defined in the equation (2), where A' is the marginal productivity and δ is the depreciation of capital.

higher consumption. Higher purchase means that checking the ability of the buyer to pay is more relevant. The development and diffusion of new technologies allows to decrease the processing costs.

The real payment made to the intermediary is characterized by a function that fulfills properties found in some empirical studies, as described in Hromcová (2008): the intermediation cost is lower in richer countries, the cost of intermediated payment diminishes over time, and the cost elasticity is close to zero, i.e. the cost is proportional to consumption purchase. We specify the intermediation cost function as a composition of three parts

$$\gamma_t(\cdot) = \gamma^{\text{location}}(j)\, \gamma^{\text{technology}}(k_t)\, \gamma^{\text{consumption}}\left[c_t(j)\right]. \tag{5}$$

The time independent part of the payment, $\gamma^{\text{location}}(j)$ is strictly increasing with the distance from home, strictly convex, twice continuously differentiable, and similarly to Ireland (1994a) we assume

$$\gamma^{\text{location}}(0) = 0 \text{ and } \lim_{j \to 1} \gamma^{\text{location}}(j) = \infty. \tag{6}$$

The function $\gamma^{\text{technology}}(k_t)$ is strictly decreasing, strictly convex, twice continuously differentiable and $\lim_{t\to\infty}\gamma^{\text{technology}}(k_t) = 0$. The time dependent part of the intermediation cost, $\gamma^{\text{technology}}(k_t)$, embodies the effect of new technologies on the cost. It includes the state of the technology frontier as well as the net of electronic infrastructures to perform the electronic payments. This cost decreases as the level of technology develops. The more capital is accumulated, the more knowledge is available, better technologies can be developed and cheaper intermediation services can be offered. The other time dependent part of the intermediation cost, $\gamma^{\text{consumption}}\left[c_t(j)\right]$, is increasing, linear in consumption and $\gamma^{\text{consumption}}(0) = 0$.

We thus concentrate directly on the effect of new technologies on the intermediation cost. However, the scale economies are also present, because higher stock of knowledge is associated with higher volume of transactions.

2.1.3 Payment choice

Consider a given level of k_t. The cost of cash goods is the same in all markets, it corresponds to the nominal interest rate. The cost of electronic goods increases with the distance from home, taking into account the assumption on the time independent part of the intermediation cost $\gamma^{\text{location}}(\cdot)$, equation (6). Whenever $R_{t+1} > 1$, there will exist at each time t an interval of markets where the intermediation cost for electronic purchases is lower that the nominal interest rate, and an interval where it is higher. Therefore, there will exist a market with cutoff index $s_t \in (0,1)$, such that in all markets with indexes $j < s_t$ consumers will use electronic payments and in all markets with indexes $j \geq s_t$ consumers will use cash to acquire the consumption goods. Thus households will choose cash goods in markets far away from home (market 0) and electronic goods in markets close to home. In the cutoff market consumers are indifferent between using cash or electronic payments. We arbitrarily assume that cash will be used at the cutoff market. In our specification the level of new knowledge increases over time. Changes in k_t affect the payment to intermediary related to technology $\gamma^{\text{technology}}(k_t)$. Technology development and interest rate are thus factors that affect the cutoff index s_t. We illustrate the effect of technology development and monetary policy on the cutoff market in Figure 1.

Define

$$c_t(j) = \begin{cases} c_t^0(j) & \text{when } \xi_t(j) = 0, \\ c_t^1(j) & \text{when } \xi_t(j) = 1. \end{cases}$$

The functions $c_t^0(j)$ and $c_t^1(j)$ characterize the cash and electronic consumption per market j, respectively. We can then write the utility function, budget and cash-in-advance constraint in a following way

$$\sum_{t=1}^{\infty} \beta^t \left[\int_0^{s_t} u\left[c_t^1(j)\right] dj + \int_{s_t}^1 u\left[c_t^0(j)\right] dj \right], \tag{7}$$

$$\begin{aligned} \int_0^{s_t} \left[c_t^1(j) + \gamma_t(j)\right] dj + \int_{s_t}^1 c_t^0(j) dj + k_{t+1} + \frac{Z_{t+1}}{p_t} + \frac{B_{t+1}}{R_{t+1} p_t} & \\ \leq A k_t + \frac{Z_t}{p_t} + \frac{B_t}{p_t} + \frac{X_t}{p_t} & \end{aligned} \tag{8}$$

and

$$\int_{s_t}^1 c_t^0(j) dj \leq \frac{Z_t}{p_t}. \tag{9}$$

2.1.4 Equilibrium

Definition: Given the set of initial conditions k_1, Z_1, B_1, p_1 and the sequence of nominal interest rates $\{R_{t+1}\}_{t=0}^{\infty}$, the equilibrium consists of sequences $\{c_t^0(j),\, c_t^1(j),\, k_{t+1},\, Z_{t+1},\, B_{t+1},\, s_t,\, X_t,\, p_{t+1}\}_{t=1}^{\infty}$ such that

(a) a representative household is maximizing the discounted utility (7) subject to the budget constraint (8) and the cash-in-advance constraint (9), choosing the sequences $\{c_t^0(j),\, c_t^1(j),\, k_{t+1},\, Z_{t+1},\, B_{t+1},\, s_t\}_{t=1}^{\infty}$,

(b) markets for goods, money and bonds clear in every period,

$$A k_t = \int_{s_t}^1 c_t^0(j) dj + \int_0^{s_t} c_t^1(j) dj + \int_0^{s_t} \gamma_t(j) dj + k_{t+1}. \tag{10}$$

$$Z_{t+1} = Z_t + X_t, \tag{11}$$

$$B_{t+1} = 0. \tag{12}$$

Let λ_t and η_t be the non-negative Lagrange multipliers associated with the budget constrain (8) and the cash-in-advance constraints (9), respectively. The equations that characterize the equilibrium are the above mentioned market clearing conditions (10),

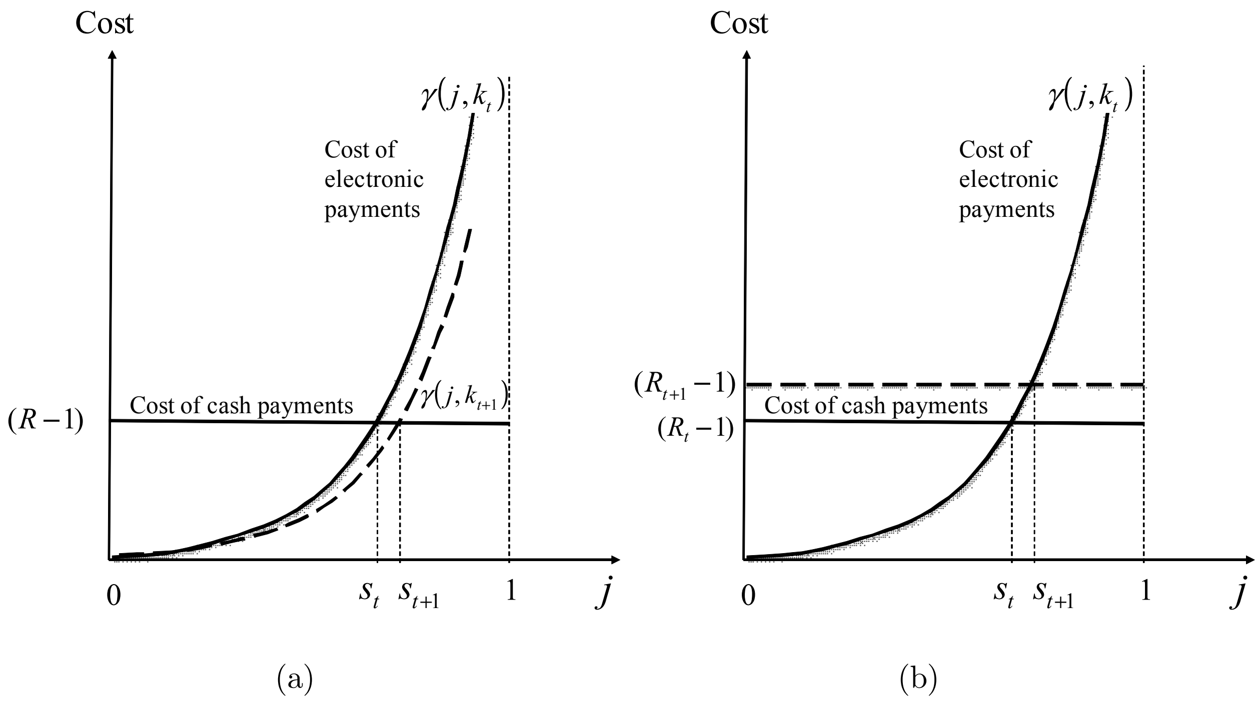

Figure 1: (a) Effect of technology development on cutoff market: setting the nominal interest factor constant, $R_t = R_{t+1} = R$, and assuming that $k_{t+1} > k_t$, we can observe that $s_{t+1} > s_t$; (b) Effect of monetary policy on cutoff market: setting the capital level constant, $k_{t+1} = k_t$, and assuming that $R_{t+1} > R_t$, we can observe that $s_{t+1} > s_t$.

(11), (12) and the first order conditions on consumption, capital, nominal balances, nominal bonds and cutoff index, respectively,

$$
\begin{aligned}
u'\left[c_t^0(j)\right] &= \lambda_t + \eta_t, && (13)\\
u'\left[c_t^1(j)\right] &= \lambda_t, && (14)\\
\lambda_t &= \beta\lambda_{t+1}A, && (15)\\
\frac{\lambda_t}{p_t} &= \beta\frac{\lambda_{t+1}+\eta_{t+1}}{p_{t+1}}, && (16)\\
\frac{\lambda_t}{p_t} &= \beta R_{t+1}\frac{\lambda_{t+1}}{p_{t+1}}, && (17)\\
u\left[c_t^0(s_t)\right] - u\left[c_t^1(s_t)\right] &= -\lambda_t\left[c_t^1(s_t)+\gamma_t(s_t)\right] + (\lambda_t+\eta_t)c_t^0(s_t). && (18)
\end{aligned}
$$

Using (13), (14), (16) and (17), we can rewrite the first order conditions on both consumptions as follows:

$$
\begin{aligned}
u'\left[c_t^0(j)\right] &= R_t\lambda_t, && (19)\\
u'\left[c_t^1(j)\right] &= \lambda_t. && (20)
\end{aligned}
$$

From the first order condition (18) we get the payment to the intermediary to be paid at the cutoff market

$$\gamma_t\left[s(R_t,k_t)\right] = \frac{1}{\lambda_t}\left\{u\left[c_t^1(\lambda_t)\right] - u\left[c_t^0\left(R_t,\lambda_t\right)\right]\right\} + R_t c^0\left(R_t,\lambda_t\right) - c^1\left(\lambda_t\right). \qquad (21)$$

Taking into account the expressions (19), (20), and (5), the equilibrium on the goods market (10) can be rewritten as

$$Ak_t = \int_{s(R_t,k_t)}^{1} c^0\left(R_t,\lambda_t\right)dj + \int_0^{s(R_t,k_t)} c^1\left(\lambda_t\right)dj + \int_0^{s(R_t,k_t)} \gamma_t(j)dj + k_{t+1}. \qquad (22)$$

The current period output is spent between cash consumption, electronic consumption, payment to the intermediary and investment. The real monetary balances, which equal the amount of cash consumption purchased in all markets, are

$$m_t = \left[1 - s(R_t,k_t)\right]c^0\left(R_t,\lambda_t\right), \qquad (23)$$

where

$$m_t = \frac{Z_t}{p_t}. \qquad (24)$$

The consumption via financial intermediaries, which equal the amount of electronic consumption purchased in all markets, is

$$e_t = s(R_t,k_t)\ c^1\left(\lambda_t\right). \qquad (25)$$

Thus the ratio of cash and electronic payments is dependent on the specification of the intermediation function, specification of the utility and the monetary policy in the previous period.

In order to see the behavior of the cash to electronic payments ratio we set up a parametric example with the CES utility function

$$u(c) = \begin{cases} \ln c & \text{for } \theta = 1, \text{ and} \\ \frac{c^{1-\theta}-1}{1-\theta} & \text{for } \theta \neq 1 \end{cases}$$

where $\theta > 0$ is the inverse of the elasticity of intertemporal substitution, and the following proportional intermediation cost [4]

$$\gamma_t(j) = \frac{j}{1-j}\gamma^{\text{technology}}(k_t)\; c^1(\lambda_t)\,. \tag{26}$$

We can then write the cutoff index combining (26) and (21) in the following form

$$s(R_t, k_t) = \frac{\phi(R_t)}{\gamma^{\text{technology}}(k_t) + \phi(R_t)} \tag{27}$$

where

$$\phi(R_t) = \begin{cases} \ln R_t & \text{for } \theta = 1, \\ \frac{\theta}{1-\theta}\left(1 - \frac{1}{R_t^{\frac{1-\theta}{\theta}}}\right) & \text{for } \theta \neq 1. \end{cases} \tag{28}$$

The cutoff index describes the proportion of markets in which agents employ services of the intermediary. From (15) we can get the evolution of the marginal utility of consumption, we can see that its growth rate is constant over time. The ratio of cash to electronic consumptions can be expressed as

$$\frac{m_t}{e_t} = \frac{\gamma^{\text{technology}}(k_t)}{\phi(R_t)R_t^{\frac{1}{\theta}}}. \tag{29}$$

The technology level (the part of the intermediation cost function that depends on the technology) and the monetary policy affect the composition of the payment methods as follows (recall that we assumed $\frac{d\gamma^{\text{technology}}(k_t)}{dk_t} < 0$)

$$\frac{d\left(\frac{m_t}{e_t}\right)}{dk_t} < 0 \quad \text{and} \quad \frac{d\left(\frac{m_t}{e_t}\right)}{dR_t} < 0. \tag{30}$$

2.2 Accepting Country

The specification of the accessing and accepting economy is the same. When writing the version of the model for the accepting country we use the analogous notation, substituting lower-case letters for capital letters and capital letters for blackboard bold ones, i.e. the level of technology in the accepting country will be denoted as K_t, the nominal interest factor between t and $t+1$ as $\mathbb{R}_{t+1}$.

[4] The time independent part $\gamma^{\text{location}}(j)$ is taken from Ireland (1994a).

2.3 Accessing Economy Before and After

Both economies know both initial conditions and when the accession takes place, i.e. T_{access} is given. Both economies can solve their respective maximization problems as all information is available to everyone. After the accession, the accessing economy is adopting the payment technology of the accepting country. We define k_t^{access} as the level of technology that determines the intermediation cost at each market after accession. Given that the accessing country's payment technology converges to the accepting one, the gap between the payment technologies of both countries will be diminished over time. The evolution of k_t^{access} will reflect the payment technology differences and will be a function of the levels of the payment technologies in both groups of countries

$$k_t^{\text{access}} = \Omega\left(k_{t-1}^{\text{access}}, K_t\right)$$

where $k_t \leq k_t^{\text{access}} < K_t$, $k_{T_{\text{access}}}^{\text{access}} = k_{T_{\text{access}}}$, $\lim_{t\to\infty} k_t^{\text{access}} = K_t$ and k_t denotes the level of capital in an economy that evolves independently of the accepting country because it does (did) not access, k_t^{access} accounts for the payment technology (capital) in the country where the accession actually happened, and K_t is the level of capital in the accepting country.[5] The intermediation cost function would be slightly modified and the ratio between the cash and electronic consumptions after the accession, equation (29), depends on the payment technologies of both groups of countries and the common monetary policy, $R_t = \mathbb{R}_t$

$$\left.\frac{m_t^{\text{access}}}{e_t^{\text{access}}}\right|_{t>T_{\text{access}}} = \frac{\gamma^{\text{technology}}\left[k_t^{\text{access}}\left(K_t\right)\right]}{\phi(R_t)R_t^{\frac{1}{\theta}}}. \tag{31}$$

Equation (31) implies that for given levels of payment technologies and a given monetary policy, any decrease in the real balances will have to be accompanied by an increase in the electronic goods. It also implies that the accession, that means higher level of payment technology, $k_t^{\text{access}} > k_t$, induces a drop in the ratio of cash and electronic payments, first element in (30).

3 Empirical analysis

According to equation (31) of the model, the use of alternative means of payment in the accessing countries is a function of the monetary policy as well as the technology level in the accessing and accepting countries. We interpret k_t (K_t) as the level of technology achieved and as the set of infrastructures developed to make payments. In order to empirically estimate this relationship, we take logs. Therefore, the baseline specification to estimate is

$$\ln(m_{it}/e_{it}) = \alpha_0 + \alpha_1(R_{it} - 1) + \alpha_2 \ln(k_{it}/K_t) + \varepsilon_{it} \tag{32}$$

where x_{it} represents a variable x in the accessing country i at time t, where $x = m/e$, $R - 1$, k/K are cash to electronic operations (dependent variable), nominal interest rate,

[5] An example of a convergence equation could be found in Lucas (2009).

and the ratio of payment technology level in the accessing countries to the payment technology level in the accepting countries (thus no index i), respectively. The error term ε_{it} is assumed to be normally distributed with zero mean and variance σ^2, $\varepsilon_{it} \sim N(0, \sigma^2)$. The estimation takes into account the possible existence of non observable heterogeneity. From the econometric point of view, the estimation of the coefficients, α_0, α_1 and α_2 should take into account the structure of the components of the error term ε_{it}, that is, the specific effects can be treated as fixed or random. If the effects are independent of the explanatory variables they form part of the error term, that in this case will be a compound term. When there is no correlation, the random effects are used since it is the most efficient alternative (Arellano and Bover, 1990), otherwise the fixed effect estimator is used. To test whether the effects are fixed or random, the Hausman statistic is used.

3.1 Data

We use panel data from the EU Eastern enlargement (2004-2007). In 2004 Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia joined the EU and Bulgaria and Romania were proposed for a later acceptance.[6] In order to have pre-accessing and post-accessing periods we take the period between 1996-2009. Data come from Eurostat and European Central Bank. Data on EU-15 and EMU is also available.[7] To allow for comparisons, all variables are expressed in euros and scaled by population.[8] We use data on cash and cards to account for the ratio of cash and non-cash operations (dependent variable). Short term (3-months) interest rate accounts for monetary policy as in Rinaldi (2001), among others. To proxy for the technology level achieved in the payment systems, we use two alternative variables widely used in the retail payment systems literature (Humphrey, 2010): per capita Automatic Teller Machines (ATM) and per capita Electronic Fund Transfers at Point of Sale (EFT-POS). The model suggests that both accessing and accepting level of technology affect payment operations. To operationalize this, the technology level achieved by accessing countries is divided by the average technology level of the accepting group. This ratio approaches the unity when accessing countries approach the accepting group. The benchmark case is the comparison between accessing countries and the EU-15, but since there is individual information on EMU countries, we estimate the model comparing accessing and EMU countries as well.

The model suggests that the institutional environment influences payment decisions. Accordingly, we introduce two alternative variables to capture the effect of accessing the EU. First, the *candidate* variable identifies the moment when the country received candidate status and official membership negotiations with Brussels started. Second, the *accessing* variable captures the moment when the country finally acceded.[9]

We also introduce a proxy for economic level (GDP per worker) to control for development and economic stability. Previous empirical papers (Humphrey, 2004, among

[6] From now on, when we refer to accessing countries we include all of them.

[7] EU-15 are Germany, France, Belgium, Netherlands, Luxemburg, Italy, Great Britain, Ireland, Denmark, Greece, Portugal, Spain, Austria, Finland and Sweden (in membership order). Great Britain, Denmark and Sweden are not part of the EMU.

[8] All variables are expressed in logs.

[9] In the estimation we take into account when the countries became members and therefore, from that moment in time, they are included in the accepting group.

others) find a positive relationship between economic development and electronic means of payments. Table 1 collects the definitions of the main variables and presents some descriptive statistics.

The two columns present the mean and the standard deviation for all accessing countries and for accepting countries (EU-15), respectively. Some interesting differences are evidenced between both sets of countries and all differences are statistically significant. First, the per capita currency in circulation in the accepting countries nearly doubles that of the accessing ones. This preliminary positive relationship is in line with previous evidence such as Drehmann et al. (2002), among others. Observing the other means of payment, accepting countries present higher level of card operations. In this case, accepting countries card operations are nearly four times the operations processed in their accessing counterparts. Accepting countries present also higher per capita EFT-POS and ATM, suggesting that the technology applied to payment systems is more widespread and developed than in accessing countries. If we look at the evolution along the period, it can be observed that card use and ATM per capita in both groups of countries exhibit an increasing trend and we can conclude that the accessing countries are heading towards the accepting ones, see Figure 2. Table 2 presents the correlation matrix of the main variables. Some pairwise correlations are very high (5 out of 21 are greater than 60%), especially ATM and EFT-POS present a correlation of 83%. To avoid multicollinearity problems, we do not include both variables together.

3.2 Results

Results for the benchmark case are presented in Table 3, panel A. Hausman test is presented at the end of the table. The test rejects the correlation of the effects in all runs and consequently, the random effect estimator is used.

We introduce ATM and EFT-POS variables one at a time. Further, the *accessing* and the *candidate* variable are introduced separately, except for the last two runs, columns 5 and 6. Both ATM and EFT-POS present a negative and significant coefficient. This indicates that the higher the value of the ratio (the closer accessing payment technology to the European one), the lesser use of cash, as expected from the results of the model. This result is consistent throughout the different specifications. EFT-POS coefficient confirms previous evidence that developed and widespread point of sale terminal networks reduce cash demand and use. Previous results on ATM are more inconclusive, some studies report a negative effect of ATM on cash use, whereas others present a positive effect (Stix, 2004). Our results are in line with the former. For example, Boeschoten (1992)

Table 1: Definitions of variables and descriptive statistics.

Variable	**ACCESSING COUNTRIES**	**ACCEPTING COUNTRIES**
Pccurrency	657.1531	1249.556
(per capita currency in circulation)	(704.4418)	(286.4857)
Pccardop	13.9415	52.5298
(*per capita card operations)*	(20.2578)	(4.5398)
Pceftpos	0.0063	0.01169
(per capita point of sale terminals)	(0.0068)	(0.0041)
Pcatm	0.0003	0.0006
(*per capita atm terminals)*	(0.0002)	(0.0001)
Pwgdp	18543.76	56978.71
(*per worker gdp)*	(10389.13)	(2571.081)
Irate	9.1054	3.0125
(*money market interest rate)*	(14.8071)	(0.5011)

Note: mean and standard deviation (in brackets) are reported.
Source: ECB and Eurostat.

Table 2: Correlations.

	Atm	Eft-pos	Interest rate	GDP	Accessing	Candidate
Atm	1.0000					
Eft-pos	0.8328*	1.0000				
Interest rate	-0.6417*	-0.6205*	1.0000			
GDP	0.7521*	0.7965*	-0.5205*	1.0000		
Accessing	0.4327*	0.3711*	-0.4374*	0.5443*	1.0000	
Candidate	0.4739*	0.2460*	-0.4404*	0.3426*	0.4201*	1.0000

*statistically significant at 0.05.

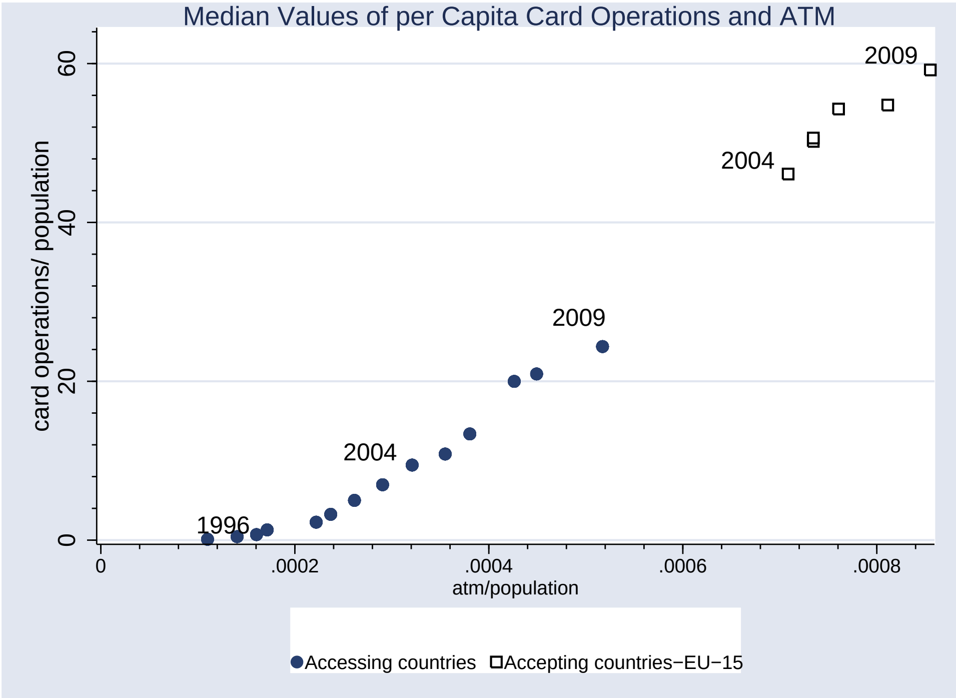

Figure 2: Relationship between technology (the number of automatic teller machines per capita) and the usage of cards (per capita card operations) in the accepting and accessing countries over the analyzed period.

Table 3: Basic Specification.

Panel A: Accepting Group European Union.

	(1)	(2)	(3)	(4)	(5)	(6)
Atm	-0.3792***		-0.4675***		-0.3792***	
	[0.0742]		[0.0756]		[0.0743]	
Eft-pos		-0.4722***		-0.5416***		-0.4722***
		[0.0573]		[0.0567]		[0.0573]
Interest rate	0.3414***	0.1791**	0.3870***	0.1910**	0.3415***	0.1791**
	[0.0768]	[0.0720]	[0.0805]	[0.0752]	[0.0768]	[0.0720]
GDP	-1.5284***	-1.0629***	-1.4293***	-0.9274***	-1.5284***	-1.0629***
	[0.2439]	[0.2361]	[0.2564]	[0.2432]	[0.2440]	[0.2361]
Accessing	0.9688***	0.7477***			0.9688***	0.7477***
	[0.2252]	[0.2023]			[0.2253]	[0.2023]
Candidate			-0.1299	-1.6594***	-2.1828***	-2.0338***
			[0.2897]	[0.3149]	[0.3902]	[0.3459]
Constant	12.8996***	8.4300***	12.9427***	9.4313***	15.0825***	10.4638***
	[2.4846]	[2.3950]	[2.4475]	[2.2496]	[2.3694]	[2.2972]
Observations	168	168	168	168	168	168
R2	0.62	0.66	0.63	0.64	0.63	0.66
Hausman test	9.43	6.36	5.85	1.77	9.26	6.37

Panel B: Accepting Group European Monetary Union.

	(1)	(2)	(3)	(4)	(5)	(6)
Atm	-0.3793***		-0.4680***		-0.3794***	
	[0.0743]		[0.0756]		[0.0743]	
Eft-pos		-0.4718***		-0.5412***		-0.4718***
		[0.0573]		[0.0567]		[0.0573]
Interest rate	0.3415***	0.1792**	0.3871***	0.1911**	0.3415***	0.1792**
	[0.0768]	[0.0720]	[0.0805]	[0.0752]	[0.0768]	[0.0720]
Gdp	-1.5285***	-1.0632***	-1.4293***	-0.9275***	-1.5285***	-1.0632***
	[0.2440]	[0.2362]	[0.2564]	[0.2433]	[0.2440]	[0.2362]
Accessing	0.9688***	0.7478***			0.9688***	0.7478***
	[0.2253]	[0.2023]			[0.2253]	[0.2023]
Candidate			-0.4578	-0.6290**	-1.4567***	-2.2329***
			[0.3003]	[0.2660]	[0.3678]	[0.3418]
Constant	12.9669***	8.2552***	13.3529***	8.1986***	14.4236***	10.4880***
	[2.4789]	[2.4073]	[2.4162]	[2.3207]	[2.3030]	[2.2962]
Observations	168	168	168	168	168	168
R2	0.63	0.66	0.64	0.67	0.63	0.66
Hausman test	9.43	6.36	6.59	5.48	9.32	6.36

***, **, * statistically significant at 0.01, 0.05 and 0.1 respectively.

for the Netherlands, Snellman et al. (2000) for several European countries and Rinaldi (2001) for Belgium, find that the use of ATM reduces cash holdings and that the presence of ATM together with EFT-POS has a negative effect on outstanding money. These negative effects could be explained by the fact that the development of ATM improved the access to 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, Rinaldi (2001). In line with these results, Markose and Loke (2003) argue that money demand functions began to break down in the late 1970s as a consequence of new technologies, such as EFT-POS and ATM, being introduced. This evidence confirms the result of the theoretical model that the use of alternative means of payment not only depends on a country's own technological development but on the accepting countries technology level as well. Further, this result agrees with Humphrey et al. (2001) who do not find evidence of a substitution effect between ATM and EFT-POS.

Nominal interest rate, that accounts for the monetary policy, presents a positive and significant coefficient. Hence, an increase in the interest rate implies an increase in cash use with respect to card use. This result contradicts previous evidence that highlights the negative relationship between cash and interest rates (Humphrey, 2004 and Snellman and Virén, 2006, among others). However, along the analyzed period interest rates of accessing countries followed macroeconomic stabilization policies in order to meet European convergence criteria resulting in a continuous deep interest rate decrease, which might have caused the observed behavior. Per worker GDP have a negative and significant coefficient, meaning that more developed countries present lower cash use, confirming previous results on international comparisons (Callado and Utrero, 2004 and 2007). Looking at the variables that account for the institutional environment, the candidate variable presents a negative and significant coefficient both when it is introduced alone and when it is introduced together with the accession dummy. The prospects of entering the EU have a positive effect on card use. This may indicate that the expectation of accessing to the EU is considered a positive shock for the reliability of the economic and the payment systems. It also reflects the fact that implementation of new payment systems started before finally entering the EU (ECB, 1999). On the other hand, *accessing* variable is positive and significant, indicating that the membership moment impacts positively the use of cash. A possible explanation is that the success of macroeconomic stabilization policies and of financial reforms developed during the candidate status, as membership confirms, make domestic liquid assets become again more and more attractive, pushing upwards the ratio of broad money to GDP (Duchene et al., 2006). Therefore, economic level, monetary policy but also technology and institutional environment matters in payment decisions.

The reference group used in the above analysis is EU-15. Afterwards, we repeat the analysis using EMU countries as accepting group. EU membership has changed in the last decade. However, it is the EMU participation that has presented more changes. As in the previous analysis, we take into account the individual membership changes. Results are presented in Table 3, panel B. Results confirm previous evidence. Economic level, monetary policy, payment system technology and institutional environment affect significantly payment choices. Again, technology developments foster card use.

The results presented in table 3 should be taken with caution, since the potential endogeneity of some of the variables have not been taken into account . This aspect is tackled in the next section.

3.3 Robustness analysis

Here we present additional evidence to examine the robustness of the results. First, we check whether the results are robust to alternative variable definition or alternative proxies. In particular, we introduce consumption per capita and long term interest rate instead of GDP per worker and short term interest rate, respectively. Main conclusions are maintained, see Table 4.

Second, we control that results are not driven by omitted variables. Previous empirical papers have shown that, even with the globalization of card use, differences among countries persist and this is due to different demographic and cultural factors. In particular we control for age, education, urban population, degree of innovation and crime. Some studies show a negative relationship between card use and age, Wasberg et al. (1992). To proxy for age, we introduce the percentage of school-age population (up to tertiary education). We expect a positive relationship, the younger you are the more cash you use. A low level of literacy and education may also be factors impinging on card use. Carner and Luckett (1992) show a positive relationship between education and card use. To proxy for education and literacy, we introduce the percentage of college graduates and the books published scaled by population. Kaynak and Harcar (2001) claim that card usage is more prevalent among urban and semi-urban areas. Traditional consumers who reside in rural areas may still prefer cash transactions. Accordingly, we use the percentage of urban population. More innovative societies are more willing to use new technologies, and therefore new methods of payments will diffuse more rapidly, Humphrey (2010). To proxy for innovation in society we use gross expenditure on research and development to GDP. Humphrey et al. (1996) find that the use of non-cash payment systems are related to per capita income, the availability of new payment systems and also the prevalence of violent crime within countries. Accordingly, we control for the level of criminality (total number of violent crimes by population). Results are collected in Table 5. Looking at the variables of interest, it can be observed that signs and significance are unaltered throughout alternative specifications, meaning that results of the analysis are robust. Looking at the control variables introduced, there is mixed evidence. Age presents a positive and significant coefficient (column 1) meaning that the younger the population, the more cash used. Education (graduates) affects negatively and significantly the cash use (column 3 and 4). Crime presents a positive and significant coefficient, meaning that the prevalence of crime prevents card use (columns 11 and 12). On the other hand, the level of urban population (columns 5 and 6) and expenditure on R&D (columns 9 and 10) present the expected sign, more urban population and higher cultural level are associated to less cash use, but are not significant. Published books do not affect cash use either (columns 7 and 8).

An additional issue in this context is the simultaneous relationship between cash and ATM (Snellman and Virén, 2006). To control for this potential bias, we use Generalized

Table 4: Robustness analysis. Alternative variable definition.

	(1)	(2)	(3)	(4)	(5)	(6)
Atm	-0.3542***		-0.4330***		-0.3542***	
	[0.0721]		[0.0741]		[0.0721]	
Eft-pos		-0.4574***		-0.5280***		-0.4574***
		[0.0606]		[0.0603]		[0.0606]
Long term	0.4914***	0.2607***	0.5391***	0.2637**	0.4914***	0.2607***
Interest rate	[0.0982]	[0.0981]	[0.1036]	[0.1026]	[0.0982]	[0.0981]
Consumption	-1.6131***	-1.1100***	-1.5232***	-0.9652***	-1.6131***	-1.1100***
	[0.2665]	[0.2667]	[0.2805]	[0.2747]	[0.2665]	[0.2667]
Accessing	0.9584***	0.7537***			0.9584***	0.7537***
	[0.2188]	[0.2020]			[0.2188]	[0.2020]
Candidate			-0.4018	-1.7755***	-1.4020***	-2.3747***
			[0.2962]	[0.3166]	[0.3624]	[0.3455]
Constant	11.6352***	7.5486***	12.0523***	8.7061***	13.0373***	9.9233***
	[2.5121]	[2.4753]	[2.4344]	[2.3091]	[2.3171]	[2.2436]
Observations	168	168	168	168	168	168
R2	0.65	0.67	0.66	0.68	0.65	0.67
Hausman test	6.50	4.22	4.42	3.37	6.44	3.40

***, **, * statistically significant at 0.01, 0.05 and 0.1 respectively.

Table 5: Robustness analysis. Control variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Atm	-0.3810***		-0.3911***		-0.3698***		-0.3558***		-0.3777***		-0.3513***	
	[0.0707]		[0.0745]		[0.0754]		[0.0745]		[0.0759]		[0.0727]	
Eft-pos		-0.4771***		-0.5048***		-0.4675***		-0.4592***		-0.4719***		-0.4195***
		[0.0581]		[0.0572]		[0.0573]		[0.0573]		[0.0596]		[0.0589]
Interest rate	0.3339***	0.1802**	0.3051***	0.1203*	0.3410***	0.1783**	0.3404***	0.1794**	0.3417***	0.1866**	0.2412***	0.1216
	[0.0729]	[0.0729]	[0.0774]	[0.0723]	[0.0766]	[0.0718]	[0.0766]	[0.0722]	[0.0777]	[0.0722]	[0.0803]	[0.0756]
Gdp	-0.9114***	-1.0741***	-1.5936***	-0.9223***	-1.5615***	-1.0897***	-1.6754***	-1.1962***	-1.5396***	-1.1941***	-1.4307***	-1.1299***
	[0.3253]	[0.2459]	[0.2610]	[0.2370]	[0.2483]	[0.2368]	[0.2641]	[0.2470]	[0.2460]	[0.2465]	[0.2436]	[0.2463]
Accessing	1.0170***	0.7363***	0.9756***	0.7503***	0.9782***	0.7563***	0.9882***	0.7576***	0.9710***	0.7610***	0.7979***	0.6683***
	[0.2127]	[0.2053]	[0.2201]	[0.1962]	[0.2250]	[0.2019]	[0.2230]	[0.2020]	[0.2259]	[0.2020]	[0.2258]	[0.2043]
Candidate	-0.5716	-2.2932***	-1.8797***	-2.1850***	-1.1823***	-2.0360***	-2.1172***	-1.9645***	-1.1833***	-1.8716***	-1.3412***	-2.3092***
	[0.3895]	[0.3503]	[0.4075]	[0.3457]	[0.3696]	[0.3454]	[0.3986]	[0.3538]	[0.3808]	[0.3732]	[0.3663]	[0.3815]
Education age	4.4351***	-0.1272										
Population	[1.2078]	[0.2224]										
Graduates			-0.2437*	-0.3083***								
			[0.1280]	[0.1109]								
Urban pop					-0.0425	-0.0808						
					[0.0867]	[0.0766]						
Publish_book							0.0042	0.0417				
							[0.0848]	[0.0748]				
R&D on gdp									-0.0034	-0.1120		
									[0.1728]	[0.1608]		
Crime											0.7380***	0.5442**
											[0.2369]	[0.2400]
Constant	-51.4940***	12.5283***	16.3451***	10.3403***	15.0393***	11.9282***	16.5165***	12.0257***	14.1927***	11.5783***	16.2229***	13.5385***
	[18.3873]	[4.2239]	[2.4765]	[2.1756]	[2.8737]	[2.6538]	[2.6791]	[2.4678]	[2.3483]	[2.3688]	[2.4105]	[2.5248]
Obs	168	168	167	167	168	168	168	168	168	168	166	166
R2	0.62	0.67	0.64	0.68	0.63	0.66	0.62	0.65	0.63	0.66	0.58	0.63
Hausman test	19.69***	10.72	6.43	5.97	8.55	6.32	13.05**	16.27***	9.13	12.41**	11.70***	21.59***

***, **, * statistically significant at 0.01, 0.05 and 0.1 respectively.

Method of Moments (GMM) estimation. Although the above mentioned simultaneity between cash and ATM can also be controlled by using a simultaneous equation estimator (e.g., maximum likelihood and two- or three-stage least squares) our choice is based on consistency concerns. In other words, the above mentioned estimators are more efficient than GMM, but they are not consistent since they do not eliminate unobservable heterogeneity. In contrast, GMM estimation implies less efficiency, but it is consistent because it eliminates unobservable heterogeneity. Traditionally GMM uses first-difference transformation. However, this technique has a weakness. It magnifies gaps in unbalanced panels (Roodman, 2006). Arellano and Bover (1995) propose a second transformation 'orthogonal deviations' that minimizes data loss and since lagged observations do not enter the formula, they are valid as instruments.[10] Since the sample is small, we decide to use this transformation in order to preserve sample size. Further, to avoid over-fitting, we collapse the instrument matrix.[11] Table 6 collects the results.

Focusing first on the diagnostic tests, Hansen's J-statistics for all specifications are too small to reject the null hypothesis that the instruments are valid. Further, AR(1) and AR(2) test statistics for first and second order serial correlation in the first-differenced residuals indicate, as required, that while we can sometimes have evidence of first order autocorrelation, we always accept the null hypothesis of no second order autocorrelation. Looking at the variables of interest, as it can be seen, results are very similar to those presented in Table 3. ATM and EFT-POS affect negatively and significantly the cash use. The institutional variables maintain the sign of the coefficients, but there are some differences with respect to the significance found in Table 3. In particular, *accessing* variable is only significant when ATM are considered, meanwhile *candidate* is significant when EFT-POS are introduced instead. The most important difference is that interest rate is no longer significant. Taking into account endogeneity issues in the estimation, the interest rate has negligible effect on the cash to electronic payments ratio as the main variable explaining its evolution is technology. Therefore, institutional variables and technology applied to payment systems impact payment decisions, as suggested by the model, and these results are robust to endogeneity.

From the time series analysis point of view some problems may arise in the results found because part of the data may be non-stationary. Accordingly, that would give rise to co-integration analysis and specification of an error-correction model. We present a battery of panel unit root tests (Table 7) and in all cases, unit root is rejected or there is no conclusive evidence. Therefore, we consider that non-stationarity is not a concern in our sample.

[10] In the estimation, lagged values of cash, interest rate, GDP per worker and banking structure are introduced in GMM-style, while ATM and EFT-POS receive the standard treatment for endogenous variables. Further, time dummies are included as IV-style instruments.

[11] We have chosen not to run two-step GMM due to well-known finite sample problems associated with the standard errors of two-step estimates. Indeed, two-step estimates of the model (not reported) suggest significant downward bias in the standard errors, even after using the Windmeijer (2005) correction.

Table 6: Robustness analysis: GMM analysis.

	(1)	(2)	(3)	(4)	(5)	(6)
Atm	-0.71360***		-0.84260***		-0.71394***	
	[0.14098]		[0.13490]		[0.14138]	
Eft-pos		-0.89734***		-0.96071***		-0.89734***
		[0.12242]		[0.10414]		[0.12242]
Interest rate	0.12129	-0.21057	0.1998	-0.20509	0.12272	-0.21057
	[0.20809]	[0.17895]	[0.22961]	[0.18193]	[0.17120]	[0.17895]
Gdp	-0.61756	0.33598	-0.30328	0.56391	-0.61613	0.33598
	[0.61825]	[0.72778]	[0.59337]	[0.69849]	[0.61204]	[0.72778]
Accessing	0.79053***	0.35058			0.78940***	0.35058
	[0.25497]	[0.29204]			[0.28038]	[0.29204]
Candidate			-0.97931	-3.77638***	-1.76008***	-3.90526***
			[0.71050]	[0.88164]	[0.68012]	[0.86343]
Constant	3.93557	-5.22009	2.44620	-3.42433	5.68431	-1.31484
	[6.25762]	[7.13449]	[5.52820]	[6.07819]	[5.56999]	[6.33952]
Observations	168	168	168	168	168	168
AR(1)	-0.02	0.33	0.28	0.47	-0.03	0.33
AR(2)	0.47	-0.93	0.48	-1.04	0.47	-0.93
Hansen test	0.00	0.00	0.00	0.00	0.00	0.00

***, **, * significant at .01, .05 and .1 respectively.

Table 7: Summary of panel data unit root tests.

a. Cash over card use

Method	Statistic	P-value	Cross-sections	Obs
Null: Unit Root (assumes common unit root process)				
Levin, Lin & Chu	-3.8228	0.0001	11	132
Breitung				
Null: Unit Root (assumes individual unit root process)				
Im, Pesaran and Shin	-6.1142	0.0000	12	154
ADF-Fisher Chi-Sqr	53.5760	0.0005	12	144
ADF-Choi test	-1.8686	0.0308	12	144
PP-Fisher Chi-Sqr	123.395	0.000	12	156
PP-Choi test	-7.3738	0.000	12	156

b. ATM

Method	Statistic	P-value	Cross-sections	Obs
Null: Unit Root (assumes common unit root process)				
Levin, Lin & Chu	-10.4013	0.000	8	103
Breitung	0.6387	0.7369	12	154
Null: Unit Root (assumes individual unit root process)				
Im, Pesaran and Shin	-6.7945	0.000	12	154
ADF-Fisher Chi-Sqr	92.6257	0.000	12	154
ADF-Choi Z test	-3.9890	0.000	12	154
PP-Fisher Chi-Sqr	105.95	0.000	12	156
PP-Choi test	-4.1928	0.000	12	156

c. EFT-POS

Method	Statistic	P-value	Cross-sections	Obs
Null: Unit Root (assumes common unit root process)				
Levin, Lin & Chu	-1.6607	0.048	8	103
Breitung	-3.2367	0.0006	12	135
Null: Unit Root (assumes individual unit root process)				
Im, Pesaran and Shin	-8.5380	0.000	12	144
ADF-Fisher Chi-Sqr	107.134	0.000	12	144
ADF-Choi test	-7.3430	0.000	12	144
PP-Fisher Chi-Sqr	95.6011	0.000	12	156
PP-Choi test	-6.7482	0.000	12	156

d. Interest rate

Method	Statistic	P-value	Cross-sections	Obs
Null: Unit Root (assumes common unit root process)				
Levin, Lin & Chu	-4.5956	0.000	12	144
Breitung	2.2510	0.9878	11	132
Null: Unit Root (assumes individual unit root process)				
Im, Pesaran and Shin	-0.3172	0.3755	12	144
ADF-Fisher Chi-Sqr	36.3442	0.0508	12	144
ADF-Choi test	0-2.3712	0.0089	12	144
PP-Fisher Chi-Sqr	27.8613	0.1803	11	143
PP-Choi test	2.2321	0.9872	12	156

e. GDP

Method	Statistic	P-value	Cross-sections	Obs
Null: Unit Root (assumes common unit root process)				
Levin, Lin & Chu	-3.0398	0.0012	12	144
Breitung	2.2873	0.9889	12	132
Null: Unit Root (assumes individual unit root process)				
Im, Pesaran and Shin	-2.6424	0.0041	12	150
ADF-Fisher Chi-Sqr	44.1657	0.0073	12	144
ADF-Choi test	-2.9020	0.0019	12	144
PP-Fisher Chi-Sqr	60.9794	0.0000	11	143
PP-Choi test	-3.8002	0.0001	12	156

4 Conclusions

We present a general equilibrium model on payment choice at retail level which allows us to analyze the evolution of consumers' payments when a country enters an economic and monetary union. The model shows that the relative importance of cash to electronic payments will depend on monetary policy and technology development. In the case of a country accessing the economic union, the effect will be based both on its own technology level and also on the one of the accepting group. If the less developed economy gradually adapts to the payment technology of the accepting countries, after the accession, the gap between the consumers' choices in both countries is diminishing over time.

The implications of the model are tested in the context of the European Union enlargement process. This extension of the EU provides data on a natural (real) experiment where the conclusions of the model can be examined. Results from the econometric analysis are in line with the theoretical model. First, technology is the main factor driving the consumers' payment choice. In particular, technology development relative to the accepting countries indicates that the closer the accessing payment technology to the European one, the lesser use of cash. Second, when controlling for endogeneity issues, the interest rate is not relevant in explaining the ratio of cash to electronic payments. This fact clearly reinforces the role of technology in the analysis. Third, the variables that account for the institutional environment are significant, even when endogeneity issue is considered. The expectation of accessing to the EU, together with the fact that the implementation of new payment systems started before finally accessing the union, is considered a positive shock for the reliability of the economic and payment systems and therefore, affects payment instrument choice. Our results are robust to different estimation techniques, alternative variable definition, different accepting group and the introduction of additional controls.

This paper provides particular evidence for the case of payment systems and consumers' payment instrument choice. It is shown that by intensively adapting payment technology to relatively higher standards, countries' payment instrument use can be influenced accordingly. This adaptation can be clearly favoured by the new institutional environment and structural transformation required by the integration into an economic union.

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