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ESSAYS ON THE USE OF PAYMENT INSTRUMENTS

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To my beloved family.

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Essays on the use of payment instruments

Abstract

The use of non-cash payment instruments in European Union (EU) countries changed quite noticeably in the past years. Electronic payment instruments usage grew, while paper-based payments declined. The objective of this thesis, comprised by three essays, is to provide empirical evidence of the impact on the use of cheques, bank cards, and credit transfers of a selected set of specific measures. As cheques are still a relevant question of concern for some countries due to their considerable social costs and risks, the first essay analyses the determinants of cheque usage in the EU, with data for the period 2000-2012. The study focuses on the effects of the application of fees in a framework where unfunded cheques are considered as an autonomous type of crime in some countries. The second essay examines the impact on cards usage of the adoption of the EMV (Europay, MasterCard and Visa) standard in the EU between 2006 and 2011. This technology protects information more effectively than magnetic stripes and aims to reduce fraud at the point-of-sale. Finally, the third essay investigates the effect of the implementation process of the Single Euro Payments Area (SEPA) – a project that intends to increase integration in retail payments – on credit transfers usage in euro area countries from 2008 to 2013. The results obtained suggest that: (i) the existence of fees influences negatively cheque usage, even when there are legal elements that increase security; (ii) the progress in the adoption of EMV technology had a positive effect in the use of cards; and (iii) the evolution in the migration to SEPA formats had a positive impact on the share of credit transfer payments.

***Keywords**: Bank card, Cheque, Credit transfer, EMV, Panel data, Retail Payments, SEPA*

Ensaios sobre a utilização de instrumentos de pagamento

Resumo

A utilização de instrumentos de pagamento que não o numerário na União Europeia (UE) registou significativas alterações nos últimos anos. O uso de instrumentos eletrónicos aumentou e os pagamentos assentes em papel reduziram-se. O objetivo desta tese, composta por três ensaios, é fornecer evidência empírica do impacto de um conjunto de medidas na utilização de cheques, cartões bancários e transferências a crédito. Dado que os cheques são ainda uma preocupação em alguns países atendendo aos custos sociais e riscos associados, o primeiro ensaio analisa os determinantes da utilização de cheques na UE, com dados para o período 2000-2012. O estudo centra-se nos efeitos da imposição de encargos num contexto em que a emissão de cheques sem provisão é considerada crime em alguns países. O segundo ensaio examina o impacto na utilização de cartões da adoção, entre 2006 e 2011, do padrão *EMV* (*Europay*, *MasterCard* e *Visa*) na UE. Esta tecnologia protege a informação de forma mais eficaz que as bandas magnéticas e visa reduzir a fraude nos pontos de venda físicos. Finalmente, o terceiro ensaio investiga o efeito da implementação da Área Única de Pagamentos em Euros (*SEPA*) – um projeto que visa impulsionar a integração nos pagamentos de retalho – na utilização de transferências a crédito nos países da área do euro entre 2008 e 2013. Os resultados obtidos sugerem que: (i) a existência de encargos influencia negativamente a utilização de cheques, mesmo quando existem fatores legais que aumentam a segurança; (ii) o progresso na adoção da tecnologia *EMV* teve um efeito positivo na utilização de cartões; e (iii) a evolução na migração para os formatos *SEPA* gerou um impacto positivo na proporção de pagamentos com transferências a crédito.

Palavras-chave: *Cartão bancário, Cheque, Dados de painel, EMV, Pagamentos de retalho, SEPA Transferência a crédito*

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Chapter 1

Introduction

Payment instruments play a crucial role to the smooth functioning of modern economies, as they are employed on a daily basis to transfer funds among various economic agents, such as consumers, merchants and public authorities. The choice between the various payment instruments available is not innocuous, since the costs to society differ according to the instrument and the potential benefits for the economy can also be diverse. In this context, it is essential to understand how certain factors influence non-cash payment instruments usage. In general, the original contribution of this thesis consists of providing new empirical evidence on the impact of specific measures adopted in EU countries on payments made with cheques, bank cards and credit transfers. The results obtained in this investigation can support policy orientations that promote a more efficient payments landscape and encourage a deeper reflexion on these topics.

This chapter provides an overview of the importance of payment instruments, as well as a concise review of the key literature on this topic. The research objectives and contribution of this thesis are also presented.

1. The role of payment instruments in modern economies

Money is ever-present in our daily lives and plays a relevant role in societies. From an economists' point of view, money is usually considered in its functional definition as being

a unit of account, medium of exchange and store of value – a definition that derives from the one proposed for the first time by Jevons (1876). However, money can be analysed from various, sometimes contradictory, perspectives (Persson, 2016). Scholars from areas that range from economics to sociology, philosophy and anthropology paid particular attention to the impact of money in social relations. Karl Marx, a philosopher, economist and sociologist of the nineteen century defended that money plays a central role in the relations between the owners of the means of production and the workers (Hart and Ortiz, 2014). For George Simmel, a sociologist and philosopher of the beginning of the twentieth century, money is a social institution that can impact social and moral relations among individuals. He argues that money acts as tool of valuation and comparison among things, generating a detachment from them. As a result, it reduces social relations to quantitative ones (Dodd, 2014), causing individualization and disorder on social relations (Coeckelbergh, 2015) because it makes individuals indifferent towards objects and people. Max Weber, a sociologist, philosopher and economist, underlines that money is a mean of exchange as long as people believe that it will be accepted. By using money that provides a specific value to objects, enhanced rationality is introduced into economic life (Carruthers and Ariovich, 2010; Reijers, 2014). Geoffrey Ingham, a sociologist born in 1942, reinforced the social nature of money by arguing that money is basically constituted by the social relations between creditors and debtors (Carruthers and Ariovich, 2010). Moreover, for the anthropologist born in 1943 Keith Hart, money is an instrument of collective memory, intensely connected with the cultural conditions of its production and use (Dodd, 2014).

Due to technological developments, the way money is used to make payments has seen significant changes. Nowadays economic agents process a large amount of transactions in order to purchase goods or pay for services. The associated payments are usually made with cash or through the transfer of funds in banking accounts. In the latter option, the transmission of money is typically ensured by payment systems. According to Kokkola (2010), payment systems comprise the instruments, procedures and systems which enable the exchange of funds in the economy. Taking into consideration their key importance to an efficient economy, payment systems are usually referred to as the plumbing or

circulatory system (Kahn and Roberds, 2009). Generally it is only when something goes wrong that end-users notice with greater awareness the payment process.

The relevance of payment systems has been growing steadily. Between 2010 and 2014, the total number of payment and terminal transactions made by non-monetary financial institutions[1] in the EU augmented from around 86 641 million to 103 160 million, reflecting an increase from 173 to about 202 payments per capita. In the euro area, the total number of transactions rose from 60 219 million to 68 073 million and the per capita number of payments expanded from around 183 to 202 during the same period. The total value of payment and terminal transactions in 2014 was around 1813% of the EU Gross Domestic Product (GDP).[2]

Payment instruments are probably the most visible part of the payment systems to the general public. A payment instrument is a tool or a set of procedures that allow the transfer of funds between economic agents (Kokkola, 2010). In the EU, the most usual non-cash payment instruments comprise cheques, cards, credit transfers and direct debits. A cheque is a written order from one party (the drawer) to another (the drawee, frequently a credit institution) requiring the drawee to pay a particular amount to the drawer or to a third party named by the drawer. A bank card is a device that can be used to withdraw money from Automated Teller Machines (ATM) or make payments at the point-of-sale/remotely (for example, through the internet). Credit transfers allow the payer to instruct the institution where it holds his account to transfer funds to a beneficiary. Finally, direct debits are based on the authorisation of the debiting of the payers bank account, being initiated by the payee.

The use of the different non-cash payment instruments has undergone some changes in the past years. In the period 2010-2014 electronic payment instruments usage grew in general, while cheque payments decreased in the EU and euro area countries (Figures 1.1 and 1.2). In both cases, cards have been gaining ground and are nowadays the most relevant non-cash payment instrument (in volume).

[1] Includes credit transfers, direct debits, card payments with cards issued by resident payment service providers (except cards with an e-money function only), e-money payment transactions, cheques and other payment services.

[2] Information available at the European Central Bank Statistical Data Warehouse.

Figure 1.1: Evolution of the number of transactions per payment instrument in the EU (between 2010 and 2014)

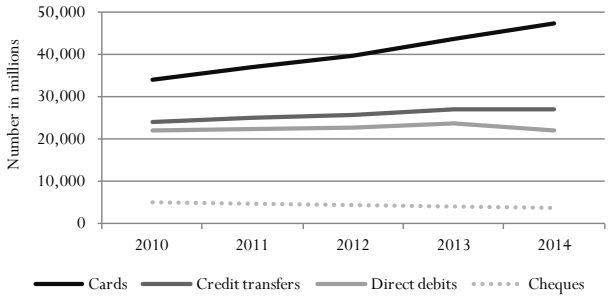
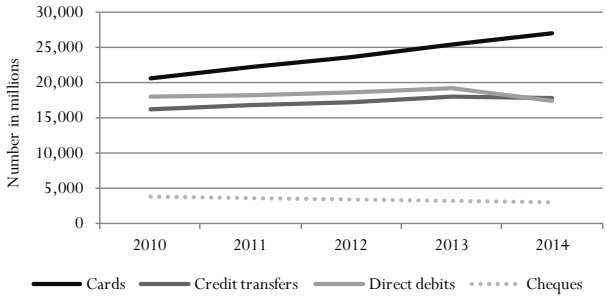


Figure 1.2: Evolution of the number of transactions per payment instrument in the euro area (between 2010 and 2014)



Source: European Central Bank Statistical Data Warehouse.

Taking into account the relevance of efficient payment instruments, not only for the adequate functioning of the economy but also for preserving confidence in the currency, this thesis focuses on this specific component of payments systems.

2. Brief review of the literature on the use of payment instruments

Research on the Economics field regarding non-cash payment instruments usage has grown considerably in the past years[3]. Early theoretical studies were mainly focused on understanding the demand for cash (Baumol, 1952, Tobin, 1956 and Whitesell, 1989). More recent theoretical investigation is generally centred on the areas of pricing, competition, interchange fees, surcharging and two-sided markets (Bolt and Chakravorti, 2008, Bolt and Chakravorti, 2010 and Humphrey, 2010). In fact, as the Bank of International Settlements and the World Bank highlight in a recent consultative report on payment aspects of financial inclusion (BIS, 2015), retail payment markets are characterised by economies of scale (i.e., a decrease in average costs per unit with an increase in the output level), economies of scope (i.e., cost rewards resulting from the provision of different services or products) and network externalities (i.e., an increase in the value of a payment system with an higher number of users). Even so, the mainstream

[3] Note that our focus is on non-cash payment instruments and, for that reason, information on the existing research on the evolution of the use of cash is not included in our analysis.

research on the non-cash payment instruments field is of empirical nature. This type of literature can be divided into two main areas: the analysis of consumers' use of payment instruments at national level and the examination of the use of payment instruments across countries.

The empirical studies on payment behaviour use data collected through surveys and/or payment diaries to households or provided, for example, by grocery stores. They are mostly focused on the impact of socio-demographic aspects (such as age, education and income), consumers' perceptions of payment attributes and characteristics of the transactions. Boeschoten (1998), Mantel (2001), Stavins (2001), Klee (2006) and Borzekowski and Kiser (2008) are examples of authors that found evidence of the effect of consumers' age, income and education on the use of payment instruments with data collected through surveys. Schuh and Stavins (2010) and Schuh and Stavins (2013) underlined the importance of consumers' perceptions of payment attributes (e.g., cost, speed, security, control, convenience and ease). Hayashi and Klee (2003) highlighted that payment choices are also related with consumers' propensity to adopt new technologies (for example, computers and cellular phones). Klee (2008) and Bounie and François (2009) emphasized the relevance of transactions characteristics, such as the physical attributes of the point-of-sale and the value of the transaction.

The literature focused on the pattern of use of payment instruments at cross-country level is sparse. The seminal paper by Humphrey et al. (1996), uses data from fourteen countries for the period between 1987 and 1993 to estimate a model of payment instrument demand. Guariglia and Loke (2004) extended this analysis using payment transactions data from fifteen countries for the period 1990-1998. Deungoue (2008) and Martikainen et al. (2015) analysed the convergence of payments in European countries during the periods 1990-2002 and 1995-2001, respectively. Pietrowiak (2014), Goczek and Witkowski (2015) and Dagdemir and Sauer (2015) also explored different sets of panel data but are mainly focused on card payments. Our investigation follows this last strand of literature, but targets the examination of the impact of specific measures on the use of payment instruments. Therefore, this thesis contributes to the literature in this field

by providing empirical evidence of the effect of a selected set of elements on the use of three payment instruments.

3. Research objectives and main contributions

In this thesis we examine the evolution in the use of certain non-cash payment instruments in the EU and in the euro area. The sample was selected taking into consideration its relevance as an example at a global level and bearing also in mind the data availability. The main research questions are: "How have legal factors affected the use of cheques; fraud-fighting measures influenced cards usage; and the implementation process of Single Euro Payments Area (SEPA) changed the use of credit transfers?" From the empirical evidence obtained, several policy orientations can be derived in order to assist policymakers in their catalyst role.

The use of payment instruments, an intrinsic part of contemporary economies (Kokkola, 2010), has evolved significantly over the past years, as the technology for making electronic payments have become increasingly available for everyday use. According to the ECB Statistical Data Warehouse, the relative importance of cheques in the EU countries (as a percentage of the total number of transactions) declined from around 11.4% in 2004 to about 3.5% in 2014, while the relative importance of card payments (except with an e-money function only) rose from 32.3% to around 46% in the same period. Understanding these changes and the role played by specific measures adopted in this field is of particular relevance.

On the one hand, research has shown that the cost to society connected with retail payments can be substantial. Using a sample of thirteen EU countries, Schmiedel et al. (2012) concluded that, on average, the costs supported by banks and infrastructures as well as retailers amounted to 0.96% of GDP. On average, debit cards revealed the lower unit social costs. Conversely, cheques had the highest unit social costs of non-cash payment instruments. On the other hand, encouraging efficiency in retail payments can promote economic growth and social welfare. Hasan et al. (2013) found evidence that the adoption of more efficient payment instruments can contribute to the positive evolution of

consumption, trade and the economy. This impact is particularly relevant for card and credit transfer payments.

Although the existing literature provides insights on some of the factors that might help explain the use of the various payment instruments, the conclusions are mainly based on data from specific countries and do not cover factors that became relevant in the recent past. Contrary to the previous studies, our goal is not to compare the effect of general determinants on different payment instruments, but rather to investigate the effect of selected measures on given payment instruments. Bearing this in mind, and taking also into consideration that the data available on these measures is limited (different information is available in terms of sets of countries and time span for the three topics), in order to take advantage of all the existing information our analysis was split into separate examinations of three payments instruments: cheques, bank cards and credit transfers. Our study also incorporates some potential socio-demographic factors identified by the research based on survey data. Due to the small sample size, parsimonious model specifications had to be defined.

This thesis is composed of three interconnected essays that have the common objective of investigating the use of payment instruments. The first essay examines how legal factors connected with the application of fees and the establishment of an autonomous type of crime for unfunded cheques contributed to the evolution of cheque payments in EU countries between 2000 and 2012. The second essay investigates in which way the migration process to EMV – a technology developed by Europay, MasterCard and Visa that protects information more effectively than magnetic stripes – has impacted card payments in the EU in the period 2006-2011. In the two essays the analysis is performed considering both the traditional dependent variable of the per capita number of payment transactions, and the share of the number of payments. As far as we know, this last measure of payment instruments usage was rarely exploited in the existing literature, despite its several potential advantages, such as considering only effective users of payment instruments and minimising the effects of variations in consumption. Moreover, we applied various estimation techniques for panel data ranging from traditional linear-based fixed effects and random effects estimators, to estimators based on Poisson and fractional

regression models (FRM). To the best of our knowledge, the last models – that present the advantage of taking into consideration the fractional nature of the dependent variables in analysis – were not considered in the studies of this field. Nevertheless, one key methodological difference between these two essays is the inclusion, in the first one, of time-invariant variables, which required special attention on the estimation techniques applied, namely by using the Hausman-Taylor estimator.

The third essay focuses on the effect of the implementation process of the SEPA project on the share of credit transfer payments in euro area countries during the period from 2008 to 2013. In this situation the analysis of the number of per capita payments was not adequate according to the specification tests performed (we believe that this results from the small dimension of the sample available), so we focused only on the share of payments. The econometric examination was performed using univariate FRM, as well as FRM that allow for the presence of neglected heterogeneity and multivariate FRM that describe simultaneously the share of interest and other shares of non-cash payments instruments, controlling for potential substitution effects between them. The results provide for the first time evidence on the impact of this project on credit transfer payments.

The three essays are presented using a similar structure to the ones of the papers submitted for consideration for publication in international journals of CEFAGE-UE Journal Ranking and in CEFAGE-UE Working Papers. Since the three essays were prepared to be read autonomously, there is an unavoidable recurrence of concepts, given that they cover a common topic and are all based on the empirical analysis of panel data.

The remainder of this thesis is organised as follows. In the next three chapters we present the essays. Each one of these chapters is organised according to the following structure: abstract, introduction, framework, data and methodology, results and concluding remarks. The last chapter provides the general conclusions obtained with the investigation, the key limitations of the research and potential topics for future analyses.

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Chapter 2

The use of cheques in the European Union: A cross-country analysis[1]

Abstract

Some European Union (EU) countries have implemented policies to discourage the use of cheques due to its considerable social costs and risks. This article provides a cross-country analysis for the period 2000-2012 of the determinants of cheque usage. Special attention is given to the effects of the application of fees in a framework where unfunded cheques are considered as an autonomous type of crime in some EU countries. Our results suggest that the existence of fees influences negatively cheque usage, even when there are legal elements that increase its security.

***JEL Classification**: E41, E42, C25, F36, G21*

***Keywords**: Cheques, European Union, Panel Data, Retail Payments*

[1] This essay was published in *Open Economies Review*.

1. Introduction

Payment habits in EU countries have been changing quite noticeably in past years. Payments with cheques, in particular, have decreased, while the relevance of electronic payment instruments (such as cards, credit transfers and direct debits) has increased. Between 2000 and 2012 the annual per capita number of payments made with cheques in the EU reduced from around 24 to about 9. This corresponded to a reduction in the share[2] of cheque payments from 18% to 5% during that period. Despite the declining tendency in cheques usage, in a number of EU countries their use is still quite substantial. For example, in 2012 more than 15 cheques per capita were used in France, Cyprus, Malta and Ireland[3]. Considering this and bearing also in mind that making payments with cheques involves considerable social costs and risks, some countries in their analysis regarding the possible evolution of retail payments might intend to reduce their use and promote the adoption of electronic payment instruments. In fact, Schmiedel et al. (2012) obtained evidence in a sample of EU countries that the average unit social cost of cheques is €3.55, which compares with €0.99 for cards. In addition, Kokkola (2010) refers that, among other risks, it is important to take into consideration the potential issues connected with the drawer's creditworthiness. As a result, in Malta an educational campaign to promote the use of cards and electronic payments was developed in 2012 and in Ireland rules to abolish the use of cheques by Government Departments, Local Authorities and State Agencies were established in 2014.

In order to define policies that effectively support a decline in the use of cheques, it is important to identify which are the determinants of cheques usage. The existing literature shed light on some of the elements that might influence the use of this payment instrument. On the one hand, a strand of empirical literature based on the analysis of individual survey data collected at the national level (Boeschoten, 1998, Stavins, 2001, Klee, 2006, Borzekowski and Kiser, 2008, and Koulayev et al., 2012) highlights the relevance of socio-demographic determinants in cheques usage. On the other hand,

[2] The share was computed considering the relative importance of the number of payments with cheques on the total number of payments made with cheques, credit transfers, direct debits and cards.

[3] According to the Bank for International Settlements, in 2014, the relative importance of cheques (in volume) was 37.5% in the United States of America, and 13.1% in France.

cross-country studies on retail payments, such as Humphrey et al. (1996) and Guariglia and Loke (2004), conclude that the economic environment and technological developments play a relevant role in shaping payment habits. Our article follows this last line of research, but also incorporates some potential socio-demographic determinants identified by the former strand of literature, as well as factors that reflect the existence of differences in the cost and security structure of cheque payments in the various countries.

Specifically, we propose the empirical examination of the impact on cheque payments of the existence of a fee associated with the use of cheques and the fact that unfunded cheques are considered as an autonomous crime (hereinafter referred to as legal variables), while controlling the effect of socio-demographic, economic, technological and institutional factors. We employ country level data from the European Central Bank Statistical Data Warehouse for the period between 2000 and 2012, as well as information on legal variables collected specifically for this research.

Cheque usage is analysed not only in terms of the traditional dependent variable of the per capita number of payment transactions, but also in terms of the share of the number of payments made with cheques, a measure of cheque usage that, as far as we known, was not considered before. In fact, while the former variable is obtained using the total population and this implies including persons that do not use any payment instruments (e.g., children) as well as persons that might not use all payment instruments (i.e., unbanked population), in our view the share or proportion of payments made with cheques (in volume), as an indicator of relative importance, eases cross-country comparisons of the intensity of cheques usage. This latter dependent variable has also the potential advantage of minimising the effects of variations in consumption (for example, due to situations of financial crisis, since it might affect in a similar way the use of other payment instruments).

The analysis of the two measures of cheque usage employs various estimation techniques: traditional linear-based fixed effects, random effects and Hausman-Taylor estimators, as well as estimators based on Poisson and fractional regression models (FRM). The latter present the advantage of taking into consideration the nature of the dependent variables in analysis. In particular, the Poisson estimator incorporates the fact that the

number of per capita payments made with cheques is a count variable and the fractional regression estimator accommodates the bounded nature on the interval (0,1) of the share of payments made with cheques.

We estimate a negative average partial effect of the existence of fees in the number of per capita and the share of payments made with cheques of around 28 and 0.13, respectively, and a positive effect related with the fact that unfunded cheques are considered as an autonomous crime of 10 and 0.04, respectively. The magnitude of these results is quite relevant because the mean of the number of per capita number and share of payments made with cheques in our sample is 8 and 0.08.

The remainder of this essay is organized as follows. Section 2 defines the background and provides a summary of related literature. Section 3 describes the data used in the study and the methodology. Section 4 reports the empirical results. Finally, Section 5 draws the conclusions and provides policy orientations.

2. Framework

This section presents an outline of the use of cheques as a payment instrument in EU countries and highlights a number of measures already adopted to reduce payments with cheques. A summary of related literature is also provided.

2.1. Brief overview of cheques as a payment instrument

According to Kokkola (2010), a payment instrument is a tool or a set of procedures that allow the transfer of funds. Non-cash payment instruments, in particular, include those instruments that are not banknotes and coins. The most usual non-cash payment instruments in EU countries comprise cheques, payment cards, credit transfers and direct debits.[4]

Cheques are one of the oldest non-cash payment instruments. Their use in Europe began around the year 1400, and even though fraud situations occurred quite frequently,

[4] For a detailed definition of each one of these non-cash payment instruments see Kokkola (2010).

cheques were considered as a convenient mean of making payments (Quinn and Roberds, 2008). The past years have seen remarkable changes in payment habits. Between 2000 and 2012 the annual number of per capita payments with cheques in the EU decreased 64%, from around 24 to about 9 payments per capita (Table 2.1). The decreasing tendency in the use of cheques is also noticeable in the United States of America and in Canada, although in these countries the per capita number of payments made with cheques remained higher.

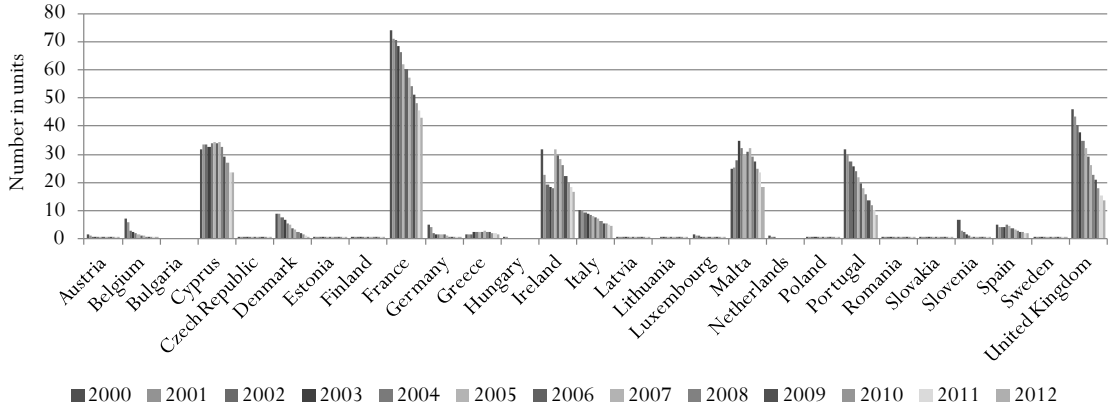
Table 2.1: Evolution of cheques usage between 2000 and 2012

	2000	2012	Variation
Number of per capita payments with cheques			
European Union	23.7	8.5	-64%
Euro Area	21.1	10.3	-51%
United States of America	148.4	58.4	-61%
Canada	54.0	21.6	-60%
Switzerland	1.6	0.0	-100%
Share of payments with cheques (in volume)			
European Union	18.4%	4.6%	-75%
Euro Area	17.8%	5.4%	-70%
United States of America	58.0%	15.5 %	-73%
Canada	28.1%	7.5%	-73 %
Switzerland	1.3%	0.0%	-100%

Source: European Central Bank Statistical Data Warehouse for data on European Union and Euro Area and Bank for International Settlements for data on the United States of America, Canada and Switzerland.

Focusing on the evolution of the per capita number of payments with cheques in the EU countries between 2000 and 2012, we conclude that the decreasing trend in the use of cheques is visible in all countries. Nonetheless, a noticeable heterogeneity still remains in the use of cheques. From the analysis of Figure 2.1 we observe that, in 2012, more than 8 cheque payments per capita were made, on average, in France, Cyprus, Malta, Ireland, the United Kingdom and Portugal. The highest usage occurred in France, with around 43 cheque payments per capita in 2012. A clearer picture can be obtained if we add to the previous analysis information regarding the percentage share of payments made with cheques.

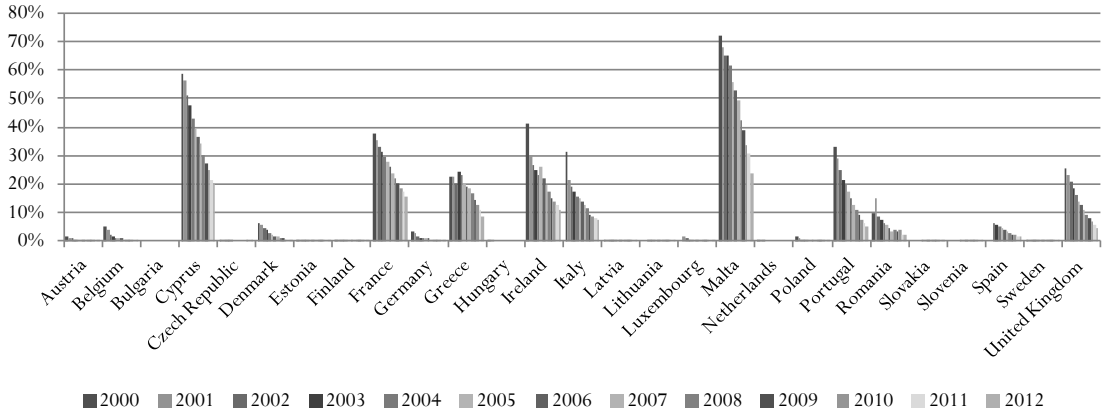
Figure 2.1: Evolution of the per capita number of payments made with cheques between 2000 and 2012



Source: European Central Bank Statistical Data Warehouse.

In the EU, the proportion of payments made with cheques (computed considering the relative importance of the total number of payments with cheques on the total number of payments made with cheques, credit transfers, direct debits and cards) has decreased from 18.4% to 4.6% between 2000 and 2012 (Table 2.1). Regarding the relative importance of cheques in all the EU countries in 2012, we observe that in Malta, Cyprus, France and Ireland, the share of payments with cheques remained above 10% (Figure 2.2).

Figure 2.2: Evolution of the share of payments made with cheques between 2000 and 2012 (in volume)



Source: European Central Bank Statistical Data Warehouse.

2.2. Outline of some of the measures adopted to reduce the use of cheques

In order to diminish the use of cheques, different approaches have been followed by various authorities, such as Central Banks. At a cross-border level, in 2002, the guaranty of €200 provided with the Eurocheque[5] was removed. In addition, the European Commission decided to keep cheques outside the scope of community legislation as it considered that, since cheques are not as efficiently processed as other payment instruments, their use in a cross-border context should be avoided.

In 2001, Slovenia abolished the guidance of realisation of cheques (i.e., cheques can only be realised if there are funds on the account) and between 2001 and 2012 the number of per capita payments with cheques reduced around 98%. In Malta, the Bankers Association, in collaboration with the Central Bank and the Association of Credit Management, implemented a campaign in 2012 to encourage the use of cards and online payments. In Ireland, cheques are no longer used by Government Departments, Local Authorities and State Agencies since the 19th of September 2014. In the United Kingdom, after an unsuccessful attempt to close the cheque clearing, it was decided, in 2011, to look for ways to improve the process. Other countries managed to reduce the use of cheques with the imposition of a fee on its use and increasing the marketing on other payment instruments provided free of charge, as occurred in Sweden, or through a raise in the processing charges and a reduction in the supply of free cheques, as happened in the Netherlands (APCA, 2011).

2.3. Literature review

The decreasing trend in the use of cheques has been reported and analysed in a number of investigations. The vast majority of the studies in this field have generally focused on the analysis of consumers' use of payment instruments at national level, using data either collected through surveys and/or payment diaries to households or provided, for example, by grocery stores. Although this literature is mainly focused on the increasing

[5] This type of cheque could be used in different countries.

use of electronic payment instruments, some studies still explore the use of cheques, but address mainly the impact of socio-demographic aspects, consumers' perceptions of payment attributes, characteristics of the transactions and financial incentives.

Boeschoten (1998), Stavins (2001), Klee (2006), Borzekowski and Kiser (2008) and Koulayev et al. (2012) are among the many authors that reported the effect of consumers' age, income and education in the use of payment instruments using data collected through surveys. More recent studies, for example of Koulayev et al. (2012), found evidence of a positive impact of age and a negative effect of income and education in the adoption and use of cheques. Schuh and Stavins (2010) and Schuh and Stavins (2013) complemented those analyses by incorporating in the explanatory factors consumers' perceptions of payment attributes (e.g., cost, speed, security, control, convenience and ease). Schuh and Stavins (2010) concluded that the use of cheques was negatively influenced by the perception of the cost and the inconvenience of cheques in comparison with alternative payment instruments. Schuh and Stavins (2013) also observed that consumers perceived cheques as being slow in terms of processing and less secure when compared with other payment instruments. The effect of transactions' characteristics in the choice of payment instruments was reported by Hayashi and Klee (2003), who found evidence of a negative impact of cashier absence and availability of self-service on consumers' probability of using cheques. Using data on payments made at grocery stores, Klee (2008) observed that the likelihood of using cheques reduced on Sundays and with smaller payments.

Humphrey et al. (2001) and Bolt et al. (2008) are among the small number of authors who were able to include information of the price of payment instruments in the analysis at country level (regarding Norway and the Netherlands). The authors concluded that the pricing of cheques could be an effective instrument in promoting the use of electronic payment instruments. Even though these studies provided empirical evidence of some of the reasons that explain the evolution in consumers' use of cheques, in particular in the United States of America (US), they have not presented detailed cross-country analyses. In fact, only few researchers studied the differences in the use of payment instruments between countries. Humphrey et al. (1996), although more focused on the shift to electronic payments, identified some of the factors that could explain the use of cheques.

The authors used data on the number of transactions per person for the period between 1987 and 1993 from fourteen countries to estimate a model of payment instrument demand with Ordinary Least Squares (OLS). They found evidence of a negative impact of Point-of-Sale (POS) terminals availability and a statistically significant substitution effect with other payment instruments. While not providing empirical evidence, the authors emphasized that the differences in the use of payments instruments (including cheques) across countries exist due to historical reasons. Indeed, theoretical studies stressed that, although cheques originate from the eastern Mediterranean, their use has been traditionally higher in the US than in Europe (in line with the data provided on Table 2.1) due to the reduced concentration in the banking sector (Humphrey, 2010) as well as owing to a nineteenth century banking legislation that discouraged the use of other payment instruments in the US (Quinn and Roberds, 2008).

Guariglia and Loke (2004) extended Humphrey et al. (1996) analysis by estimating static equations using the within estimator and dynamic equations using the difference Generalized Method of Moments (GMM) and considering data on the per capita volume and value of payment transactions from fifteen countries for the period between 1990 and 1998. The authors obtained empirical evidence of a substitution effect between cards and cheques in the volume and value of transactions with cheques. Deungoue (2008) and Martikainen et al. (2015), while focusing their analysis on the convergence of payment behaviour in European countries (for the periods from 1990 to 2002 and 1995 to 2001, respectively), put forward some possible reasons for the differences in payments with cheques. In both cases, the results suggested that payments with cheques were not converging in the EU. Deungoue (2008) argued that this could be due to card competition and to the existence of different rules in the various EU countries (although this was not empirically tested).

The abovementioned studies shed light on some of the factors that explain the use of cheques. Nonetheless, legal factors associated with this payment instrument were not considered by those authors. As a result, the questions "what is the effect in the use of cheques in EU countries of the application of fees and the establishment of an autonomous type of crime for unfunded cheques, as well as what policy orientations can be derived

from the empirical evidence?" remain to be answered. Therefore, we intend to contribute to the existing literature through the investigation, at the EU level, of the impact of the abovementioned legal factors, taking also into consideration the effect of socio-demographic, economic, technological and institutional factors, both in terms of the per capita number and share of payments made with cheques. As the use of cheques involves considerable social costs for EU countries that still rely on this payment instrument (see Schmiedel et al. (2012)), the proposed analysis is of particular relevance to policymakers, such as Central Banks, as it can unveil elements that could be taken into consideration when defining policies that intend to discourage cheques usage.

3. Data and methodology

In this section we present a brief description of both the analysed variables and the methodology adopted in the econometric approach.

3.1. Data and descriptive statistics

The analysis was performed using data from the European Central Bank Statistical Data Warehouse regarding the per capita number and share of payments made with cheques in the EU countries. The data comprises all payment transactions initiated with cheques. According to the methodological notes of this database, it is considered as a cheque any written order from one party (the drawer) to another (the drawee, which is usually a credit institution) requiring the drawee to pay a specified amount to the drawer or to a third party named by the drawer. Cheques are only counted on the payee's side when submitted for cheque clearing.

In terms of explanatory variables, and considering that this study intends to offer an examination of the impact in the use of cheques of legal factors not considered in the existing literature, two legal variables were included in the analysis: (i) the application of fees; and (ii) the establishment of an autonomous type of crime for unfunded cheques. In order to collect information on the existence of fees associated with the use of cheques we

consulted the EU National Central Banks[6] and included in the model a time-invariant dummy variable (*fees*).[7] In addition, to verify if legal rules can impact the use of cheques, we also confirmed with National Central Banks if writing unfunded cheques was considered as an autonomous crime and included another time-invariant dummy variable (*crime*).

The choice of payment instruments can also be related with its users' characteristics. In general terms, cheques can be used by consumers and businesses (including from the public sector). In our model, we tried to capture the relevance of consumers' characteristics through socio-demographic factors typically only included in the analysis of survey data (e.g., in Boeschoten (1998), Stavins (2001) and Klee (2006)). In fact, investigations based on national payments data found that the education level of consumers has a negative impact in the use of cheques, while age might have a positive effect. Hence, in order to capture the effect of those characteristics at an aggregate level we included: (i) the share of population with upper secondary or tertiary education attainment (*edu*); and (ii) the median age of the population (*age*). We also attempted to reflect the business environment using two economic variables: the percentage change in the real Gross Domestic Product (*gdp*) and the private consumption as a percentage of GDP (*pcons*).

On the other hand, technological and institutional factors, usually incorporated in the existing literature on the analysis of cross-country differences in payment habits (e.g., in Humphrey et al. (1996) and Guariglia and Loke (2004)), were also included. We added as technological factors the number of Automated Teller Machines or ATM (*atm*) and POS terminals (*pos*) per thousand inhabitants. In fact, ATM facilitate cash withdraws and can also promote the use of cards for certain transactions. POS terminals, on the other hand, support payments with cards. These factors might assist the substitution of cheques at the point-of-sale. In addition, we also included institutional country characteristics: two

[6] In some cases we obtained the information on the website of the Central Banks and/or of commercial banks. In the collection of the information we requested data for the period under analysis. Since not all time information was provided by Central Banks, we considered it as time-invariant in the model.

[7] One of the elements that might affect the use of payment instruments is price. However, at cross-country level there is no information available on this factor. Humphrey et al. (1996) computed a proxy for the price of payment instruments used on their analysis that consisted on the amount of fees, but concluded that the influence was very modest. Our variable differs from the proxy proposed by Humphrey et al. (1996) since it captures the impact of the existence of fees, not the effect of their amount.

dummy variables that reflect the fact that countries belong (or not) to the euro area (*euroarea*) and the impacts of the beginning of the recent financial crisis and of the SEPA project[8], in particular, the launch of the SEPA credit transfers scheme (*2008*). We also incorporated a variable denoting the number of offices or places of business that provide payment services (i.e., that execute payment transactions on behalf of a natural or legal person) per thousand inhabitants (*offices*), as they can facilitate the handling of cheques by consumers and businesses. In order to account for possible substitutability effects, we included the number of per capita payments with cards (*cards*) and the number of cash withdrawals (*cash*) as a simple proxy for cash usage. Credit transfers and direct debits are generally used for payments of a different nature (e.g., rents) and, therefore, were not considered as direct substitutes of cheques at the point-of-sale. An interaction term between the variables *2008* and *fees* was also included in order to identify if the impact of the establishment of fees changed after the beginning of the recent financial crisis and of the SEPA project. Detailed information on the variables used in the empirical analysis can be found in Table A2.1 of the Appendix.

Table 2.2 presents the descriptive statistics for the dependent and independent variables used in the model. The mean number of per capita payments made with cheques between 2000 and 2012 was 8, while the mean share of cheque payments (in volume) was 0.08 or 8%. The variation between the minimums and maximums was quite substantial in both variables. In around 85% of the sample there are fees associated with the use of cheques, while unfunded cheques are only considered as an autonomous crime in around 48% of the sample. In what concerns to socio-demographic factors, we observe considerable differences in the education level between countries, while age characteristics are more similar. The economic and institutional factors reveal a diversity of situations, as we would expect.

[8] The Single Euro Payments Area (SEPA) is a project that aims to harmonise retail payments in euro by enabling individuals, firms and public administrations to make and receive cashless payments throughout the Member States of the EU and Iceland, Liechtenstein, Monaco, Norway, Switzerland and San Marino using just one bank account located in any of these countries and a single set of payment instruments (credit transfers, direct debits and cards). For more information see, for example, Virtanen (2014).

Table 2.2: Descriptive statistics of the dependent and independent variables for EU countries (2000-2012)

Variable	Mean	Std. Dev.	Min.	Max.	No. Obs.
Dependent variables					
cheques	8.01	14.70	0	74.00	349
propcheques	0.08	0.14	0	0.72	334
Independent variables					
Legal factors (L_i)					
fees	0.85	0.36	0	1	351
crime	0.48	0.50	0	1	351
Socio-demographic factors (SD_{it})					
edu	0.67	0.14	0.21	0.87	351
age	38.91	2.25	32.40	45.00	351
Economic factors (E_{it})					
gdp	0.02	0.04	-0.16	0.12	350
pcons	0.77	0.08	0.47	0.93	351
Technological factors (T_{it})					
atm	0.65	0.33	0.03	1.66	350
pos	14.36	8.52	0.06	37.80	341
Institutional factors (I_{it})					
offices	0.57	0.29	0.09	1.84	338
euroarea	0.50	0.50	0	1	351
2008	0.38	0.49	0	1	351
cash	21.98	11.54	0.48	47.87	323
cards	53.72	51.44	0.04	230.10	345

The table reports the descriptive statistics of the dependent and independent variables in the period between 2000 and 2012 for the 27 EU countries. "Std. Dev." stands for standard deviation, "Min." for the smallest value of the observations, "Max." for the highest value of the observations and "No. Obs." for the number of observations.

3.2. Model specification and methodology

The empirical analysis of the effect on cheques usage of: (i) legal factors connected with the existence of a fee and the fact that unfunded cheques are considered as an autonomous type of crime in certain countries; and (ii) socio-demographic, economic, technological and institutional factors, was made by estimating a static model with the following functional form:

$$Y_{it} = G[\beta_0 + \beta_1 L_i + \beta_2 SD_{it} + \beta_3 E_{it} + \beta_4 T_{it} + \beta_5 I_{it} + \beta_6 (2008 \times fees)_{it} + \varepsilon_{it}] \qquad (1)$$

where Y_{it} is either the number of per capita payments made with cheques or the share of payments made with cheques (in volume), with i $(i = 1, \dots N)$ representing each country and t $(t = 1, \dots 13)$ denoting the time period; L_i refers to two time-invariant dummies of legal factors (i.e., *fees* and *crime*); SD_{it} regards to socio-demographic factors (i.e., *edu* and *age*); E_{it} denotes economic factors (i.e., *gdp* and *pcons*); T_{it} regards to technological factors (i.e., *atm* and *pos*); I_{it} refers to institutional determinants (i.e., *offices*, *euroarea*, *2008*, *cash* and *cards*); $(2008 \times fees)_{it}$ is an interaction term, $\varepsilon_{it} = \alpha_i + u_{it}$, being α_i the country-specific effects and u_{it} the idiosyncratic error term. Finally, β_j, $j = 1, \dots 6$, are vectors of parameters associated to each type of explanatory variables. Whenever $G(.)$ is a nonlinear function, average partial effects (APE) are computed in order to measure the effect of unitary changes in these explanatory variables on the response variable.

The next subsections detail the econometric approach to model the two measures of cheque usage in analysis. The number of per capita payments with cheques, widely analysed by the literature, is modelled with linear models for panel data and a new approach based on count data regressions. Then, the share of payments made with cheques is described by FRM.

3.2.1. *Models for the number of per capita payments with cheques*

In order to choose the most appropriate estimator for the examination of the effect of selected factors on the number of per capita payments made with cheques, we began by considering standard linear models, where model (1) is simply the linear index. In particular, we considered the fixed effects (or within) estimator and the random effects estimator (Wooldridge, 2002). In the former, the fixed effects α_i are eliminated by mean-differencing and, therefore, it is possible to obtain consistent estimates even with endogenous regressors, as long as the independent variables are only correlated with the time-invariant component of the error (i.e., α_i). However, because in the framework of this estimator it is not possible to estimate the coefficients of time-invariant variables such as those referring to the legal factors, our interest is focused on the random-effects estimator. This estimator allows the estimation of coefficients of time-invariant variables,

but assumes that individual unobserved effects are random and not correlated with the explanatory variables.

A robust Hausman (1978) test was performed to validate the random effects estimator. As usual, under the null hypothesis the individual effects are random. In addition, a RESET test was applied to the random effects model to confirm the adequacy of the specification. To examine the robustness of the results we also validated the possibility that some of the explanatory variables (i.e., the technological variables *atm* and *pos*, as well as the institutional variables *cash* and *cards)* were correlated with the individual-level random effects, by using an alternative estimator based on instrumental variables proposed by Hausman and Taylor (1981) that includes elements from the fixed and random effects models. In this estimator, the time-variant variables are used not only to estimate their own coefficients but also as instruments in order to estimate the coefficients of time-invariant variables[9]. To assess overidentifying restrictions in the model, we performed the Sargan-Hansen test (Cameron and Trivedi, 2009). The null hypothesis of this test postulates that the instruments used in the model are valid.

Although linear models have been widely applied on the previous literature, they can have some shortcomings when using the type of data under investigation. In fact, the number of per capita payments made with cheques is a count variable with nonnegative integer values. According to Wooldridge (2002), linear models might not be the best solution, since they can generate negative predicted values. Therefore, a Poisson regression estimated by quasi-maximum likelihood (QML) was also tested[10]. In this framework, in (1), $G[.] = \exp[.]$. Three alternatives were considered: a fixed effects Poisson model, a random effects Poisson model where the random effects follow a gamma distribution, and a random effects Poisson model where the random effects follow a lognormal distribution. To validate the adequacy of the random effects models, RESET tests were performed. Finally, the linear random effects estimators were compared with

[9] In our analysis we considered that the variables *atm*, *pos*, *cash* and *cards* as endogenous. All these time-variant variables exhibited sufficient within-panel variation to serve as their own instruments.

[10] Note that, according to Gourieroux et al. (1984), the Poisson estimator with robust standard errors is consistent, even under misspecification of the Poisson distribution, as long as the mean is correctly specified.

the selected (lognormal) Poisson random effects estimator using a J-test for non-nested regression models (Baum, 2006).

3.2.2. *Models for the share of payments with cheques*

Considering that the variable regarding the share of payments made with cheques is bounded between zero and one, linear models are not adequate according to Papke and Wooldridge (1996), Ramalho et al. (2011) and Ramalho and Ramalho (2015). A more appropriate econometric approach, highlighted by Ramalho et al. (2011) and Papke and Wooldridge (1996), is the assumption of a functional form that imposes the needed constraints on the conditional mean of the dependent variable. We therefore used a FRM estimated by pooled QML with a robust version of the variance of the estimated parameters. The variable of interest Y_{it} is now defined on the interval (0,1) and G written as a logit $\left(G[.] = \frac{\exp[.]}{1+\exp[.]}\right)$, cloglog ($G[.] = 1 - \exp[.]$) and probit ($G[.] = \phi[.]$, with ϕ defined as a standard normal distribution) conditional mean functions. To verify if the FRM were adequate, a RESET test of the specification of the fractional model was performed.

4. Empirical results

This section provides the analysis of the results of the alternative estimators, available in Table 2.3. The model selection strategy is presented and the effects of both the legal variables and the remaining covariates are discussed.

4.1. Model selection

In terms of model selection for the analysis of the number of per capita payments made with cheques, in the linear specification the random effects model was not rejected by both the Hausman and the RESET tests. The results of this model, in terms of coefficient magnitude and individual significance, are very similar to those of the fixed effects and the Hausman-Taylor estimators, which are also consistent in the presence of fixed effects. On the other hand, of the three Poisson-based nonlinear estimators considered, only the random effects Poisson model with a lognormal distribution was selected, with a RESET

test presenting a p-value of 0.1482. When comparing the linear random effects with the selected Poisson random effects model using a non-nested hypothesis test we obtain a p-value of 0 and reject the correct specification of the linear random effects model. The opposite comparison leads to a p-value of 0.107, which yields the non-rejection of the Poisson random effects with lognormal distribution model. For that reason, we will focus our analysis on the results obtained in this last model. Notice the differences in variable significance relatively to the traditional linear model approach (Table 2.3 and Table 2.4) – in some cases the linear model increases the effect (for example, in variable 2008 the effect is approximately 16 times larger than that of the Poisson model) and in other cases it deflates (as it happens with *crime*, where the effect is about 2.8 times smaller than that of the selected Poisson model).

For the analysis of the share of the number of payments made with cheques we used three FRM. Since only the model with a probit conditional mean function was not rejected by the RESET test, we focus our analysis on its results. Note that, in comparison with the selected model for the number of payments, the model for the share presents much more individually significant variables (8 instead of 2 with a significance level of 1%), which suggests that the set of covariates under analysis provides a better description of the share behaviour than that of the traditional number of payments.

4.2. The effect of legal variables

Even though Humphrey et al. (1996) concluded that the impact of payment instrument prices was very modest[11], according to our estimation results the existence of fees has a statistically significant negative impact on both the per capita number and share of payments made with cheques (Table 2.3). The estimated APE is -28.02 and -0.13 on each of the models (Table 2.4), which reflects a quite relevant effect since the mean of the number of per capita payments made with cheques in our sample is around 8 and the mean of the share is about 0.08. This influence was very clear in Sweden, where the decision to

[11] The authors used a proxy for the prices of the various payment instruments due to unavailability of data for all countries included in the model.

charge a fee per cheque in the beginning of the 1990s led to a sharp reduction in their adoption without any political convulsion, according to Nyberg (2008).

Our findings also suggest that the existence of an autonomous type of crime for unfunded cheques impacts positively the per capita number and share of payments made with cheques. The APE of the variable *crime* is 10.49 and 0.04, respectively. Overall, the existence of fees has a larger impact than legal penalties on the use of cheques. So, even when countries have legal provisions that increase protection and make cheques usage more attractive (in particular with larger amounts), the establishment of fees is effective in reducing cheques usage.

4.3. The effect of socio-demographic, economic, technological and institutional factors

Regarding socio-demographic factors, age characteristics reveal a statistically significant negative impact on both the Poisson random effects with lognormal distribution model and the FRM with a probit conditional mean function. This might be surprising since, c*eteris paribus*, it is expectable that an older population uses more cheques as there might be a greater difficulty in the use of electronic payment instruments. However, nowadays cheques are typically used in large value payments, for example connected with the acquisition of home appliances, as well as the payment of children extra-curricular activities or tuition fees. In fact, a survey made in Ireland concluded that the use of cheques in 2014 was still dominated by smaller businesses and consumers. In both situations, around 50% of cheques issued were payable to business (CBI, 2014). This fact might justify the impact obtained, since normally those purchases are not made frequently by older persons. The variable connected with the education level of the population is only statistically significant in the share analysis. Higher levels of education are negatively related with the share of payments made with cheques. This result is in line with the conclusions of Koulayev et al. (2012) employing survey data on the use of payment instruments in the US. The observed impact can result from the fact that populations with average higher education levels replace more easily the use of cheques with electronic payment instruments.

In terms of the economic variables, the evolution of the variable *pcons* shows a statistically significant positive effect on the use of cheques, which is expectable as we considered this variable as an indicator of the business environment. Conversely, the effect of technological elements is not very clear. Only POS terminals have a statistically significant positive effect in the proportion of payments made with cheques. This can be related with the fact that the number of POS terminals that already exist in several EU countries is very high and, for that reason, is not contributing to a greater substitution of cheque payments by cards. It can also result from the fact that the number of transactions considered in our analysis (namely in the computation of the share of payments with cheques) refers to both retail and large value transactions, while POS terminals are used, in most cases, in low value transactions. The substitution effect that is expectable in low value transactions with cheques can therefore not be visible if the number of large-value transactions is significant.

Finally, in what concerns to institutional factors, we observe that the variable that captures the impact of the beginning of the SEPA project and of the recent financial crisis has a statistically significant negative effect in both models. The impact of the SEPA project will probably increase in the future, when the focus is placed on the cards industry. In addition, the interaction between the variable *fees* and *2008* is statistically significant in the analysis of the per capita number of cheque payments. The interaction effect shows that, before 2008, the APE of the application of fees on the number of per capita payments made with cheques was around -28.02. After 2008, this effect increased to -29.38. This reflects that, following the launch of the implementation of the SEPA project and the start of the recent financial crisis, the impact of the adoption of fees in the use of cheques was enhanced. In addition, the effect on the Poisson model of the number of offices that provide payment services is positive and statistically significant. As offices are used by consumers and businesses to deliver cheques for processing, a higher number of offices make it more convenient. The share of payments with cheques appears to be positively related with belonging to the euro area, whereas cards seem to play a role in substituting cheques. Contrary to the expected, cash did not reveal a statistically significant connection with the use of cheques. Note that the APE of some of these factors is quite significant when compared to legal determinants. This can reflect the fact that

specific country characteristics might play a very important role in the use of cheques, therefore restricting the potential impact of the adoption of measures that influence the previously mentioned legal elements.

Table 2.3: Estimation results of the impact of legal factors in EU countries (2000-2012)

Variables	Model of the number of per capita payments with cheques						Model of the share of payments with cheques (in volume)		
	Fixed effects	Random effects	Hausman-Taylor	Poisson (fixed effects)	Poisson (random effects with gamma distribution)	Poisson (random effects with lognormal distribution)	FRM (logit)	FRM (cloglog)	FRM (probit)
fees	-	-32.5580***	-33.1471***	-	-3.0578***	-4.4768***	-2.5971***	-2.3433***	-1.3017***
		(12.0884)	(12.5613)		(0.8835)	(0.7319)	(0.1783)	(0.1606)	(0.0793)
crime	-	3.6868	3.8804	-	0.8905	1.6765**	0.7249***	0.6566***	0.3756***
		(3.8371)	(4.8394)		(1.1082)	(0.8067)	(0.1518)	(0.1407)	(0.0693)
edu	-10.4664	-14.1013	-12.4294	1.5121	-05322	-0.2949	-4.0573***	-3.3963***	-2.2733***
	(10.6976)	(10.4751)	(13.1406)	(1.2167)	(0.7544)	(1.4652)	(0.2962)	(0.2702)	(0.1478)
age	0.0978	-0.1420	-0.0216	-0.2277**	-0.2972**	-0.2598**	-0.6299***	-0.5758***	-0.2964***
	(0.4669)	(0.4460)	(0.5959)	(0.0982)	(0.1298)	(0.1059)	(0.0521)	(0.0458)	(0.0277)
gdp	-8.6021**	-7.0659*	-7.8520	1.0351	0.7302	0.6312	-2.4337	-1.3085	-1.2322
	(4.1377)	(4.2083)	(4.9797)	(0.8745)	(1.0467)	(0.9083)	(2.7714)	(2.5472)	(1.2462)
pcons	-31.9871**	-27.8039**	-30.1482**	4.9484***	3.9143*	3.9646***	5.9998***	5.4869***	3.0304***
	(12.2546)	(11.0688)	(13.4158)	(1.5942)	(2.1316)	(1.3149)	(0.7976)	(0.7618)	(0.3601)
atm	-11.5692**	-10.6317**	-11.0735**	0.0569	0.1216	0.1994	0.2465	0.3911	-0.1699
	(4.5310)	(4.3357)	(4.9015)	(0.4265)	(0.5904)	(0.4534)	(0.4151)	(0.3742)	(0.2056)
pos	-0.0500	-0.0342	-0.0343	0.0080	0.0208	0.0181	0.0732***	0.0665***	0.0353***
	(0.1405)	(0.1218)	(0.1344)	(0.0107)	(0.0170)	(0.0121)	(0.0076)	(0.0072)	(0.0034)
offices	3.6257*	4.1059**	3.8469*	0.3747***	0.4630	0.4347**	0.2124	0.2013	0.2401
	(1.9891)	(2.0440)	(2.0689)	(0.1421)	(0.5530)	(0.1704)	(0.2789)	(0.2442)	(0.1536)
euroarea	1.8568	2.0722	1.9765	0.0596	0.1528	0.1694	0.9547***	0.9056***	0.4845***
	(1.2003)	(1.3284)	(1.3970)	(0.0932)	(0.3666)	(0.1415)	(0.1417)	(0.1191)	(0.0726)
2008	-7.2961**	-7.2756**	-7.2427**	-0.0612	-0.0530	-0.0721*	-0.4621**	-0.5363***	-0.1944*
	(2.8535)	(2.9442)	(3.4593)	(0.0411)	(0.0850)	(0.0429)	(0.2320)	(0.1958)	(0.1120)

(continue)

Table 2.3: Estimation results of the impact of legal factors in EU countries (2000-2012) (continued)

Variables	Model of the number of per capita payments with cheques						Model of the share of payments with cheques (in volume)		
	Fixed effects	Random effects	Hausman-Taylor	Poisson (fixed effects)	Poisson (random effects with gamma distribution)	Poisson (random effects with lognormal distribution)	FRM (logit)	FRM (cloglog)	FRM (probit)
cash	-0.0572	-0.0280	-0.0510	-0.0016	0.0116	0.0038	-0.0019	-0.0018	0.0030
	(0.0830)	(0.0732)	(0.0828)	(0.0113)	(0.0175)	(0.0096)	(0.0112)	(0.0096)	(0.0062)
cards	-0.0309	-0.0257	-0.0303	-0.0055	-0.0037	-0.0041	-0.0074***	-0.0065***	-0.0038***
	(0.0272)	(0.0247)	(0.0314)	(0.0036)	(0.0057)	(0.0036)	(0.0025)	(0.0024)	(0.0011)
2008 x fees	8.9334**	8.9976***	8.9619**	-0.2150**	-0.2073	-0.2178**	-0.1943	-0.1630	-0.0454
	(3.1951)	(3.2580)	(3.7245)	(0.0976)	(0.1816)	(0.1037)	(0.2669)	(0.2565)	(0.1169)
Hausman test p-value	-	0.9921	0.9370	-	-	-	-	-	-
RESET test p-value	-	0.4532	-	-	0.0296	0.1482	0.0000	0.0000	0.3660
Sargan-Hansen test p-value	-	-	0.5130	-	-	-	-	-	-
J-test p-value	-	0	-	-	-	0.107	-	-	-
No. Obs.(NxT)	301	301	301	290	301	301	290	290	290

The table reports the fixed effects, random effects, Hausman-Taylor, Poisson fixed effects, Poisson random effects with gamma distribution, Poisson random effects with lognormal distribution and FRM with a logit, cloglog and probit distribution functions (with robust standard errors) estimation results for the dependent variables under analysis: number of per capita payments with cheques and share of payments with cheques (in volume). Standard errors are in parenthesis. Constant term coefficient not reported. Variables in value have been adjusted for inflation. Note that: * indicates significance at the 10% level, ** at the 5% level and *** at the 1% level. "No. Obs." stands for the number of observations.

Table 2.4: APE of selected models

Variables	Model of the number of per capita payments with cheques	Model of the share of payments with cheques (in volume)
	Poisson (random effects with lognormal distribution)	FRM (probit)
fees	-28.0150***	-0.1346***
crime	10.4913**	0.0388***
edu	-1.8454	-0.2350***
age	-1.6258**	-0.0306***
gdp	3.9500	-0.1274
pcons	24.8098***	0.3132***
atm	1.2480	-0.0176
pos	0.1133	0.0036***
offices	2.7206**	0.0248
euroarea	1.0604	0.0501***
2008	-0.4512*	-0.0201*
cash	0.0237	0.0003
cards	-0.0259	-0.0004***
2008 x fees	-1.3628**	-0.0047

The table reports the APE computed for the following models: Poisson random effects with lognormal distribution and FRM with a probit distribution function.

5. Concluding remarks

This essay investigated, from an empirical point of view, the effect on cheques usage at the EU level of the application of fees and the establishment of an autonomous type of crime for unfunded cheques, while controlling for the impact of socio-demographic, economic, technological and institutional factors. The original aspects of this article consist not only in the inclusion in the analysis of new and relevant factors collected specifically for this study, but also on the use of a novel dependent variable – the share of the number of payments made with cheques – that, due to its nature, can be a more reliable measure of comparison between countries and on the employment of updated estimation techniques – more adequate to the characteristics of the data. The findings obtained are relevant as they provide new insights to policymakers, such as Central Banks, that intend to adopt measures to discourage cheques usage in countries where they are still frequently used, given that this payment instrument is associated with high social costs and few benefits to economic growth when compared, for example, with debit cards.

Our key finding is that the existence of fees influences negatively cheques usage. This effect is quite relevant when compared to the mean of the per capita number and share of payments made with cheques and to the positive impact that results from the application of an autonomous crime regime to unfunded cheques. Hence, policymakers that intend to discourage the use of cheques can boost the implementation of measures that reduce the attractiveness of cheques by increasing their cost. In particular, they might intercede by supporting the establishment of fees by the banking community. They may also deter legal protection and discourage the implementation of protection laws on cheques, although this measure is relatively less relevant.

Our results also suggest that socio-demographic characteristics of consumers and the business environment can have an important role. Since the adoption of electronic payment instruments will probably be quicker in countries where the population has higher education levels, policies and measures adopted should be appropriately differentiated and/or targeted at individuals with lower education levels. Improving financial literacy education on specific groups should generate increased awareness and confidence on electronic payment instruments and, as a result, expand their usage. It is also important to note that companies, compared to consumers, have more information on payment instruments and are more cost aware and efficiency seeking. Thus, the implementation of policies that bring more clarity on the costs and benefits (namely to merchants and governments) of the use of different payment instruments can be a good approach to reduce the use of cheques. This strategy could be more effective with a preceding survey that details information on the users and on the type of transactions where cheques are sill the preferred payment instrument (for example, cheques might be the preferred payment instrument in large value transactions due to the time delay that occurs between its delivery and the clearing process). This could help identify alternative payment instruments that are more adequate to each type of transaction.

Finally, we also obtained evidence of the importance of the technological infrastructure and the institutional environment on smoothing the shift to more efficient payment instruments. In particular, policymakers should bear in mind that the technological infrastructure might play a role according to the implementation stage of the

network in each country. Focusing the attention on enhancing the use of cards (in particular of debit cards) can be a good approach in discouraging cheques usage. These substitution effects might be reinforced in the future through projects at the EU level, such as the SEPA project. Implementing or increasing the prices associated with the services connected with cheques processing in bank branches or decreasing the number of offices might indirectly discourage cheques usage.

Notwithstanding the above, authorities should bear in mind that, even though social costs associated with the use of payment instruments provide the basis for policy intervention, the level of involvement should be carefully considered. If the existing framework of each country is not regarded, the adoption of the discussed measures can bring unintended distortions to the payments market (e.g., by increasing the use of cash, which has high costs to society). In addition, attention should be made to the fact that policy orientations provided by this study were derived using data for a specific time period (i.e., between 2000 and 2012). Finally, we also recall that the road to more efficient payment instruments is not done exclusively by reducing the use of cheques. Efforts should also be applied in providing secure and efficient electronic payment instruments.

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Appendix

Table A2.1: Description of the dependent and independent variables used in the empirical analysis

Variable	Description	Source
	Dependent variables	
cheques	Per capita number of payments made with cheques.	ECB SDW
propcheques	Share of the number of payments made with cheques computed considering the relative importance on the total number of payments made with cheques, credit transfers, direct debits and cards.	Authors' calculation based on data from the ECB SDW
	Independent variables	
	Legal factors (L_i)	
fees	Dummy variable that equals 1 if fees are applicable on the use of cheques and 0 otherwise.	National Central Banks
crime	Dummy variable that equals 1 if unfunded cheques are considered as an autonomous crime and 0 otherwise.	National Central Banks
	Socio-demographic factors (SD_{it})	
edu	Percentage of persons with upper secondary or tertiary education attainment.	Eurostat
age	Median age of population (in years).	Eurostat
	Economic factors (E_{it})	
gdp	Real percentage change in the GDP.	Eurostat
pcons	Private consumption as a percentage of the GDP.	Eurostat
	Technological factors (T_{it})	
atm	Number, per thousand inhabitants, of ATM (device that permits authorised cardholders, typically using machine-readable plastic cards, to withdraw cash from their accounts and/or access other services, such as balance enquiries, transfer of funds or acceptance of deposits) at the end of each year.	ECB SDW
pos	Number, per thousand inhabitants, of POS terminals (device allowing the use of payment cards at a physical point-of-sale) in the end of each year.	ECB SDW
	Institutional factors (I_{it})	
offices	Number of places of business in the country per thousand inhabitants at the end of each year. Includes only those offices that provide payment services with cashless clearing and settlement.	ECB SDW
euroarea	Dummy variable that equals 1 when the country is from the euro area and 0 otherwise.	ECB SDW
2008	Dummy variable that equals 1 from 2008 onwards (i.e., after the beginning of the recent financial crisis and of the implementation of the SEPA project) and 0 otherwise.	ECB
cash	Number of cash withdrawals per capita.	ECB SDW
cards	Number of cards transactions per capita.	ECB SDW

Chapter 3

Is EMV adoption changing card payments? Evidence from the European Union

Abstract

The EMV standard – a technology developed by Europay, MasterCard and Visa that protects information more effectively than magnetic stripes – aims to reduce fraud in face-to-face card payments. By influencing the perceived/real safety of card payments, this standard might be shaping payment habits. This article examines the effect on cards usage of the migration process to EMV in the European Union. Using data for the period 2006-2011, we found evidence that the progress in the adoption of this standard had a statistically significant positive impact in card payments when controlling the effects of socio-demographic, economic, technological and institutional factors, particularly in non euro area countries.

***JEL Classification**: E41, E42, C25, F36, G21*

***Keywords**: Bank cards, EMV, European Union, Panel Data, Retail Payments*

1. Introduction

Cards are nowadays the most used non-cash payment instrument in the European Union (EU). According to the ECB Statistical Data Warehouse (ECB SDW), the relative importance of card payments was of around 46% in 2014. Nevertheless, the use of this payment instrument can be compromised by security issues, in particular fraud. One of the key measures adopted to prevent and reduce fraud situations was the commitment, by the European Payments Council (EPC) – a coordination and decision-making body of the European banking industry in the field of payments –, to migrate, by 2010, all cards and terminals to the Europay, MasterCard and Visa (EMV) standard which uses cryptographic techniques that can reduce fraud in face-to-face transactions. The aim of this essay is to investigate, from an empirical point of view, what was the impact of the process of adoption of the EMV standard in the use of cards in 27 EU countries between 2006 and 2011 (the time for which detailed information is available). In fact, during this period, most of the countries obtained a very noticeable improvement, even though full migration was not achieved in all of them. Overall, the share of EMV-compliant cards in the EU increased from around 53% to about 88% and the most recent data made available by the ECB reveals that the percentage of EMV transactions at point-of-sale terminals in the euro area in December 2014 was only 78.6%.

Verifying if the process of migration to the EMV standard enhanced the use of this payment instrument – by increasing the security of card payments – is of particular importance. Research made by Hasan et al. (2013), Hasan et al. (2014) and World Bank (2014) has shown that promoting card payments can stimulate consumption and trade, as well as encourage economic development. In addition, social costs supported with payments can be reduced if the use of more efficient payment instruments is promoted. According to Schmiedel et al. (2012), in a sample of EU countries, the weighted average social cost per payment transaction of debit cards amounts to €0.70, while the same cost for cheques reaches €3.55. Authorities and regulators can be therefore interested in encouraging the use of debit cards. But this concern is also shared by other entities. Payment service providers, merchants and consumers can have also a keen interest in a wider penetration of card payments, as investments made can be more easily recovered,

trade and consumption might be facilitated and consumers' demand for safe and efficient payment instruments satisfied.

The existing literature based on survey data provides an examination of the impact of the perception of safety and risk issues on the use of payments instruments (see, for example, Jonker, 2007, Bolt and Chakravorti, 2008b, Ching and Hayashi, 2010 and Kosse, 2013a), while cross-country papers on retail payments (for example, Humphrey et al., 1996, Guariglia and Loke, 2004 and Amromin and Chakravorti, 2007) focus on the effect of economic, technological and institutional factors on cards usage. Our article follows this last strand but targets a new research topic: the impact of the implementation of the EMV technology in the use of cards. Therefore, our study complements and extends previous work in a number of dimensions. First, to the extent of our knowledge, this is the first study that estimates the effect of the progress in the migration to the EMV technology on card payments in EU countries. Second, we analyse cards usage both in terms of the per capita number and share of payments made with cards. There are several advantages in considering the share of card payments, such as not including in the computation persons that do not use payment instruments, having a variable that can minimise the effect of variations in consumption, as it might affect in a similar way the use of the other payment instruments and taking into account the relative importance towards other selected payment instruments. Third, we perform the analysis using a comprehensive set of estimation techniques: traditional linear-based fixed effects and random effects, as well as estimators based on Poisson and fractional regression models. The latter models present the advantage of taking into consideration the fractional nature of one of the dependent variables under examination.

Our results provide evidence that, when controlling the effect of socio-demographic, economic, technological and institutional factors, the use of cards was positively influenced by the process of adoption of the EMV standard. This result is particularly relevant in non euro area countries. Taking into consideration that, according to the data made available by EMVCo[1], at the end of 2014 the adoption rate of EMV in cards was less

[1] The figures represent the statistics from American Express, Discover, JCB, MasterCard, UnionPay and Visa.

than 84% in Europe (Zone 1)[2] and around 7% in the United States of America, there is still room for further improvements in EMV migration not only at EU level but also in other countries. Therefore, the involvement of the various stakeholders in fraud prevention is of particular importance, as it can promote the use of cards and, for that reason, contribute to the achievement of the goals of authorities, payment service providers and consumers.

This essay proceeds as follows. Section 2 provides an overview of the use of cards, a brief analysis of the migration process to the EMV standard in the EU and a literature review. Section 3 introduces the data used in the analysis and describes the empirical specification and the methodology. Section 4 presents the results. Section 5 discusses the outcomes and concludes.

2. Framework

In this section we present some stylised facts about the evolution of card payments in the EU, as well as the migration process to EMV. In addition, we also provide a literature review.

2.1. Card payments and the EMV migration process in the EU

In the past years cards usage has increased globally. Between 2006 and 2011, the number of per capita payments made with cards in the EU amplified 36% from around 54 to 74 payments per capita (Table 3.1). This development is also clear when we analyse the evolution of the share of payments made with cards (computed considering the relative importance of the number of payments with cards on the total number of payments made with cards, credit transfers, direct debits and cheques). In the EU this share increased from about 35% in 2006 to 42% in 2011. In the euro area the proportion of payments with cards augmented from around 30% to 37%.

[2] Please consult the following page for a definition of the countries included in the statistics: https://www.emvco.com/documents/EMVCo_EMV_Deployment_Stats.pdf.

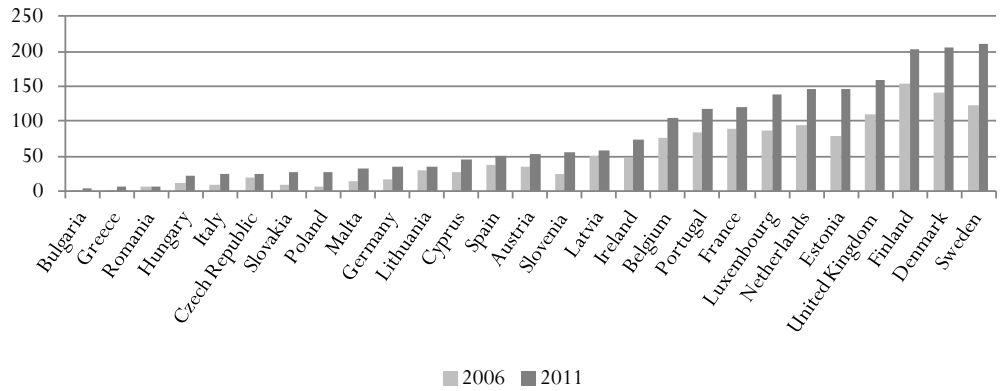
Table 3.1: Evolution of cards usage between 2006 and 2011

	2006	2011	Variation
Number of per capita payments with cards			
European Union	54.2	73.8	36%
Euro Area	49.5	66.7	35%
United States of America	161.4	235.2	46%
Canada	167.2	210.7	26%
Switzerland	53.7	77.3	44%
Share of payments with cards (in volume)			
European Union	34.7%	41.8%	20%
Euro Area	30.4%	36.5%	20%
United States of America	51.6%	64.4%	25%
Canada	65.1%	73.6%	13%
Switzerland	36.4%	43.0%	18%

Source: European Central Bank Statistical Data Warehouse for data on European Union and Euro Area and Bank for International Settlements for data on the United States of America, Canada and Switzerland.

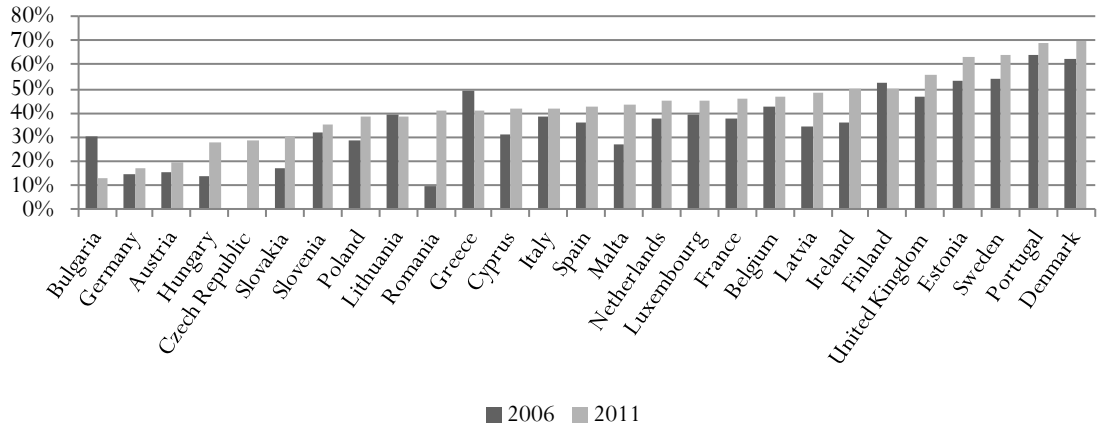
The increasing trend in cards usage is visible in all EU countries (Figure 3.1). Yet, there are still considerable differences across them. In 2011, more than 200 transactions per capita were performed in Finland, Denmark and Sweden. In contrast, in twelve EU countries the number of per capita transactions with cards was less than 50. In 2011, the proportion of payments made with cards was above 65% in Denmark and Portugal, while it was below 20% in Austria, Germany and Bulgaria (Figure 3.2). This heterogeneity suggests that the evolution in card payments will probably not be a consequence only of the diversity of Gross Domestic Product (GDP) or financial systems sophistication, even though Martikainen et al. (2015) found evidence of a convergence process of cards usage across countries in their analysis of the convergence of European retail payments.

Figure 3.1: Evolution of the per capita number of payments made with cards between 2006 and 2011



Source: European Central Bank Statistical Data Warehouse.

Figure 3.2: Evolution of the share of payments made with cards between 2006 and 2011 (in volume)

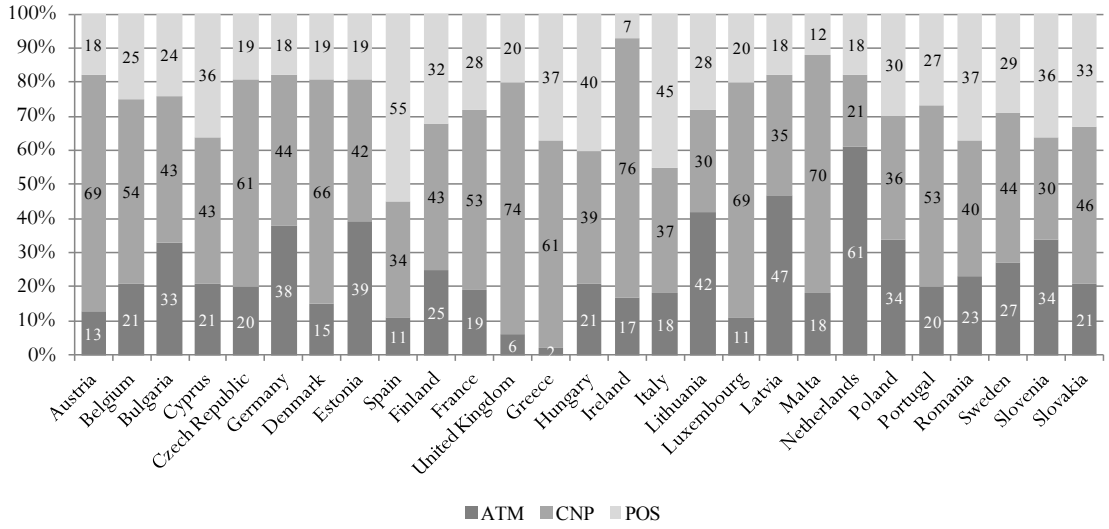


Source: European Central Bank Statistical Data Warehouse.

The divergence in the use of cards in EU countries reveals that there is still room for further increases in the use of this payment instrument, since it can have potential benefits to the economy. Nevertheless, this cannot be done without ensuring that card payments are not only efficient but also secure. In the EU, developments in card fraud are being closely monitored by the European Central Bank (ECB), as reflected in the four card fraud reports that have been published in 2012, 2013, 2014 and 2015 (ECB, 2012, 2013a, 2014a, 2015a). The total value of fraudulent transactions with cards (from an issuing point of view) amounted to €1.16 billion in 2011 (ECB, 2013a).[3] In Figure 3.3 we observe that the fraud resulting from card-not-present (CNP) payments (i.e., payments made through the internet, post or telephone) was the most relevant in EU countries in 2011, except in Spain and Italy were fraud took place mainly at point-of-sale (POS) terminals and Lithuania, Latvia and the Netherlands where the majority of fraud occurred on transactions at Automated Teller Machines (ATM).

[3] For more information on the methodology followed in the analysis see ECB (2012, 2013, 2014a, 2015a).

Figure 3.3: Distribution of the value of card fraud by transaction channel from an issuing perspective in 2011



Source: ECB (2013).

The fraudulent use of cards is not a recent phenomenon. To support the establishment of an integrated, secure and efficient card payments landscape in the EU, several measures have been adopted by legislators, regulators and other authorities in the past years. One of those key measures was the commitment, by the EPC, to migrate all cards and terminals to the EMV standard by 2010 (EPC, 2009). The EMV is a microchip technology that allows the authentication of transactions through dynamic encryption protocols that are much harder to counterfeit than magnetic stripes and protect information more effectively. The migration to this standard reduced face-to-face fraud according to Anderson and Murdoch (2014). However, fraud levels connected with distance payments (e.g., on e-commerce) and the use of magnetic stripe outside of the Single Euro Payments Area[4] (SEPA) increased after the beginning of EMV migration. This resulted from the fact that, even though cards were originally introduced in the 1930s for payments at physical points-of-sale, the technological progress and the appearance of electronic commerce enhanced cards usage in remote payments (ECB, 2014b).

This impact of EMV adoption on fraud is visible in several EU countries. Some of the most cited cases in literature relate to France and United Kingdom – both examples of

[4] Currently SEPA consists of the EU Member States plus Iceland, Norway, Liechtenstein, Switzerland, Monaco and San Marino.

countries where full migration was already achieved. In France, with the upgrade to the EMV specification that occurred between 2001 and 2008, fraudsters turned their focus to transactions with weaker authentication methods. CNP fraud increased from 25% in 2006 to about 54% of all card fraud on French-issued cards in 2009 (King, 2012). In the United Kingdom, the migration to the EMV standard finished in 2006 and fraud also shifted to card payments with magnetic stripes, as well as to distance payments. Fraud on purchases made over the internet, mail order and telephone order grew from £183 million in 2005 to £328 million in 2008 (Sullivan, 2013).

In order to address the new challenges posed to fraud fight, the EPC approved, in 2011, a set of resolutions that aimed to increase security in CNP environments and reduce the negative impact of an incomplete migration to the EMV standard outside SEPA (EPC, 2011). In addition to the migration to the EMV standard, EU authorities adopted several other measures to improve the security of card payments. In 2008, the ECB made available a set of oversight standards that were prepared to ensure the safety and efficiency of card payment schemes operating in the euro area (ECB, 2008). A guide for the assessment of card payment schemes against these standards was published in 2015 (ECB, 2015b). In January 2012, the European Commission submitted to public consultation a Green Paper (COM (2011) 941 final) in order to launch the debate on the way forward to achieve an integrated market for card, internet and mobile payments. The Commission vision was that a full integration would bring substantial benefits for consumers, businesses, public administrations and merchants, generating important economic gains. Following the results of the public consultation, the European Commission adopted, in July 2013, a legislative package that included: (i) a proposal for a revised Payment Service Directive (PSD2) that intended to encourage the usage of more efficient payment instruments by enhancing transparency in their costs (COM (2013) 547 final)[5]; and (ii) a proposal for a Regulation on interchange fees[6] for card-based payment transactions that aimed to regulate the maximum level of those fees, as well as business practices in the

[5] Directive (EU) 2015/2366 of the European Parliament and of the Council of 25 November 2015 on payment services in the internal market, amending Directives 2002/65/EC, 2009/110/EC and 2013/36/EU and Regulation (EU) No 1093/2010, and repealing Directive 2007/64/EC. The Directive entered into force in January 2016.

[6] According to ECB (2014b), interchange fees are paid by the acquirer (i.e., a payment service provider that accepts and processes card transactions) to the issuer (i.e., a payment service provider that enters into a contractual relationship with the cardholder) in order to balance the costs supported by both sides.

payments field (COM (2013) 550 final).[7] In April 2014, the ECB published a report with the status of card payments in Europe and its views and objectives regarding the implementation of SEPA[8] for cards. While acknowledging that the harmonization of payment behaviour is not the final goal, the ECB understands that the increasing trend in the use of cards emphasizes the need to make more uniform *"(…) the principles, business practices and rules, and technical standards relating to card payments"*, with a particular focus on security issues (ECB, 2014b:5). In December 2014, the European Banking Authority (EBA) made public a set of guidelines that aim to reinforce the security of internet payments across the EU, namely with cards (EBA, 2014).

2.2. Literature review

The growth of card payments caught the attention not only of policymakers, but also of researchers (Scholnick et al., 2008). Literature on card payments is rising both from the theoretical and empirical perspectives. According to Bolt and Chakravorti (2008), Bolt and Chakravorti (2010) and Humphrey (2010), the existing theoretical analyses in this field are typically focused on the areas of pricing, interchange fees, surcharging and two-sided markets. These theoretical studies provide a relevant support for the understanding of some of the specific characteristics of card payments.

The empirical studies regarding payment behaviour with cards usually focus on the examination of the impact of socio-demographic factors, including age, education, income and foreign backgrounds (see, for example, Mantel, 2001, Stavins, 2001, Rysman, 2007, Borzekowski and Kiser, 2008, Dahlberg and Öörni, 2010, Koulayev et al., 2012 and Kosse and Jansen, 2013). These studies are mainly based on household surveys, retailers' data or payment card industry datasets. Some articles also use aggregate data of payment transactions in each country. In general, the investigations found evidence of a positive effect of education and income on the use of cards and a positive (negative) effect of age on the use of debit (credit) cards. Nevertheless, the range of factors being considered in the

[7] Regulation (EU) 2015/751 of the European Parliament and of the Council of 29 April 2015 on interchange fees for card-based payment transactions has already entered into force.

[8] The SEPA project aims to harmonize retail payments in euro by allowing cross-border payments to be made as easily, securely and efficiently as national payments (ECB, 2014b).

literature has been rising in the past years. Hayashi and Klee (2003) highlighted that payment choices are also related with consumers' propensity to adopt new technologies and the characteristics of the transactions, such as the physical attributes of the point-of-sale and the value of the transaction. This last line of investigation was also explored by Klee (2008) and Bounie and François (2009) through the examination of the impact of product and transaction characteristics and opportunity costs on payment choice. Ardizzi and Iachini (2013) also found evidence of the importance of technological factors in the use of cards. The relevance of cards' attributes (e.g., possibility to track transactions, existence of surcharges, cost to the consumer and ease and convenience of use) to payment behaviour was investigated by Schuh and Stavins (2013). In addition, Carbó-Valverde and Liñares-Zegarra (2011) as well as Ching and Hayashi (2010) draw attention to the fact that reward programs could also promote the use of cards. The role of fraud and safety has been gradually included in the analysis of card payments. Jonker (2007) found that the absence of perceived physical danger or financial risk had an impact on whether and how frequently consumers used cards. In a status report, Bolt and Chakravorti (2008b) underlined the relevance of security in card payments to consumers. Ching and Hayashi (2010) emphasized the effect of perceived safety in the use of payment instruments. The more recent papers of Kosse (2013a) and Kosse (2013b) refer that newspaper articles about fraud on debit cards, as well as the perceived safety of this payment instrument could also play a role in the use of cards. Ardizzi (2012) provided evidence of a decrease in card fraud loss rate in face-to-face transactions with the migration to the EMV standard in Italy.

Notwithstanding the above, the cross-country analysis of the use of cards is still relatively limited. Humphrey et al. (1996), provided the first examination of the number of (debit and credit) card transactions per person in fourteen countries for the period between 1987 and 1993. The authors estimated a model of payment instrument demand with Ordinary Least Squares (OLS) and found evidence of a negative (positive) effect of POS terminals availability in the use of credit (debit) cards. They also reported a positive (negative) effect of crimes in the use of credit (debit) cards. Guariglia and Loke (2004) extended the analysis by estimating static equations using the within estimator and dynamic equations with the difference Generalized Method of Moments (GMM),

considering data on the per capita volume and value of card payment transactions from fifteen countries for the period between 1990 and 1998. The authors obtained empirical evidence of a positive influence of POS terminals in both the value and volume of card transactions per capita. Amromin and Chakravorti (2007) investigated the evolution of the number of debit card transactions in thirteen countries between 1988 and 2003 with a fixed effects model and concluded that it was positively affected by the number of debit cards and POS terminals. Pietrowiak (2014) analysed the effect of a selection of factors on the share of card payments on consumer spending at the point-of-sale between 1991 and 2011 for eight EU countries and, among other conclusions, obtained evidence that the dependent variable under analysis was influenced by the number of cards and POS terminals. Goczek and Witkowski (2015) examined some of the cross-country determinants of retail card payments in EU countries between 2000 and 2012.The authors focused on four different measures: (i) total value of annual card payments per capita; (ii) number of terminals per one million inhabitants; (iii) number of cards per one thousand inhabitants; and (iv) card transactions as a fraction of total noncash transactions. Using dynamic models the authors concluded that the number of ATM (used as proxy for cash usage) has a negative impact on the share of card transactions, while POS terminals, the number of cards and past habits have a favourable influence on that variable. Finally, Dagdemir and Sauer (2015) investigated the impact of a set of variables on the volume of card transactions in a panel of 22 countries for the period 2009-2013. They found a positive effect of the use of cash and GDP on cards usage.

The existing studies provide an overview of some of the factors that can influence cards usage, but none of them analyses, from an empirical point of view, the impact of the migration process to the EMV standard in the use of cards. Obtaining empirical evidence of the effect, on card payments, of the progress in EMV migration can be of particular importance to authorities and payment service providers at EU level and for other countries that are still on earlier stages of adoption of the EMV technology (e.g., the United States of America[9]).

[9] In October 2014, the President of the United States of America set a policy that requires newly issued and existing government cards to be enabled with chips. In October 2015, the liability on fraud shifted to most merchants and processors not using EMV technology.

3. Data and methodology

In this section is presented a brief description of the data used, the empirical model and the methodology followed in the analysis.

3.1. Data and descriptive statistics

The analysis was performed using annual country level data from the ECB SDW regarding the per capita number and share (in volume)[10] of payments made with cards in EU countries during the period 2006-2011. According to the methodological notes of the ECB SDW, the number of payments made with cards includes payment transactions performed with cards that have a debit, credit or delayed debit function at a terminal or via other channels, both where the acquirer and the issuer of the card are the same or different entities. Payments were counted on the card-issuing side and include transactions both within and outside the country of issue. E-money transactions, cash withdrawals and deposits and credit transfers at ATM were not included. In our analysis we do not separate debit and credit cards since data on EMV migration is not available with this level of granularity.

Three variables were considered as potential candidates to measure the migration to the EMV standard: (i) the EMV-compliant cards as a percentage of total cards in circulation (*emvcard*); (ii) the EMV-compliant ATM as a percentage of total ATM (*emvatm*); and (iii) the EMV-compliant POS terminals as a percentage of total POS terminals (*emvpos*). From the analysis of Table 3.2, we can observe that the evolution of the number of per capita payments with cards between 2006 and 2011 in the EU countries had a tendency very similar to the progress of the share of EMV-compliant cards, ATM and POS terminals. This relation (measured by the Pearson correlation coefficient) was stronger regarding cards (0.99) than POS terminals (0.94) and ATM (0.78). Considering this, and

[10] Computed considering the relative importance of the number of payments made with cards on the total number of payments with cards, cheques, credit transfers and direct debits.

in order to avoid colinearity between the regressors and ensure a parsimonious specification of the model, we opted to include only the variable *emvcard*.[11]

Table 3.2: Evolution of card payments and the share of EMV adoption in cards, ATM and POS terminals in EU countries (2006-2011)

	2006	2007	2008	2009	2010	2011
Number of per capita payments with cards	54.2	55.4	59.5	63.1	68.1	73.8
Share of card payments (in volume)	34.7%	36.9%	38.3%	39.2%	40.1%	41.8%
Share of EMV-compliant cards	52.5%	60.0%	66.5%	70.8%	81.0%	87.7%
Share of EMV-compliant ATM	58.9%	80.8%	91.2%	92.1%	96.1%	96.7%
Share of EMV-compliant POS terminals	49.6%	65.5%	74.0%	79.5%	89.6%	94.4%

Source: European Central Bank Statistical Data Warehouse and European Central Bank. The table reports the evolution between 2006 and 2011 of card payments and the share of EMV adoption in cards, ATM and POS terminals in EU countries.

In order to control for other factors that might influence cards usage, additional independent variables were included in the model. Detailed information regarding the variables used in the analysis can be found in Table A3.1 of the Appendix. According to the existing literature based on surveys, namely the studies of Mantel (2000), Stavins (2001), Rysman (2007), Borzekowski and Kiser (2008), Dahlberg and Öörni (2010) and Koulayev et al. (2012), socio-demographic factors can affect card usage. To incorporate those elements, we included in the specification variables that refer to the age and education level (*age* and *edu*) of the population. Stavins (2001) concluded that younger consumers have an higher probability of using debit cards and are less prone to use credit cards and Koulayev et al. (2012) found that older households are more likely to adopt and use credit and debit cards. Therefore, we expect that the variable *age* might have a positive relationship with the use of cards due to the median age of the EU population for the period under analysis (Table 3.3). The education level – measured as the percentage of persons with upper secondary or tertiary education attainment – is expected to support the contact with electronic payment instruments and, therefore, should have a positive relationship with the use of cards. Taking into consideration the potential effect of the

[11] Note in addition that, when the other variables are included, we do not obtain adequate specifications according to the RESET test.

economic context, as reported by Humphrey et al. (1996) and Guariglia and Loke (2004), the percentage change in the real Gross Domestic Product (*gdp*) was also included as explanatory variable. Since real GDP growth reflects the evolution in a country's economic situation, we expect a positive effect in the use of cards. The technological environment might also play a role in card payments by facilitating the use of cards (Humphrey et al., 1996, Guariglia and Loke, 2004, Amromin and Chakravorti, 2007, Pietrowiak, 2014 and Goczek and Witkowski, 2015). For that reason, the number of POS terminals (*pos*) per thousand inhabitants was also incorporated in the model. It is expectable that this variable has a positive impact in cards usage. Taking into consideration the size of our sample and the need to have a parsimonious specification, the number of ATM was not included in the model. In fact, ATM can be used to make payments with cards, but also to withdraw cash and, for that reason, a clear impact in the use of cards is not expectable. To take institutional characteristics into account, a dummy variable that reflects the fact that countries belong (or not) to the euro area (*euroarea*) was also added. Information on the number of cards per million inhabitants issued in EU countries (*ncards*) was included as well (following Pietrowiak, 2014 and Goczek and Witkowski, 2015). We expect that this factor promotes card payments. The number of crimes per capita recorded by the police (*crime*) was also included, since, as highlighted by Humphrey et al. (1996), an increase in crimes might lead to a reduction in the use of cash and an increase in the use of other payment instruments, namely cards.[12] In order to account for possible substitutability effects, the number of per capita payments with cheques (*cheques*) and the number of per capita cash withdrawals (*cash*) as a simple proxy for cash usage were also considered. Finally, an interaction term between the variables *euroarea* and *emvcard* was also included to verify if the impact of the progress in EMV migration was different in countries that belong (or not) to the euro area.[13]

[12] We also tested the inclusion of a dummy variable that aimed to capture the impact of the recent financial crisis, but the model has not passed the specification tests.

[13] Due to the lack of available data, we were not able to include information on the costs supported by payment service providers, merchants and consumers that can be relevant to the cards industry. However, Bolt et al. (2008) found that pricing had a small effect on payment choice using data from the Netherlands and Norway. Moreover, there is evidence on the fact that, in general, costs are not properly perceived by the payment instruments users. For example, Jonker (2007) mentions that, because Dutch consumers tend to cover the costs of retail payments via indirect and hidden direct costs, the use of payment instruments seems to be "free" for them.

Table 3.3 provides an outlook of the aggregate descriptive statistics of the variables under analysis. Between 2006 and 2011, around 66 card payments per capita were made in EU countries and the mean of the share of this type of payments was 40%. Regarding the EMV adoption, we observe that around 67% of cards were EMV-compliant. However, the migration process was very different across EU countries. In what concerns the control variables, it is worth noting that in the period between 2006 and 2011 the education level had a relatively large variation between EU countries, while age characteristics were more stable, mainly within countries. The economic environment changed a lot within countries and the technological context revealed important variations between countries.

Table 3.3: Descriptive statistics of the dependent and independent variables for EU countries (2006-2011)

Variable	Mean	Std. Dev.	Min.	Max.	No. Obs.
Dependent variables					
ncards	65.79	56.14	1	209.78	162
propcards	0.40	0.15	0.09	0.70	158
Independent variables					
EMV adoption factor (M_{it})					
emvcard	0.67	0.36	0	1	159
Socio-demographic factors (SD_{it})					
edu	0.69	0.13	0.29	0.86	162
age	39.57	2.10	33.40	44.60	162
Economic factor (E_{it})					
gdp	0.01	0.05	-0.16	0.12	162
Technological factor (T_{it})					
pos	16.58	8.68	2.20	37.80	159
Institutional factors (I_{it})					
crime	0.05	0.03	0.01	0.15	159
euroarea	0.55	0.50	0	1	162
ncards	1.37	0.46	0.43	3.26	162
cash	23.27	10.77	5.81	47.03	155
cheques	6.99	13.11	0	60.37	162

The table reports the descriptive statistics of the dependent and independent variables in the period between 2006 and 2011 for the 27 EU countries. "Std. Dev." stands for standard deviation, "Min." for the smallest value of the observations, "Max." for the highest value of the observations and "No. Obs." for the number of observations.

3.2. Model specification and methodology

In order to study the effect on the use of cards of the migration process to the EMV standard, the following equation was estimated:

$$Y_{it} = G\left[\beta_0 + \beta_1 M_{it} + \beta_2 (euroarea \times emvcard)_{it} + \beta_3 SD_{it} + \beta_4 E_{it} + \beta_5 T_{it} + \beta_6 I_{it} + \varepsilon_{it}\right] \quad (1)$$

where Y_{it} (the dependent variable) is the per capita number or share of payments made with cards, with i ($i = 1, \dots N$) representing each country and t ($t = 1, \dots 13$) representing time period; M_{it} refers to the migration to EMV in cards (i.e., *emvcard*); $(euroarea \times emvcard)_{it}$ is an interaction term between the variables *euroarea* and *emvcard*; SD_{it} denotes socio-demographic factors (i.e., *edu* and *pop*); E_{it} regards to the real percentage change in GDP (i.e., *gdp*); T_{it} refers to technological elements (i.e., *pos* and pos^2, which stand for the number, per thousand inhabitants, of POS terminals); I_{it} represents institutional determinants (i.e., *crime*, *euroarea*, *ncards*, *cash* and *cheques*) and $\varepsilon_{it} = \alpha_i + u_{it}$, where α_i refers to the country-specific effects and u_{it} denotes the idiosyncratic error term. β_j, $j = 1, \dots 6$ are vectors of parameters associated to each type of explanatory variables. In nonlinear models, average partial effects (APE) were computed in order to measure the effect of changes in the covariates on the response variable, averaged across the population.

3.2.1. *Models for the number of per capita payments with cards*

A natural starting point is to consider standard linear models, where (1) is the linear index. The random effects estimator and the fixed effects (or within) estimator were used (Cameron, 2005 and Wooldridge, 2002). In the random-effects, it is assumed that α_i is purely random. In the fixed effects, the time-invariant component of the error (α_i) is allowed to be correlated with the regressors. In order to validate which estimator was most suitable, we performed a robust Hausman test. Furthermore, a RESET test was applied to the random effects model to confirm the adequacy of the specification.

Nevertheless, since linear models can generate negative predicted values, they might not be econometrically sound choices when we are dealing with count data, according to

Wooldridge (2002). Considering that the number of per capita payments made with cards is a count variable, a Poisson model estimated by pooled quasi-maximum likelihood (QML) with robust standard errors was also considered[14]. In this case, G of (1) is defined as $G[.] = \exp[.]$. In the estimation three alternatives were tested: a fixed effects Poisson model, a random effects Poisson model where the random effects follow a gamma distribution, and a random effects Poisson model where the random effects follow a lognormal distribution. The adequacy of the random effects models was validated through RESET tests. To verify if the link specification of the model was correct a goodness of fit or GOFF test was also applied. In order to choose the most adequate model we used a J-test for non-nested regression models (Baum, 2006).[15]

3.2.2. *Models for the share of payments with cards*

According to Papke and Wooldridge (1996), Ramalho et al. (2011) and Ramalho and Ramalho (2015), linear models are not adequate to the analysis of the share of payments made with cards, since they do not guarantee that predicted values lie between zero and one. A more appropriate econometric approach is the assumption of a functional form that defines the required constraints on the conditional mean of the dependent variable. For that reason we considered a fractional regression model (FRM) estimated by pooled QML with a robust version of the variance of the estimated parameters. Our variable of interest Y_{it} is now defined on the interval (0,1) and G written as a logit $\left(G[.] = \frac{\exp[.]}{1+\exp[.]}\right)$, cloglog ($G[.] = 1 - \exp[.]$) and probit ($G[.] = \phi[.]$, with ϕ defined as a standard normal distribution) conditional mean functions. A RESET test of the specification of the FRM was performed to verify if the models used in the analysis of the proportion of payments made with cards were adequate.

[14] Note that, according to Gourieroux et al. (1984), the Poisson estimator with robust standard errors is consistent, even under misspecification of the distribution, as long as the mean is correctly specified.

[15] Even though some authors, such as Avery (1996), Guariglia and Loke (2004) and Amromin and Chakravorti (2007), highlighted potential endogeneity issues in their analyses due to possible simultaneity (namely with technological factors and other payment instruments), we concluded that, in our examination, these effects have not revealed a statistically significant effect, since we obtained adequate models according to the specification tests performed.

4. Empirical results

In this section we discuss the model selection and present the key results obtained in the regression analysis and the APE (presented in Tables 3.4 and 3.5).

4.1. Model selection

The examination of the model of the number of per capita payments made with cards began with the linear fixed and random effects estimators. The random effects approach was not rejected by the Hausman test. However, this specification is not correct according to the RESET test. Next, we tested a fixed effects Poisson model and a random effects Poisson model with gamma and lognormal distributions. We focused our attention on the random effects models, considering the results obtained in the linear analysis. Both random effects models revealed a correct specification according to the RESET and GOFF tests. In addition, the correct specification of both models is not rejected in the non-nested hypothesis test. In fact, the results obtained with the gamma and the lognormal distributions are very similar.

The investigation of the proportion of the number of payments made with cards was performed using a FRM estimated with pooled QML. Although all the models passed the RESET test, only the model with a cloglog conditional mean function revealed an adequate link specification in the GOFF test. In this model we obtain seven individually significant variables at a significance level of 1%, instead of the three and four achieved in the random effects Poisson model with gamma and lognormal distributions. This result suggests that the set of covariates in analysis provides a better description of the payment behaviour measured in terms of proportion.

4.2. The effect of EMV migration

We obtained evidence of a statistically significant positive effect of the migration process to the EMV standard in the per capita number and share of payments made with cards in EU countries during the period comprised between 2006 and 2011. The interaction between the variable *euroarea* and *emvcard* is also statistically significant and

reflects the fact that the positive effect of EMV adoption is considerably reduced in countries that belong to the euro area. This can result from the fact that the euro area includes countries where the share of EMV-compliant cards was already 100% in 2006 (i.e., France and Luxembourg) or where full migration was very quickly achieved (as happened in Austria and Belgium). Comparing the APE of the Poisson model with a gamma distribution (*emvcard*: 26.37 and *euroarea x emvcard*: -20.93) with the Poisson model with a lognormal distribution (*emvcard*: 21.33 and *euroarea x emvcard*: -16.54) we conclude that the differences are not very large. The APE of the variables *emvcard* and *euroarea* x *emvcar*d are 0.17 and -0.11 in the analysis of the share of payments made with cards. In both cases the magnitude of the results is quite relevant as the mean of the per capita number and share of card payments is 65.79 and 0.40 in our sample.

At the end of 2011, the share of EMV transactions (i.e., card transactions in which an EMV-compliant card is used at an EMV-compliant terminal and EMV technology is applied in the processing of the transaction) at EU level[16] amounted to 79.7% (ECB, 2014b) and no large progresses have been registered in the past years. Consequently, there is an incentive to the various stakeholders involved in the payments chain to conclude the EMV migration of the infrastructures within the EU and to invest in other fraud prevention solutions that ensure the robustness and safety of the various channels where card payments are made.

4.3. The effect of socio-demographic, economic, technological and institutional factors

The examination of card payments should also take into consideration that the use of this payment instrument can be influenced by socio-demographic, economic, technological and institutional factors.

The positive impact of the socio-demographic factors on the number of per capita payments with cards is in line with the results of other authors, such as Stavins (2001) and Koulayev et al. (2012) for credit cards. In fact, the higher the percentage of population

[16] Computed as the number of EMV transactions at POS terminals divided by the total number of transactions at POS terminals irrespective of the country of issuance of the card.

with upper or tertiary education attainment, and the higher the median age, the larger the proportion of population that should find it easier to use electronic payment instruments, such as cards. The opposite effect was obtained on the model of the share of payments made with cards. This result can be due to the fact that socio-demographic factors affect in a different magnitude payments made with cards, cheques, credit transfers and direct debits. Therefore, a negative effect in the share of payments with cards can result, for example, from a bigger positive impact in the use of credit transfers and direct debits than in the use of cards.

The role of economic conditions is also in accordance with the existing literature. The evolution of the GDP revealed a positive impact in the per capita number of cards payments, as also reported by Humphrey et al. (1996). In fact, GDP growth can reflect the businesses environment and therefore it can contribute to the evolution of payments made with cards. The positive effect, at a decreasing rate, of POS terminals in cards usage highlights the relevance of technological factors, in line with the results of Guariglia and Loke (2004), Amromin and Chakravorti (2007), Pietrowiak (2014) and Goczek and Witkowski (2015). POS terminals are typically used for low-value payments made by consumers and facilitate the use of cards at the point-of-sale. Regarding institutional factors, we observe that the fact that a country belongs to the euro area has a statistically significant positive impact in the number of per capita payments made with cards. This effect can be surprising, since according to ECB (2014b) the use of cards varies significantly among countries owing more to different national market infrastructures and payment preferences than to currencies. Since we are using a dummy variable to capture the fact that a country belongs (or not) to the euro area, our result might be reflecting the effect of other elements that are common among these countries, for example, similar approaches in the retail payments field.

The positive effect in the share of payments made with cards of the variable *crime* might reflect a shift from cash payments when crime records increase, as previously identified by Humphrey et al. (1996). The negative impact of *ncards* can result from the fact that cards can be used to either withdraw cash or make card payments. In earlier stages, users typically focus on the first type of operations. For example, between 2006 and 2011 the

per capita number of cash withdrawals increased more significantly in Belgium, Cyprus Lithuania, Poland and Romania. The variable *ncards* also reflects a higher level of bancarisation, which can contribute to a greater use of credit transfer and direct debits. In addition, the positive impact of the variable *cash* may result from a complementary relation between cards and cash, according to Guariglia and Loke (2004) and Dagdemir and Sauer (2015). This can be connected with consumers' preferences to use cash in small daily transactions, as well as merchants' behaviour connected with the fees supported on card payments. The negative effect of the variable *cheques* can reflect the fact that cards are replacing cheque payments.

Table 3.4: Estimation results of the relevance of EMV adoption in EU countries (2006-2011)

Variables	Model of the number of per capita payments with cards					Model of the share of payments with cards (in volume)		
	Fixed effects	Random effects	Poisson (fixed effects)	Poisson (random effects with gamma distribution)	Poisson (random effects with lognormal distribution)	FRM (logit)	FRM (cloglog)	FRM (probit)
emvcard	-3.6575	-1.0616	0.4106***	0.4707***	0.4808***	0.7348***	0.6049***	0.4409***
	(9.0168)	(10.8345)	(0.1183)	(0.1484)	(0.1282)	(0.1744)	(0.1402)	(0.1055)
emvcard x euroarea	10.1324	14.0463	-0.3648***	-0.3736**	-0.3727***	-0.4417***	-0.3662**	-0.2622**
	(9.9795)	(10.1763)	(0.1231)	(0.1894)	(0.1391)	(0.2041)	(0.1595)	(0.1246)
edu	64.4871	82.2397	1.0336**	0.7115	0.9350*	-1.4817***	-1.1788***	-0.9115***
	(67.9227)	(53.3667)	(0.4935)	(0.7985)	(0.5303)	(0.3445)	(0.2440)	(0.2135)
age	2.3831	-0.1211	0.0874***	0.0593*	0.0527*	-0.0897***	-0.0668***	-0.0562***
	(2.5143)	(2.3121)	(0.0302)	(0.0339)	(0.0302)	(0.0233)	(0.0192)	(0.0138)
gdp	20.6323	27.2294**	0.3236	0.4810***	0.4733**	0.0544	0.1175	0.0168
	(12.3414)	(13.6771)	(0.1993)	(0.1572)	(0.2212)	(0.4895)	(0.3793)	(0.2998)
pos	5.9947***	6.6285***	0.0927***	0.1135***	0.1112***	0.0843***	0.0687***	0.01516***
	(1.4547)	(1.4798)	(0.0115)	(0.0399)	(0.0174)	(0.0173)	(0.0132)	(0.0106)
pos^2	-0.0983***	-0.1039***	-0.0016***	-0.0019*	-0.0019***	-0.0012***	-0.0010***	-0.0007***
	(0.0240)	(0.0266)	(0.0002)	(0.0011)	(0.0003)	(0.0004)	(0.0003)	(0.0002)
crime	213.3574	479.0259	-2-2682	3.2255	2.5867	2.4640**	1.8409**	1.5396**
	(393.7878)	(328.6892)	(3.9045)	(3.8124)	(4.2124)	(1.0823)	(0.7695)	(0.6714)
euroarea	-4.6445	-6.7666	0.2761**	0.2940**	0.2892**	-0.0591	-0.0222	-0.0454
	(5.1535)	(5.0919)	(0.1156)	(0.1377)	(0.1286)	(0.1742)	(0.1373)	(0.1056)
ncards	24.4167*	23.1745*	0.1467**	0.1172	0.1209	-0.1771*	-0.1379**	-0.1103**
	(12.1500)	(13.0961)	(0.0700)	(0.1507)	(0.0774)	(0.0906)	(0.0666)	(0.0559)

(continue)

Table 3.4: Estimation results of the relevance of EMV adoption in EU countries (2006-2011) (continued)

Variables	Model of the number of per capita payments with cards					Model of the share of payments with cards (in volume)		
	Fixed effects	**Random effects**	**Poisson (fixed effects)**	**Poisson (random effects with gamma distribution)**	**Poisson (random effects with lognormal distribution)**	**FRM (logit)**	**FRM (cloglog)**	**FRM (probit)**
cash	-1.8972	-0.7779	-0.0042	0.0028	0.0021	0.0213***	0.0159***	0.0133***
	(1.1387)	(0.8571)	(0.0039)	(0.0052)	(0.0040)	(0.0034)	(0.0024)	(0.0021)
cheques	-1.2139	-0.4290	0.0028	0.0011	0.0020	-0.0146***	-0.0119***	-0.0089***
	(0.8933)	(0.5681)	(0.0073)	(0.0105)	(0.0065)	(0.0037)	(0.0030)	(0.0023)
Hausman test	-	0.2092	-	-	-	-	-	-
p-value								
RESET test	-	0.0003	-	0.4014	0.1559	0.5110	0.4950	0.5050
p-value								
GOFF test	-	-	-	-	-	0.0140	0.5240	0.0170
p-value								
J-test	-	-	-	0.7420	0.9440	-	-	-
p-value								
No. Obs. (NxT)	142	142	141	142	142	138	138	138

The table reports the fixed effects, random effects, Poisson fixed effects, Poisson random effects with gamma distribution, Poisson random effects with lognormal distribution and FRM with a logit, cloglog and probit distribution functions (with robust standard errors) estimation results for the dependent variables under analysis: number of per capita payments with cards and share of payments with cards (in volume). Standard errors are in parenthesis. Constant term coefficient not reported. Variables in value have been adjusted for inflation. Note that: * indicates significance at the 10% level, ** at the 5% level and *** at the 1% level. "No. Obs." stands for the number of observations.

Table 3.5: APE of selected models

Variables	Model of the number of per capita payments with cards		Model of the share of payments with cards (in volume)
	Poisson (random effects with gamma distribution)	Poisson (random effects with lognormal distribution)	FRM (cloglog)
emvcard	26.3731***	21.3334***	0.1748***
emvcard x euroarea	-20.9329**	-16.5360***	-0.1058**
edu	39.8659	41.4899*	-0.3406***
age	3.3227*	2.3367*	-0.0193***
gdp	26.9491***	21.0009**	0.0340
pos	6.3608***	4.9348***	0.0199***
pos^2	-0.1064*	-0.0831***	-0.0003***
crime	180.7248	114.7826	0.5319**
euroarea	16.4704**	12.8325**	-0.0064
ncards	6.5679	5.3639	-0.0398**
cash	0.1551	0.0954	0.0046***
cheques	0.0641	0.0907	-0.0034***

The table reports the APE computed for the following models: Poisson random effects with gamma distribution, Poisson random effects with lognormal distribution and FRM with a cloglog distribution function.

5. Concluding remarks

Using cross-country data for the period 2006-2011 and both linear and non-linear models, we find that the adoption process of the EMV standard had a positive influence on the per capita number and share of payments made with cards in EU countries (when controlling for the effect of socio-demographic, economic, technological and institutional factors), particularly in non euro area countries. In fact, EMV migration might enhance the real/perceived safety of card payments by its users, leading to an increase in the use of this payment instrument.

Against this result, we can derive some policy orientations. First, investing in fraud prevention can have a positive effect in cards usage and, for that reason, might reduce the use of less efficient means of payment. There are, therefore, clear incentives to conclude the migration to this standard in both the SEPA and other countries, such as the United States of America, that are at earlier stages of EMV adoption. Second, since EMV only reduces fraud in face-to-face transactions, other measures will have to be implemented in the short term in CNP environments to avoid fraud shifting to those areas. The

intervention of the various stakeholders (namely, policymakers and payment service providers) is key to ensure the continuous safety of card payments. In general, the analysis of the evolution of cards usage and fraud levels can provide a good indicator of the need for public intervention in this field. For that reason, policymakers should ensure the monitoring of the trends in both card payments and fraud levels in the various channels where cards are used, in order to verify if it is necessary to make use of the catalyst role to promote additional investments in fraud prevention that guarantee that card payments remain safe.

This investigation added new empirical evidence to the literature about the role of fraud prevention measures in the use of payment instruments. Even so, the empirical investigation of card payments remains an interesting avenue for more research. Future investigation could focus on deepening the examination of the impact of fraud on card usage in the EU. The public data on the various types of card fraud is still very limited, so when more data is available, analyses that clarify the connection between fraud, measures to reduce it and the use of cards will be of great importance.

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Appendix

Table A3.1: Description of the dependent and independent variables used in the empirical analysis

Variable	Description	Source
	Dependent variables	
cardspc	Number of card payments per capita (except e-money).	ECB SDW
propcard	Share of the total number of payments with cards computed considering the relative importance of the number of payments with cards on the total number of payments made with cards, credit transfers, direct debits and cheques.	Authors' calculation based on data from the ECB SDW
	Independent variables	
	EVM migration factor (M_{it})	
emvcard	EMV-compliant cards as a percentage of total cards in circulation.	ECB
	Socio-demographic factors (SD_{it})	
edu	Percentage of persons with upper secondary or tertiary education attainment.	Eurostat
age	Median age of population (in years).	Eurostat
	Economic factor (E_{it})	
gdp	Real percentage change in the GDP.	Eurostat
	Technological factor (T_{it})	
pos	Number, per thousand inhabitants, of POS terminals (device allowing the use of payment cards at a physical point-of-sale) in the end of each year.	ECB SDW
	Institutional factors (I_{it})	
crime	Number of crimes (per capita) recorded by the police.	Eurostat
euroarea	Dummy variable that equals 1 when the country is from the euro area and 0 otherwise.	ECB SDW
ncards	Number of all issued cards except with e-money function.	ECB SDW
cash	Number of cash withdrawals per capita.	ECB SDW
cheques	Number of cheque transactions per capita.	ECB SDW

Chapter 4

The impact of SEPA in credit transfer payments: Evidence from the euro area[1]

Abstract

This article analyses the effect of the implementation process of the Single Euro Payments Area (SEPA) project on credit transfer payments in euro area countries during the period between 2008 and 2013. Using both univariate and multivariate fractional regression models, we found that, when controlling for socio-demographic, economic, technological and institutional factors, the progress in the migration to SEPA formats had a relevant positive impact on the share of payments made with credit transfers. Our results provide for the first time empirical evidence of the direct effect of the implementation of SEPA on payment habits and highlight potential policy implications for the payments landscape.

***JEL Classification**: E41, E42, C25, C35, F36, G21*

***Keywords**: Credit Transfers, European Union, Panel Data, Retail Payments, SEPA*

[1] This essay was published in *Research in International Business and Finance*.

1. Introduction

The Single Euro Payments Area (SEPA) project is, undoubtedly, a key milestone for European integration. By establishing a single set of conditions, rights and obligations for euro payments regardless of the location, this project aims to increase harmonization and efficiency in euro payments and, for that reason, contribute to take complete advantage of the Economic and Monetary Union (ECB, 2013). Understanding the impact of the progress in SEPA migration on the use of credit transfers is of great interest to both payment service providers and policymakers. The implementation process required significant investments by the banking community, for which a financial return is expected in the near future. By supporting the SEPA project, authorities intended to encourage the substitution of less efficient means of payment, since this might reduce the costs supported by society with the use of payments instruments (Schmiedel et al., 2012) and also contribute to economic growth (Hasan et al., 2013).

Examining the overall impact of SEPA implementation on credit transfer payments in euro and non area countries will only be feasible in the years following the complete conclusion of the migration (i.e., after 31 October 2016). Note that a considerable period after completing SEPA migration must be guaranteed before a general analysis is performed, since the possible substitution effects with other payment instruments might take some time to occur. Yet, at this stage, it is feasible to evaluate what was the impact of the progress in the migration in euro area countries. In fact, between 2008 and 2013 the migration of credit transfers to SEPA standards has seen considerable progress. In December 2008 only 2% of euro area credit transfers were SEPA compliant, but in December 2013 around 74% of credit transfers were made in accordance with SEPA rules.

In this context, this essay examines the effect of the progress in SEPA migration on credit transfer payments in euro area countries between 2008 and 2013. While a small number of the existing papers have explored the potential benefits of the implementation of SEPA (see an overview in Schmiedel, 2007) and a few cross-country studies identified some of the factors that might influence the use of credit transfers (for example,

Humphrey et al., 1996, Deungoue, 2008 and Martikainen et al., 2015), none of them focuses on the effect of SEPA adoption on credit transfer payments. Thus, this study complements the existing literature in several ways. First, according to our knowledge, it provides the first empirical examination of the effect of SEPA migration on the use of credit transfers, therefore enriching the existing literature which is mainly focused on the theoretical analysis of SEPA or on the computation of potential economic benefits of this project. Second, the analysis of the effect of SEPA migration progress on the use of credit transfers – measured as the proportion of the number of credit transfer payments on the total number of payments made with credit transfers, direct debits, cards and cheques – is performed using estimation techniques that take into account the fractional nature of the dependent variable under estimation. Third, the analysis includes not only the most well-known fractional regression models (FRM), which are univariate in the sense that only the share of interest is described, but also FRM that allow for the presence of neglected heterogeneity, recently proposed by Ramalho and Ramalho (2015), and multivariate FRM that describe simultaneously the share of interest and other shares of non-cash payments instruments, controlling for potential substitution effects between them.

From our regression results we conclude that, after taking into consideration the potential impact of socio-demographic, economic, technological and institutional variables, the progression in the migration of credit transfers to SEPA formats had a statistically significant positive effect on the use of this payment instrument. This result suggests that the migration to SEPA impacted credit transfer payments in more than just a technical way. The fact that the pattern of use of this payment instrument was affected by the project can unveil future advantages when full migration is achieved in terms of: (i) the returns obtained by payment service providers with the use of this payment instrument; (ii) the social costs supported with the use of payment instruments; and (iii) the evolution of consumption and trade. Indeed, since the use of this payment instrument is still relatively low in some euro area countries (for example, in Portugal, Spain, France and Malta, the share of payments made through credit transfers in 2013 was less than 20%), the migration to SEPA might contribute to an increase in credit transfers usage, with the potential benefits that might result from it.

The remainder of this essay is structured as follows. Section 2 presents an outline of the use of credit transfers in euro area countries and of the SEPA project, as well as a summary of relevant literature. Section 3 describes the data and illustrates the methodology used. Section 4 reports the empirical results. Section 5 discusses the findings and concludes.

2. Framework

In this section it is presented a summary of the evolution of credit transfer payments in euro area countries between 2008 and 2013, as well as a brief overview of the SEPA project. The relevant literature is also reviewed.

2.1. Credit transfer payments in the euro area

According to Kokkola (2010), credit transfers have been one of the most commonly used non-cash payment instruments in the euro area. In fact, the share of payments made with credit transfers in the euro area (computed considering the relative importance of the number of credit transfer payments – SEPA compliant or not –, on the total number of payments made with credit transfers, direct debits, cards and cheques) has been stable across the period in analysis, ranging from around 33% in 2008 to about 32% in 2013 (Table 4.1).

The relative importance of this payment instrument in the euro area is quite substantial when compared to the United States of America (US) or Canada. Still, it is lower than the proportion found in Switzerland (of around 51% in 2013). In fact, the majority of cashless payments in Switzerland are made by credit transfers due to the historical relevance of the Swiss Postal Administration which contributed to a payment culture based on credit transfers (BIS, 2011).

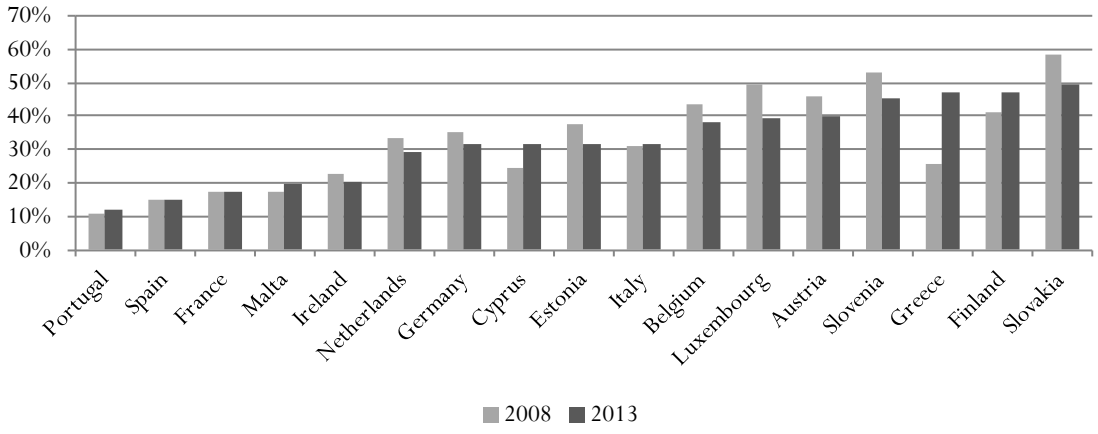
Table 4.1: Evolution of the share of payments made through credit transfers between 2008 and 2013 (in volume)

	2008	2013	Variation
Euro area	33.1%	32.2%	-3%
United States of America	6.8%	7.3%	7%
Canada	10.2%	9.6%	-6%
Switzerland	55.3%	51.1%	-8%

Source: European Central Bank Statistical Data Warehouse for data on the European Union and the euro area and Bank for International Settlements for data on the United States of America, Canada and Switzerland.

Focusing on the various euro area countries, we can observe considerable differences among them. On the upper bound we have countries such as Slovakia, Finland, Greece, Slovenia and Austria, where the proportion of credit transfer payments was above 40% in 2013. Typically, the countries where the relative importance of this payment instrument increased from 2008 to 2013, were those with a lower share of credit transfer payments in the beginning of the period (with the exception of Ireland and Finland). Even so, there are still countries on the lower bound, like Portugal, Spain, France and Malta, where the share of payments made with credit transfers remained below 20% in the period comprised between 2008 and 2013 (Figure 4.1).

Figure 4.1: Evolution of the share of credit transfer payments (in volume) between 2008 and 2013 in euro area countries



Source: European Central Bank Statistical Data Warehouse.

The differences on the intensity of use of credit transfers in the various euro area countries leave room for further expansions in the usage of this payment instrument in the future, with potential impacts on the economy. Indeed, the empirical evidence suggests

that migration to electronic payment instruments, such as credit transfers, might stimulate the real economy. According to Hasan et al. (2013), credit transfer payments revealed the second strongest relation, after card payments, with the evolution of the economy, consumption and trade. In addition, it might generate greater efficiency in terms of the costs supported by society with the use of payments instruments. Schmiedel et al. (2012) concluded that the weighted average unit social cost of credit transfers in a sample of EU countries amounted to €1.92 per transaction, which compares with about €3.55 in cheques.

2.2. Brief overview of the SEPA project

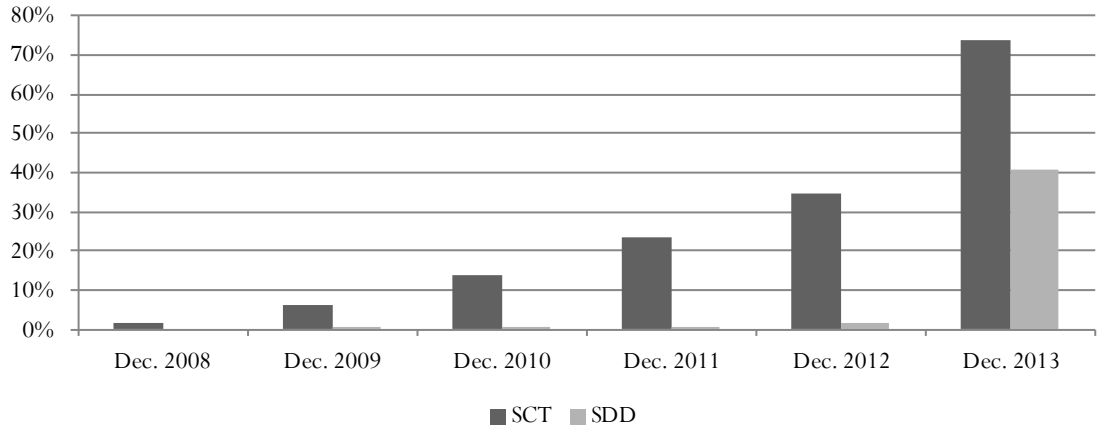
In the last years, one of the key elements that might have impacted the payments landscape, namely credit transfer payments in the euro area, was the implementation of the Single Euro Payments Area or SEPA project. This area comprises 28 EU Member States, as well as Iceland, Norway, Liechtenstein, Monaco, Switzerland and San Marino. The project results from an initiative to promote payments integration in the European Union (EU) that began around 1999, when the European Central Bank (ECB) highlighted the need to establish a single payments area to improve the service levels of domestic and cross-border retail payments (ECB, 1999). It aims to harmonize retail payments in euro made by consumers, merchants, corporations and other entities between or within national boundaries, as well as to improve transparency and provide more efficient retail payments (ECB, 2013b).

The adoption by the European Parliament and the Council of the European Union of Regulation (EC) No 2560/2001 (repealed by Regulation (EC) No 924/2009), that established that the charges for cross-border euro payments within the EU should be equal to domestic euro payments, changed the cost structure and returns of banks. This led to the creation, in 2002, of the European Payments Council (EPC) by the banking community. This coordination and decision-making body of the European banking industry on issues related to payments seeks to support payments integration, in particular the SEPA project. Since the efforts of the European banking community were not enough to ensure the implementation of SEPA, Regulation (EU) No 260/2012 was adopted in

March 2012 by the EU Council and the European Parliament. This Regulation established rules for the initiation and processing of credit transfer and direct debit transactions in euro. It also required the use of common standards, such as the International Bank Account Number (IBAN) – an international payment account number identifier. Furthermore, the Regulation set 1 February 2014 as the deadline for replacing national credit transfers and direct debits with their SEPA equivalents in the euro area (hereinafter referred to as SEPA credit transfers or SCT and SEPA direct debits or SDD) and 31 October 2016 as the deadline for Member States with other currencies. Nonetheless, the Regulation provided the Member States with the possibility to adopt derogations to some of the abovementioned rules and standards. For instance, Member States could provide consumers with conversion services that allowed them to continue using the national payment account number identifier (i.e., the Basic Bank Account Number or BBAN) instead of IBAN until 1 February 2016. Taking into consideration the slow migration level in some Member States, particularly in SDD, the European Commission published on 9 January 2014 a proposal for a Regulation amending Regulation (EU) No 260/2012 with an additional migration period for the euro area of six months (i.e., until 1 August 2014). This Regulation (EU) No 248/2014 was adopted on 26 February 2014.

Figure 4.2 displays the evolution of the share of SCT and SDD transactions in the euro area. The migration process to SCT in the euro area was much smoother than the SDD migration. In 2011, around 23.7% of the total number of credit transfer transactions processed corresponded to SCT, while only 0.5% of the total number of direct debit transactions processed was SEPA compliant. The migration to SDD in the euro area only started improving in 2013.

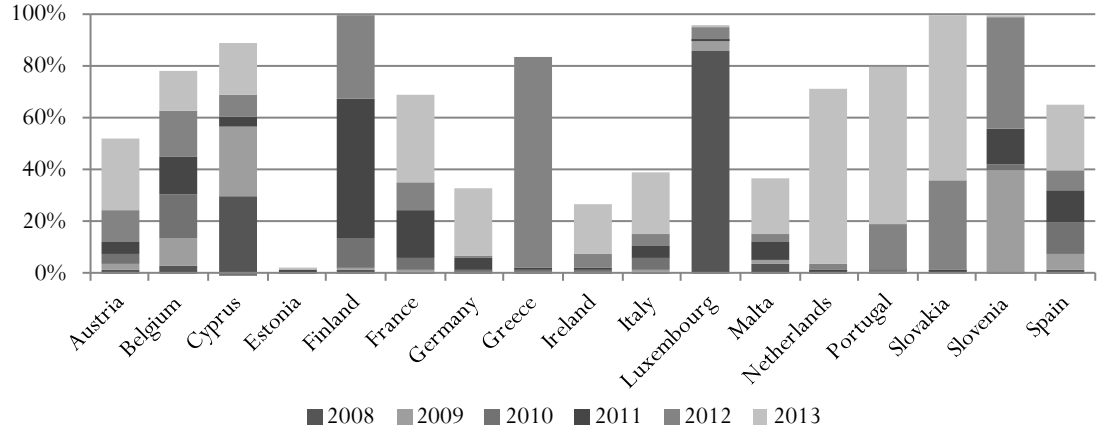
Figure 4.2: Evolution of the share of SCT and SDD transactions in the euro area between 2008 and 2013



Source: European Central Bank.

Although the adoption process of SCT was relatively gradual in the euro area, significant differences in the rate of progression existed between countries. For instance, Luxembourg achieved a very high rate of SCT transactions in 2008 (of around 86%) while the Netherlands, Slovakia and Portugal registered a significant acceleration in the compliance with SEPA in 2013. By the end of 2013 only Finland and Slovakia had completed the migration to SCT.

Figure 4.3: Evolution of the SEPA adoption process in euro area countries between 2008 and 2013



Source: European Central Bank.

2.3. Literature review

Credit transfer payments have not been widely explored in the existing literature. According to our understanding this can derive from two factors. First, this type of payment instrument is not commonly used in the US when compared to other countries, as highlighted in Table 4.1. This results from historical reasons regarding, for example, the geographical size of the country and the concentration of the banking system (Humphrey, Sato, et al., 1996). Nonetheless, a significant part of the research made on the use of payment instruments is focused on the US. Second, credit transfers might be mainly used for bill payments and not payments at the point-of-sale (such as shops), being this last type of payments more investigated in the existing studies.

The small number of studies that incorporate credit transfer payments in the analysis include the papers of Stavins (2001), Mantel (2001), Hayashi and Klee (2003), Bolt et al. (2008) and Schuh and Stavins (2013). The investigation performed by Stavins (2001) highlighted the importance of socio-demographic factors such as income, age, education level and marital status on consumers' use of cash, cheques, cards and credit/debit ACH transactions (i.e., credit transfers and direct debits). The author obtained evidence of a positive impact of the education level and a negative effect of age characteristics on ACH transactions. Other factors have also been discussed in the literature. Hayashi and Klee (2003) incorporated in the investigation the effect of the adoption of new products (for example, computer and cellular phones) and found a positive impact on bill payments. Schuh and Stavins (2013) extended further the examination of consumers' payment habits by focusing separately on their adoption and use. The authors concluded that the adoption of online banking bill payments (i.e., bill payments made from a bank account and initiated by a consumer using the bank's website) was negatively influenced by age. In some papers, the examination of this payment instrument is made together with other payment instruments. For example, Mantel (2001) focused on the effect of socio-demographic factors, the level of adoption of new products and the perception of the characteristics of electronic payment instruments regarding control, convenience of use and security, on the (aggregate) consumers' usage of electronic payment instruments.

Moreover, Bolt et al. (2008) collected data from the Netherlands and Norway to assess the relevance of pricing policies.

The abovementioned studies – based on survey data – draw attention to the important role played by consumers' socio-demographic characteristics in explaining the use of payment instruments, namely credit transfers. Nevertheless, those studies do not provide information on the patterns of use of this payment instrument at cross-country level. Humphrey et al. (1996) estimated a model of payment instrument demand with Ordinary Least Squares (OLS) in fourteen countries for the period 1987-1993 that included electronic giro payments (these payments incorporated direct debits and credit transfers). The analysis provided evidence of a negative effect of the real Gross Domestic Product (GDP) growth, the number of Automated Teller Machines (ATM) and Point-of-Sale (POS) terminals. Deungoue (2008) and Martikainen et al. (2015) focused their investigation on the convergence of payment behaviour in European countries for the periods from 1990 to 2002 and 1995 to 2001, respectively. Both studies found evidence of convergence in credit transfer payments in Europe.

Some authors tried to anticipate the potential benefits of SEPA implementation. Schmiedel (2007) presents an overview of those studies, as well as the results of an investigation performed in cooperation with the banking industry that identifies the potential economic consequences of SEPA. In a more recent study, Virtanen (2014) examines, from a theoretical perspective, the key characteristics of the SEPA project and discusses some of the expected effects. We can therefore conclude that although the literature identifies some of the factors that might influence the use of credit transfers, the existing papers do not focus on the impact of SEPA adoption on the use of this payment instrument from an empirical point of view.

Taking into consideration that the full migration to SCT in the euro area countries was achieved on 1 February 2016, only in a few years will it be possible to compare the evolution in credit transfer payments before and after the conclusion of the implementation of SEPA. Even so, at this moment it is possible to investigate what was the effect of the progression in the migration to SEPA. As a result, we aim to contribute to the existing literature by answering the question "what was the impact in the use of credit

transfers in euro area countries of the progress of adoption of SEPA standards and rules between 2008 and 2013?".

3. Data and methodology

In this section it is presented a brief descriptive analysis of the data employed in the model and a summary of the methodology adopted in the empirical examination.

3.1. Data and descriptive statistics

For the analysis we used data from the European Central Bank Statistical Data Warehouse (ECB SDW) regarding the share (in volume) of payments made with credit transfers and other cashless payment instruments (i.e., direct debits, cheques and cards) in 17 euro area countries[2] during the period 2008-2013. Through credit transfers the payer can instruct the institution where it holds his account to transfer funds to a beneficiary. According to the methodological notes of the ECB SDW, credit transfers are counted on the payer's side and comprise both payment transactions that take place between two accounts held at different or at the same bank. SCT are also included in the data.

Regarding the independent variables, we incorporated information on the progress of the migration to SEPA as well as control variables regarding socio-demographic, economic, technological and institutional effects. Detailed information on the variables used in the analysis can be found in Table A4.1 of the Appendix. To investigate the impact of the progress of SEPA migration on credit transfer payments we included two variables: *mig* and *conv*. The variable *mig* reflects the evolution of the share of SCT transactions as a percentage of the total volume of all credit transfers initiated in a country. The migration of credit transfers to SEPA formats should provide substantial benefits for the various stakeholders according to ECB (2013): consumers will be able to use a single account to make payments in the SEPA area and those payments will be faster and simpler; merchants will benefit from easier remote business payments; companies will be able to receive and

[2] Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia and Spain. Latvia and Lithuania were not included since they joined the euro area in 2014 and 2015.

send payments in various countries using common technical standards and a single account, what should smooth liquidity management; and payment service providers will be able to process cross-border credit transfers in a more cost efficient way. It is thus expectable that the use of credit transfers is positively influenced by the migration. The variable *conv* reflects whether in a certain country it is allowed to offer consumers with conversion services to IBAN for national transactions until 1 February 2016. The expected impact of this element is not straightforward. On the one hand, providing conversion services can be more convenient for consumers and impact positively on the use of credit transfers. However, on the other hand, if IBAN is not asked to consumers, they might not become aware of the advantages of SEPA. The other possible derogations were not statistically significant so, to ensure a parsimonious specification, they were not included in the final model. Moreover, an interaction term between the variables *mig* and *conv* was also included to allow the effect of the migration to the SEPA to change according to the possibility (or not) of offering conversion services to IBAN.

To take into account the possible impact of socio-demographic factors on credit transfers usage, as identified in studies based on survey information (see, for example, the papers of Stavins, 2001 and Hayashi and Klee, 2003), data on the share of population with upper secondary or tertiary education attainment (*edu*) and the median age of the population (*age*) was added to the model. According to the existing literature, the education level should have a positive impact because it might ease the use of electronic payment instruments. The effect of age is not consensual in the studies based on survey data and in various cases was not statistically significant. Even though the analyses based on survey data do not incorporate information regarding the economic context, this factor might play a role in a cross-country framework. In fact, Humphrey et al. (1996) found a negative relation between the use of electronic giro and real income per capita due to the economic characteristics of the countries that had higher per capita electronic giro payments. So, in our model we incorporated information on the percentage change in the real Gross Domestic Product (*gdp*). Technological factors were also taken into consideration since the number of ATM and POS terminals per thousand inhabitants might facilitate cash withdrawals or the use of cards. A negative impact of the variables *atm* and *pos* is therefore expectable, as previously obtained by Humphrey et al. (1996). Finally, to

account for potential substitution effects in the univariate analysis we also added a variable that might capture the most relevant substitution effect taking into consideration the nature of credit transfer payments – the per capita number of payments made with direct debits (*ddebits*).

The descriptive statistics for the dependent and independent variables are presented in Table 4.2. Between 2008 and 2013, around 33% of the payments in the euro area were made with credit transfers. During this period the highest share of payments was made with cards and the lowest with cheques. On average, the share of SCT was 28% in euro area countries. The differences across the sample were quite remarkable, as reflected by the standard deviation. It is also interesting to note that the technological environment revealed the diverse situations that exist in euro area countries.

Table 4.2: Descriptive statistics of the dependent and independent variables for euro area countries (2008-2013)

Variable	Mean	Std. Dev.	Min.	Max.	No. Obs.
Dependent variables					
propct	0.33	0.12	0.11	0.59	102
propdd	0.18	0.13	0.01	0.50	102
propcard	0.42	0.13	0.14	0.69	102
propcheq	0.07	0.10	0	0.43	102
Independent variables					
SEPA adoption factors (S_{it})					
mig	0.28	0.34	0	1	102
conv	0.35	0.48	0	1	102
Socio-demographic factors (SD_{it})					
edu	0.67	0.14	0.29	0.85	102
age	40.25	2.56	33.40	45.30	102
Economic factor (E_{it})					
gdp	-0.01	0.03	-0.14	0.09	101
Technological factors (T_{it})					
atm	0.85	0.32	0.41	1.66	102
pos	21.08	8.33	6.15	38.12	95
Institutional factors (I_{it})					
ddebits	34.02	32.32	1.10	120.96	102

The table reports the descriptive statistics of the dependent and independent variables in the period between 2008 and 2013 for the 17 euro area countries. "Std. Dev." stands for standard deviation, "Min." for the smallest value of the observations, "Max." for the highest value of the observations and "No. Obs." for the number of observations.

3.2. Model specification and methodology

In our empirical analysis we investigate the effect of the SEPA project using estimation techniques specifically adapted to the fractional nature of the dependent variable. Moreover, we complement the typical univariate analysis with models that allow for the presence of neglected heterogeneity and multivariate models that, besides the share of credit transfer payments, account for alternative shares of payment instruments.

The analysis of the effect on the share of payments made with credit transfers of the migration process to SEPA was performed by estimating the following model:

$$Y_{it} = G\left[\beta_0 + \beta_1 S_{it} + \beta_2 (mig \times conv)_{it} + \beta_3 SD_{it} + \beta_4 E_{it} + \beta_5 T_{it} + \beta_6 I_{it} + \varepsilon_{it}\right] \quad (1)$$

where Y_{it} refers to the share of payments made with credit transfers (in volume) in the univariate analysis or the share of payments made with credit transfers, direct debits, cards or cheques in the multivariate analysis, with i ($i = 1, \dots N$) representing each country and t ($t = 1, \dots 6$) denoting the time period; S_{it} refers to migration indicators which comprise the variables mig – the share of SCT transactions on the total volume of all credit transfer transactions initiated in a country –, and $conv$ – a dummy variable that captures if in a country it is allowed to offer consumers with conversion services to IBAN for national transactions until 1 February 2016; $(mig \times conv)_{it}$ is an interaction term between the variables mig and $conv$; SD_{it} denotes socio-demographic factors (i.e., *edu* and *age*); E_{it} regards to the variable gdp; T_{it} represents technological determinants (i.e., *atm* and *pos*); and I_{it} is the institutional factor reflecting the use of direct debits (i.e., *ddebits*) – only included in the univariate case. In addition, $\varepsilon_{it} = \alpha_i + u_{it}$, where α_i refers to the country-specific effects and u_{it} denotes the idiosyncratic error term. Finally, β_j, $j = 1, \dots 6$, are vectors of parameters associated to each type of explanatory variables. Note that, due to the small dimension of the sample, a parsimonious specification of the model had to be considered.

3.2.1. *Univariate analysis*

To estimate the model a natural starting point is to consider linear models. Nonetheless, this type of models might not be adequate for the analysis of the share of payments made with credit transfers. In fact, according to Papke and Wooldridge (1996), Ramalho et al. (2011) and Ramalho and Ramalho (2015), linear models do not guarantee that the predicted values lie between zero and one. A more appropriate approach is the assumption of a functional form that defines the required constraints on the conditional mean of the dependent variable. So, for the analysis of the FRM we considered three conditional mean functions: logit $\left(E(Y|X) = \frac{e^{X\beta}}{1+e^{X\beta}}\right)$, complementary loglog $\left(E(Y|X) = 1 - e^{X\beta}\right)$ and probit $(E(Y|X) = \phi(X\beta), [.]$, with ϕ defined as a standard normal distribution). The models were estimated by pooled Quasi-Maximum Likelihood (QML) using a robust version of the variance of the estimated parameters.

Although we consider a wide variety of explanatory variables in our analysis, it is possible that other factors may influence the share of interest. Therefore, we also consider estimators that take into account this potential neglected heterogeneity (that might generate bias in the standard FRM estimators). Specifically, we employ Generalized Method of Moments (GMM) estimators recently proposed by Ramalho and Ramalho (2015), designated as GMMx, applied with two link functions, the logit and complementary loglog (note that the probit specification cannot be employed in the framework of this GMM estimator).

In order to ensure the adequacy of the models, we performed a RESET test of the specification and a generalized goodness-of-functional form or GOFF test, as indicated in Ramalho et al. (2013). Average partial effects (APE) were computed to measure the effect of changes in the covariates on the response variable, averaged across the population.

3.2.2. *Multivariate analysis*

The level of adoption of a payment instrument is frequently connected, at least to a certain extent, with payment instruments choice. In fact, the characteristics and the inherent pros and cons of different payment instruments might play a role on payment

habits. In order to capture the relationship between non-cash payment instruments, a multivariate fractional analysis was also considered. This type of analysis allows us to simultaneously investigate the effect of selected independent variables on the share of payments made with credit transfers, as well as on other payment instruments. Hence, it is possible to evaluate if the conclusions obtained in the univariate scenario change when a disaggregation of all non-cash payment instruments (i.e., credit transfers, direct debits, cheques and cards) is made.

Since the share of payments made with cheques assumes the value zero in certain cases, we are not able to use the Dirichlet-Multinomial model – a multivariate extension of the beta-binomial model (see Mullahy, 2011 and Murteira and Ramalho, 2016). So, we considered a Fractional Multinomial Logit (FML) model – an extension of the fractional response model proposed by Papke and Wooldridge (1996) to the multivariate case. The FML model, which is estimated by QML, takes into consideration the bounded nature of the shares and the fact that the proportions must add up to one. Being c_{ij} the share of the number of payments with *j*th payment instrument made in the *i*th country, the conditional mean function is $E(Y_{ij}|X_i) = \frac{e^{x_i\beta_j}}{\sum_{h=1}^{J} e^{x_i\beta_h}}$.

We considered as dependent variables the share of payments made with credit transfers, as well as the share of payments made with direct debits (the reference category), cheques and cards (in volume). Each of the dependent variables ranges between zero and one and they sum up to the unity, reflecting the fact that increases in the proportion of payments made with credit transfers must imply a reduction in the share of payments with the other non-cash payment instruments. To take into account any possible heteroscedasticity, robust standard errors are used. Since the regression coefficients cannot be interpreted directly, APE implemented according to Buis (2008) are analysed instead. These effects reflect how changes in one independent variable affect a dependent variable when all the other variables are kept at the mean (Molowny-Horas et al., 2015).

4. Empirical results

In this section the model selection strategy, as well as the estimation results, are presented for the univariate and multivariate cases.

4.1. Model selection

For the univariate examination of the share of credit transfer payments logit, complementary loglog and probit FRM estimated with pooled QML were used. According to the results of the RESET test only two models have a correct specification: the FRM with a logit conditional mean function and the FRM with a probit conditional mean function. However, only the model with a logit conditional mean function revealed an adequate link specification in the GOFF test. The univariate analysis was also performed using the GMMx estimator with two link functions – logit and complementary loglog to take into account potentially neglected heterogeneity. According to the RESET test only the model with a logit link function is correctly specified. Overall, the coefficients retain the statistical significance, the direction of the impact and the magnitude in comparison with the APE of the logit FRM (Table 4.4). Therefore, neglected heterogeneity appears not to be a problem in our framework, which reinforces the validity of the results of the standard logit FRM. For that reason, our univariate analysis will focus on that model.

To capture the relationships that might exist between the various non-cash payment instruments, a multivariate investigation was performed with a FML estimated by QML. Note that the results of the multivariate analysis reveal that some of the variables are no longer statistically significant (Table 4.4), suggesting that when a broader set of payment instruments is taken into consideration the relative importance of some factors is reduced.

4.2. The effect of SEPA adoption process

Both the univariate and multivariate results provide evidence that our key interest variable – the progress of SEPA migration in credit transfers – has a statistically significant positive effect in the use of credit transfers. See the results for the remaining shares

included in the multivariate analysis in the Appendix (Table A4.2). The impact measured by the APE is 0.067 in the univariate model and 0.086 in the multivariate analysis, which is relevant taking into consideration that the mean of the share of credit transfer payments in our sample is 0.33. This positive effect is a good indicator to policymakers, since it can reflect the use of a more efficient mean of payment. In addition, it is also encouraging to payment service providers, given that it might reveal acceleration in the recovery of the costs supported with SEPA implementation through the fees charged to the users of this payment instrument.

The univariate analysis suggests that the fact that in a certain country payment service providers are allowed to offer consumers with conversion services to IBAN until 1 February 2016 affects negatively credit transfer payments (with an APE of -0.047). Moreover, the interaction between the variable *mig* and *conv* appears to have a negative effect of 0.061, indicating that the positive impact in credit transfer payments of the progress in SEPA migration is reduced in countries that allow conversion services for IBAN. However, in the multivariate analysis both the variable *conv* and the interaction term *mig* x *conv* are not statistically significant. We can therefore conclude that when we take into consideration the relationship between non-cash payment instruments the potential impact of derogations is mitigated and the effect of SEPA migration gains more relevance.

4.3. The effect of socio-demographic, economic, technological and institutional factors

In terms of socio-demographic factors, only the variable *edu* is statistically significant in both models and is associated with an increase in payments made with credit transfers. This conclusion is in line with the findings of Stavins (2001) and Hayashi and Klee (2003) and can derive from the fact that the higher the percentage of population with upper or tertiary education attainment, the larger the proportion of population that should find it easier to use credit transfers. The fact that age characteristics of the population are not statistically significant in the multivariate model is not surprising since the effect of age was also not statistically significant in other papers (see, for example, the analysis of

Hayashi and Klee, 2003). Although economic factors did not reveal a statistically significant impact, the number of ATM and POS terminals per thousand inhabitants appear to be negatively related with credit transfer payments, in line with the conclusions previously obtained by Humphrey et al. (1996). The negative effect is possibly connected with the fact that ATM and POS terminals can ease the use of cash and cards. In the univariate analysis, the substitution effect of direct debits reveals a statistically significant impact, highlighting the importance of the inclusion of other payment instruments in the analysis, and therefore reinforcing the results of the multivariate model.

Table 4.3: Estimation results of the impact of SEPA in euro area countries (2008-2013)

Variables	Univariate analysis					Multivariate analysis
	FRM (logit)	FRM (cloglog)	FRM (probit)	GMMx (logit)	GMMx (cloglog)	FML
mig	0.3194**	0.2347**	0.2010***	0.3198***	0.2501***	1.0613***
	(0.1272)	(0.1026)	(0.0776)	(0.1197)	(0.0243)	(0.2613)
conv	-0.2221**	-0.2159***	-0.1173**	-0.2122***	-0.1908***	-0.1436
	(0.0892)	(0.0654)	(0.0476)	(0.0824)	(0.0110)	(0.4337)
mig x conv	-0.2896*	-0.2079*	-0.1937**	-0.3612**	-0.2645***	-1.1629***
	(0.1521)	(0.1232)	(0.0918)	(0.1431)	(0.0247)	(0.4219)
edu	2.4235***	1.9892***	1.4601***	2.6228***	2.2190***	0.6644
	(0.2805)	(0.2413)	(0.1651)	(0.2671)	(0.0310)	(1.4880)
age	0.0544***	0.0424***	0.0334***	0.0530***	0.0466***	-0.0584
	(0.0141)	(0.0121)	(0.0084)	(0.0160)	(0.0016)	(0.0703)
gdp	-1.2075	-0.9520	-0.7347	-1.2112	-1.1242***	-0.7043
	(0.8837)	(0.6775)	(0.5498)	(0.8925)	(0.1083)	(0.8748)
atm	-0.3352***	-0.3017***	-0.1871***	-0.3088***	-0.2806***	-1.0618
	(0.0826)	(0.0739)	(0.0471)	(0.0695)	(0.0076)	(0.7452)
pos	-0.0279***	-0.0232***	-0.0166***	-0.0265***	-0.0216***	0.0143
	(0.0042)	(0.0034)	(0.0025)	(0.0037)	(0.0004)	(0.0268)
ddebits	-0.0072***	-0.0059***	-0.0043***	-0.0068***	-0.0056***	-
	(0.0013)	(0.0010)	(0.0008)	(0.0012)	(0.0002)	
RESET test p-value	0.2710	0.0880	0.4510	0.1370	0.0270	-
GOFF test p-value	0.1040	0.0760	0.0800	-	-	-
No. Obs.(NxT)	95	95	95	95	95	95

The table reports the estimation results of the: (i) univariate analysis of the share of payments made with credit transfers (in volume) considering a FRM with a logit, cloglog and probit distribution functions; and (ii) multivariate analysis of the share of payments made with credit transfers using a FML model. In the multivariate analysis the results for the shares of the other non-cash payment instruments (i.e., direct debits, cheques and cards) are presented only in Table A4.2 of the Appendix, given the scope of the analysis. Robust standard errors are in parenthesis. Constant term coefficient not reported. Variables in value have been adjusted for inflation. Note that: * indicates significance at the 10% level, ** at the 5% level and *** at the 1% level. "No. Obs." stands for the number of observations.

Table 4.4: APE of selected models

Variables	Univariate analysis		Multivariate analysis
	FRM (logit)	GMMx (logit)	FML
mig	0.0671**	0.0658***	0.0861**
	(0.0266)	(0.0245)	(0.0357)
conv	-0.0466***	-0.0436**	-0.0635
	(0.0168)	(0.0172)	(0.0662)
mig x conv	-0.0608*	-0.0743**	-0.0751
	(0.0319)	(0.0294)	(0.0552)
edu	0.5088***	0.5396***	0.4216***
	(0.0594)	(0.0553)	(0.1074)
age	0.0114***	0.0109***	0.0043
	(0.0029)	(0.0032)	(0.0085)
gdp	-0.2535	-0.2492	-0.2369
	(0.1853)	(0.1835)	(0.1749)
atm	-0.0704***	-0.0635***	-0.1220**
	(0.0173)	(0.0142)	(0.0588)
pos	-0.0058***	-0.0054***	-0.0043**
	(0.0009)	(0.0008)	(0.0019)
ddebits	-0.0015***	-0.0014***	-
	(0.0003)	(0.0002)	

The table reports the APE computed for the following models: FRM with a logit distribution function, GMMx with a logit distribution function and FML. Robust standard errors are presented in parenthesis. Note that: * indicates significance at the 10% level, ** at the 5% level and *** at the 1% level.

5. Concluding remarks

This essay examines the impact of the migration progress to SEPA between 2008 and 2013 on the share of payments made with credit transfers in euro area countries. The key finding is that the evolution in the migration to SEPA formats influenced positively the use of credit transfers. Moreover, we also conclude that socio-demographic and technological elements, as well as substitution effects with other non-cash payment instruments also played a role in explaining credit transfers usage. The positive impact of the migration on credit transfer payments can lead to enhanced efficiency in retail payments (both in terms of cost and time of processing) as well as improved competition and innovation in this market (ECB, 2015c). An increase in the use of this payment instrument might stimulate the economy, consumption and trade, according to Hasan et al. (2013).

On 1 August 2014 euro area countries concluded the migration of credit transfers to SEPA formats, but the full process will only be complete at a later stage. On the one hand,

euro area countries which applied derogations to the provisions of Regulation (EU) 260/2012 extended the deadline to comply with some SEPA rules until February 2016. On the other hand, non-euro area SEPA countries were given the limit of 31 October 2016 to complete migration (ECB, 2015c). Considering the results obtained in our analysis, it is expectable that, in the years following the completion of SEPA implementation in credit transfers, this type of payments might be significantly affected. In fact, the still relatively low share of credit transfer payments in some countries of the euro area leaves room for further increases in the use of this payment instrument. This evolution will be also shaped by other elements, such as the demand for faster retail payment solutions or "instant payments" (i.e., electronic retail payment solutions available 24/7/365 with immediate or close-to-immediate interbank clearing of the transaction and crediting of the payee's account, according to ECB, 2015), as it might further boost the use of credit transfers. Hence, there is ample room for further investigation in this field. For example, it will be important, with post-2016 data, to explore in which way the pattern of use of non-cash payment instruments was affected by SEPA and measure the contribution of this project to economic growth.

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Appendix

Table A4.1: Description of the dependent and independent variables used in the empirical analysis

Variable	Description	Source
	Dependent variables	
propct	Share of the number of payments made with credit transfers computed considering the relative importance of the number of payments made with credit transfers on the total number of payments made with credit transfers, direct debits, cards and cheques.	Authors' calculation based on data from the ECB SDW
propdd	Share of the number of payments made with direct debits computed considering the relative importance of the number of payments made with direct debits on the total number of payments made with credit transfers, direct debits, cards and cheques.	Authors' calculation based on data from the ECB SDW
propcard	Share of the number of payments made with cards computed considering the relative importance of the number of payments made with cards on the total number of payments made with credit transfers, direct debits, cards and cheques.	Authors' calculation based on data from the ECB SDW
propcheq	Share of the number of payments made with cheques computed considering the relative importance of the number of payments made with cheques on the total number of payments made with credit transfers, direct debits, cards and cheques.	Authors' calculation based on data from the ECB SDW
	Independent variables	
	SEPA migration factor (S_{it})	
mig	Share of SEPA credit transfers as a percentage of the total volume of credit transfers.	ECB
conv	Dummy variable that equals 1 if in the country payment service providers are allowed to offer consumers with conversion services to IBAN for national transactions until 1 February 2016 and 0 otherwise.	ECB
	Socio-demographic factors (SD_{it})	
edu	Percentage of persons with upper secondary or tertiary education attainment.	Eurostat
age	Median age of population (in years).	Eurostat
	Economic factor (E_{it})	
gdp	Real percentage change in the GDP.	Eurostat
	Technological factor (T_{it})	
atm	Number, per thousand inhabitants, of ATM (device that permits authorised cardholders, typically using machine-readable plastic cards, to withdraw cash from their accounts and/or access other services, such as balance enquiries, transfer of funds or acceptance of deposits) at the end of each year.	ECB SDW
pos	Number, per thousand inhabitants, of POS terminals (device allowing the use of payment cards at a physical point-of-sale) in the end of each year.	ECB SDW
	Institutional factors (I_{it})	
ddebits	Number of direct debit transactions per capita.	ECB SDW

Table A4.2: APE of other payment instruments shares used in the multivariate analysis for the period 2008-2013 in euro area countries

Variables	APE	
	Share of card payments	Share of cheque payments
mig	0.0977** (0.0403)	-0.0377*** (0.0217)
conv	0.1151 (0.0779)	-0.0424 (0.1116)
mig x conv	-0.1941** (0.0851)	0.0988** (0.0393)
edu	-0.3414 (0.2332)	-0.1856* (0.0433)
age	-0.0105 (0.0068)	-0.0067** (0.0028)
gdp	0.2626** (0.1370)	-0.0264 (0.0931)
atm	0.0071 (0.0830)	-0.0121 (0.0186)
pos	0.0080** (0.0032)	0.0012** (0.0005)
No. Obs.	95	95

The table reports the APE of the remaining shares considered in the multivariate analysis using the FML. Robust standard errors are presented in parenthesis. Note that: * indicates significance at the 10% level, ** at the 5% level and *** at the 1% level.

Chapter 5

Conclusion

Identifying the effect of specific policy measures implemented in the recent past is very important for policymakers and regulators that aim to promote the adoption of socially efficient payment instruments. Using panel data for EU and euro area countries, on specific periods between the years 2000 and 2013, according to data availability and the timing of relevant measures, we tested the empirical relevance of key factors on the use of cheques, bank cards and credit transfers on three complementary essays.

The results obtained allowed us to answer our main research questions. In the first essay the results unveiled that the existence of fees, even when legal factors that increase security are in force, have a significant negative impact on cheques usage. Despite the general decrease on cheque payments, they are still a relevant payment instrument in some countries. According to the most recent data made available by the Bank for International Settlements, in 2014 the relative importance of cheques (in number of transactions) was 37.5% in the United States of America (US), 13.1% in France, 10.5% in India and 9.5% in Mexico. This corresponded to 45 cheque transactions per inhabitant during the year in the US and 37.7 in France, for example. Since cheque payments generate substantial costs to society as well as risks to its users, discouraging its use can be of interest to some national authorities. Bearing in mind our results, this might be accomplished by supporting the establishment of fees by the banking community.

From the analysis conducted on the second essay, we obtained evidence of a significant positive effect of the migration process to the EMV standard in card payments on EU countries during the period comprised between 2006 and 2011. As reported by EMVCo, at the end of 2014 the adoption rate of EMV in cards was less than 84% in Europe (Zone 1), around 25% in the Asia Pacific region and about 7% in the US. Taking into consideration that card payments (namely with debit cards) can encourage efficiency in retail payments (Schmiedel et al., 2012) and stimulate consumption and trade (Hasan et al., 2013, 2014; Moody's, 2016; WorldBank, 2014), some authorities might be interested in promoting its usage. By ensuring a complete migration to the EMV standard, the perceived and/or real security of this type of payment instrument might be improved and card payments boosted.

The evaluation of the progress in SEPA migration made on the third essay led us to conclude that, between 2008 and 2013, credit transfer payments in euro area countries were positively impacted by this project. This new empirical evidence suggests that, in the years following the completion of SEPA implementation in credit transfers, this type of payments might be affected, generating additional benefits to payment service providers, as well as to the economy (Hasan et al., 2013 and Schmiedel et al., 2012).

In a global perspective, our conclusions corroborate that legal factors do play an important role in explaining cheques usage, the EMV adoption is indeed shaping card payments, and SEPA implementation has more than a technical impact on the use of credit transfers. Moreover, our results highlight that socio-demographic, economic, technological and institutional factors influence payment habits not only at an individual level (for example, consumer habits), as already evidenced by several studies based on survey data, but also in a cross-country perspective. The relevant role played by these factors is important not only to the policymakers of the countries considered in the analysis, but also for others that might be in the process of implementing identical measures or may intend to do so in the future. For instance, since credit transfer payments in Portugal are still below the EU average (according to ECB SDW, in 2014 the relative importance of credit transfer payments was 14.4% while the EU average was 26.2%) there might be some room for expansion in the future. Nevertheless, one should bear in

mind that the use of cards is already above the EU average (in 2014, the share of card payments – except with e-money function only – was 67.3% in Portugal while the EU average was 46.0%).

Our investigation contributes to the literature in a number of ways. First, it provides novel empirical evidence on the impact of legal factors, as well as of the EMV standard adoption and of the migration to SEPA in the use of selected payment instruments. Second, the analysis includes a dependent variable rarely explored in existing studies – the proportion of the number of payments – which might be more adequate than the traditional per capita use of payment instruments, since it provides an indication of relative importance *vis-à-vis* other particular payment instruments. Third, the econometrical analysis is performed using estimation techniques that take into account the nature of the dependent variables under estimation. As far as we know, some of the models used (such as the fractional regression models) have never been considered in the literature of this research area.

Notwithstanding the above, one should also bear in mind that the increasing digitalization of payments can have relevant impacts in societies. On the one hand, digitalization might generate a loss of anonymity. This can be positive if it contributes to reduce illegal transactions and the shadow economy. But it can pose relevant questions in terms of data protection for all the other users, as every payment becomes traceable regardless of its amount or purpose. On the other hand, dematerialization might generate an amplified detachment of things and people with potential societal and moral implications. Moreover, digitalization might promote the exclusion of unbanked population, raising vital issues on the area of financial inclusion. In fact, cash is the only option available to unbanked population and, according to the World Bank[1], in 2014 there were 2 billion adults unbanked in the world. An increased concentration of control and power of decision in a limited number of institutions should also be taken into consideration. With cash, economic agents can be more independent in the way they store and use their money, namely outside the banking system. By replacing cash by electronic payments, economic agents agree to grant entities such as payment service providers and

[1] Information available at http://www.worldbank.org/en/programs/globalfindex.

IT providers with the ability to process all the payments made. In addition, economic agents might lose the freedom to determine if they intend to spend or save money if negative interest rates are established in cashless societies, as they would need to pay for leaving their money in the bank. In light of these facts, some people advocate the emergence of virtual currencies as a rival to state currency (Dodd, 2014) and a form of participatory democracy (Ansart and Monvoisin, 2016).

Other issues also remain to be examined in order to enhance our understanding of the (present and future) use of payment instruments. The data available limited our analysis to specific periods and groups of countries. Therefore, as more data becomes available, it will be important to examine the evolution in the results. For example, it could be interesting to investigate the effect of actual prices on payment instrument choice, even though existing studies found only a small impact. It may as well be an attractive avenue to include more accurate information on cash usage, in order to examine in more detail the potential substitution effects. It could be also relevant to explore the impact of habits and cultural differences on specific payment instruments usage.[2] Furthermore, the retail payments market is undergoing outstanding changes: technology is evolving at a fast pace, with the emergence of contactless and mobile payments as well as 24/7 payment solutions; novel (non-banks) payment service providers are entering the market; the use of virtual currencies is expanding and new regulation and legislation is entering into force. These increasingly global changes will probably shape and redefine the use of payment instruments in the future. Addressing how these issues influence payment habits will require a holistic approach and will be of great importance for the various players of the payments landscape.

Although nowadays the focus is typically on greater efficiency and security, the possible social, political and moral implications should also be considered, at least to a certain extent, by relevant stakeholders. Public administrations, for example, can play a

[2] We tried to incorporate lagged dependent variables in earlier versions of our analysis by using the Generalised Method of Moments (GMM). We applied the Windmeijer (2005) robust estimator and, following Roodman (2009), and in order to avoid weakening the Sargan and Hansen test, we used a reduced number of instruments and collapsed them. In addition, as first differencing increased the gaps in our panel, we used the orthogonal deviations transformation. The test results were not in favour of these models. In our fractional regression models we also considered an estimator for dynamic panel data proposed by Ramalho et al. (2015), but no convergence was obtained. When more data is available, this line of analysis could be resumed.

relevant role through the adoption of payment instruments that take into consideration senior citizens capacity to adapt to new technologies. Regulators, when acting as catalysts of innovation, could also bring those topics to the discussions. Raising collective awareness is also vital: consumers and companies should be actively involved in these matters, for example, by contributing to public consultations and participating in working groups.

There are many options for the future evolution of payments instruments. Rigorous scientific research will be essential for the adequate and systematic assessment of the solutions adopted to ensure, on the one hand, security and efficiency and, on the other hand, innovation and convenience that suit users demands.

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