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In 2013 all ECB publications feature a motif taken from the €5 banknote.

NOTE: This Occasional Paper should not be reported as representing the views of the European Central Bank (ECB). The views expressed are those of the authors and do not necessarily reflect those of the ECB.

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ABSTRACT

Financial integration in some segments of the financial markets started to deteriorate during the recent period of economic turmoil in Europe. This paper examines whether this phenomenon also holds true for the European retail payments market. In comparison with other segments of the financial markets, the integration of the retail payments market has been more difficult to quantify, and the effects of recent developments – including the creation of the Single Euro Payments Area (SEPA) and the economic crisis – have been hard to evaluate using existing measures of integration. As an indicator of financial integration, convergence in the European retail payments market is measured during the period 1995-2011 for the most used retail payment instruments: cash, debit card, credit card, direct debit, credit transfer, cheque and e-money. Two methods for estimating convergence are used: sigma convergence and beta convergence. There is some evidence of convergence for all payment instruments, except for cheques and e-money. The results suggest that the cross-country dispersion of the use of payment instruments has declined over time in Europe. The pace of convergence has picked up since the introduction of the single currency. There is also some evidence of beta convergence. In contrast to some other segments of the financial markets, integration in the retail payments market has not deteriorated during the financial crisis.

JEL codes: F36, G20.

Keywords: retail payments, financial integration, convergence

NON-TECHNICAL SUMMARY

Based on economic theory and empirical evidence, financial integration promotes competition, efficiency and growth. Even though there are an increasing number of studies on integration in other segments of the financial markets, the level and evolution of integration in the retail payments market has been difficult to measure, and the empirical literature is very limited. The present study evaluates the level and evolution of integration by measuring the cross-country convergence of payment behaviours in the European retail payments market. The findings increase the general understanding of how integration has evolved since the introduction of the single currency, the creation of the Single Euro Payments Area (SEPA) and during the recent economic crisis.

The analysis is based on data on the volume and the value of transactions made in cash, by debit card, credit card, direct debit, credit transfer and cheque, and in e-money, in the 27 countries of the European Union (EU) over the period 1995-2011. The present paper is the first to use recent enough data to fully measure the impact of the introduction of the single currency on retail payment integration. Moreover, the study provides some preliminary results regarding the impact of SEPA and the recent economic crisis on the integration process.

The study applies two methods to quantify convergence: sigma convergence and beta convergence. The rationale behind sigma convergence is that if countries become increasingly homogeneous over time, the cross-country distribution of transactions should become less dispersed. In estimations, this translates to the standard deviation having a negative time trend, i.e. it decreases over time. Beta convergence is based on the idea of a catching-up process; in countries which start from low-level use of a particular payment instrument, the volume or the value of transactions should grow faster than in countries which start from a higher level.

It is found that countries have become less dispersed in terms of cash, debit card, credit card, direct debit and credit transfer use in the period after the introduction of euro. However, in terms of cash use, cross-country convergence is very slow. For cheques and e-money, the standard deviation is volatile and there is no unambiguous evidence of sigma convergence, even in the period after the introduction of the euro. For beta convergence, countries that started from a low level of debit and credit card use have been catching up, when card use is measured in terms of the number of per capita transactions. There is also evidence of beta convergence for the value of direct debits and credit transfers.

Based on the results of the study, the positive financial integration process in the retail payments market, which has been stronger since the introduction of the single currency, seems to have continued regardless of the period of financial turmoil. However, despite the evidence of convergence for most payment instruments, payment behaviours have been slow to change and there are significant cross-country differences. The present paper intends to aid policy-makers and market stakeholders in assessing the current and expected level of integration and future developments in the European retail payments market.

1 INTRODUCTION

Financial integration is important for both the smooth operation and the efficiency of the payment system; promoting financial integration is also one element of the Eurosystem's mission.[1] Measuring and monitoring the state of integration in the financial market is, therefore, of great interest to the European Central Bank (ECB). To assess developments in the integration of the financial markets, the ECB has constructed several quantitative indicators (ECB (2009)). During the recent economic crisis, integration has given way to more urgent matters and there is, in fact, some evidence that integration in the financial markets started to deteriorate during the period of economic turmoil (ECB (2009); ECB (2012)). In comparison to other segments of the financial markets, integration in the retail payments market has been more difficult to quantify, and the effects of recent developments, including the creation of the Single Euro Payments Area (SEPA) or the economic crisis, have been hard to evaluate with existing measures of integration.

In this paper, integration is measured according to the convergence of cross-country payment habits. Integration of the retail payments market is likely to affect competition, prices and the payment infrastructure. More specifically, integration aids the cross-border diffusion of new and more efficient payment technologies and practices. For payment providers, implementing new payment technologies is easier in a harmonised and integrated market. For consumers, the acceptance and availability of new payment instruments, and greater awareness of these instruments, increase the use of new payment technology. In an integrated market, it thus can be expected payment behaviours to converge towards the use of more sophisticated and efficient payment instruments.

The degree of integration in the European capital and financial markets varies between market segments. The money, bond and equity markets have reached a high level of integration, following the introduction of the single currency in 1999, while integration in other market segments, such as retail banking, has been more modest (ECB (2010)). Unlike large value payments, the procedures, instruments and services offered to customers in the field of retail payments have not yet been harmonised. This shortcoming is being addressed in the context of the Single Euro Payments Area (SEPA) project, which aims to achieve a fully integrated retail payments market and promote the integration of the retail banking market in general. Within SEPA, no distinction is made between national and cross-border payments; all euro payments are treated as domestic payments. However, even the successful introduction of SEPA does not guarantee the convergence of actual payment behaviour. Payment habits are slow to change, and payment market and pricing structures differ across Europe (see e.g. Heikkinen (2007); Jonker and Kosse (2008)).

The efficiency and performance of the retail payments system is an economically significant question; according to a study by Schmiedel et al. (2012), the social costs of retail payments amount to approximately 1% of the GDP of the European Union (EU). The convergence of retail payments has many implications for the overall performance of the economy. The financial integration of the retail payments market facilitates the cross-border movement of people, goods and capital, and thus promotes the integration of the European single market. The convergence of payment behaviours can have an important role in the diffusion of new payment technologies and thus economic performance; there is empirical evidence that the electronification of the retail payments system promotes economic growth (Hasan et al., (2012a) and banking performance (Hasan et al., (2012b)). The convergence of cross-country habits is important because payment instruments are network goods; the benefit of using a payment instrument depends on the number of other people using it: [2]

1 See "The mission of the Eurosystem" on the ECB's website (http://www.ecb.int/ecb/orga/escb/html/mission_eurosys.en.html).

2 For a review of the literature on network externalities and two-sided markets, see, for example, Rochet and Tirole (2006).

for example, the benefit of having a payment card depends on how many retailers accept it, which in turn depends on how many people use the card. A well-known feature of network goods is that the market needs to reach a minimum size to achieve a sustainable equilibrium. If cross-country payment habits converge towards the use of non-cash payment instruments, the overall European market reaches the point at which there is enough critical mass for the market to become viable and grow further. SEPA is likely to accelerate this development by increasing network compatibility and economies of scale (Bolt and Schmiedel (2011)).

In the present study, integration in the European retail payments market is measured using data on payments made in cash and using non-cash payment instruments. Building upon the quantitative financial integration measures used in Adam et al. (2002), an estimate of the effects of introducing the single currency on the integration of the retail payments market can be made. The aim of this study is to answer two questions: first, did the retail payments market become more integrated during the period 1995-2011, as evidenced by the convergence of payment behaviours? Second, has integration been stronger in the period after the introduction of euro than in that before? The answers to these two questions provide important information concerning the level and evolution of integration in the European retail payments market. In this study, some preliminary evidence is also provided on the way in which integration has evolved since the creation of SEPA and during the economic crisis.

The methods used to estimate convergence in different segments of the financial markets were originally developed in the literature on empirical growth. The study employs two such methods, namely sigma and beta convergence, to study integration in European retail payments. Earlier studies have relied on broad measures describing the financial market infrastructure (Schmiedel and Schönenberger (2005)), the concentration of the national retail payment infrastructure or the number of credit transfers processed in SEPA format (ECB (2010)), for example. In this paper, actual data on the volume and the value of transactions made in cash, by credit card, debit card, direct debit, credit transfer, cheque and e-money in the 27 EU countries during the period 1995-2011 are used to measure integration, rather than broad measures on retail payment infrastructure.

The study finds evidence that some degree of convergence for different payment instruments took place during our study period. The only exceptions are for cheques and e-money, for which there is no unambiguous evidence of either sigma or beta convergence. Evidence of convergence is most prevalent when it is measured as a decrease in the cross-country dispersion of the use of payment instruments over time. This sigma convergence was most evident during the last twelve years of our study period. Moreover, the speed of convergence has increased since the introduction of the single currency for most of the payment instruments studied. Beta convergence was also estimated, the negative relationship between the previous period's volume or value of transactions and the subsequent growth rate of transactions. Evidence of beta convergence is found for the volume of debit card and credit card transactions, and for the value of the remote payment instruments, that is, for direct debits and credit transfers.

Based on the findings of the study, there is evidence of convergence for the payment behaviours in European countries, and the convergence process has accelerated since the introduction of the single currency. Cheques and e-money are, however, the exceptions, as countries diverge in their use of these two payment instruments. Moreover, the speed of sigma convergence for cash is very slow. Even though cross-country differences in payment behaviours remain significant for card payments, credit transfers and direct debits, it can be concluded that the countries in the European Union are now less dispersed than they were before the introduction of the single currency and the creation of SEPA. Interestingly, the integration process in the retail payments market has withstood the pressures of the recent economic crisis relatively well.

The remainder of this paper is structured as follows: in Section 2, the relevant empirical literature is reviewed; in Section 3, the sample data and summary statistics are described; and in Section 4, the concept of measuring convergence is introduced. In Section 5, the empirical results on the integration of European retail payment markets are presented; the final section concludes.

2 LITERATURE REVIEW

This study is related to two strands of empirical literature: that on payment instrument demand and that on the integration of the financial markets.[3] The methods used to measure sigma and beta convergence are derived from neoclassical growth theory and were thus originally developed and applied in the economic growth literature – important contributions include those from Barro and Sala-i-Martin (1992), Sala-i-Martin (1996) and Mankiw et al. (1992). The concept and methods of convergence have since been applied to various contexts and the literature is extensive.

Adam et al. (2002) classify, review and apply existing indicators for capital market integration to measure integration in the European financial markets. The indicators are classified into four groups: indicators using interest-rate differentials to measure convergence in the interbank, government bond, mortgage and short-term corporate loan markets; indicators using the correlation with stock market returns to measure stock market integration; indicators based on the decisions of households and firms; and indicators based on cross-country institutional differences. This paper follows and extends the approach by Adam et al. (2002) by applying the sigma and beta convergence methods to the retail payments market.

Hartmann et al. (2003) measure the integration in the financial structures in the euro area by applying the sigma convergence method to countries' asset and liability components, namely currency and deposits, loans, and debt securities. By graphing the evolution of the standard deviations, the authors find that, with the exception of the bond market, countries have more heterogeneous financial structures. Pagano and von Thadden (2004) find convergence in bond yields under the European Monetary Union, and attribute remaining yield differentials to fundamental country-specific default risks. Similarly to Hartmann et al. (2003), Pagano and von Thadden (2004) do not estimate sigma convergence, but rather rely on visual inspection.

Baele et al. (2004) extend the price- and quantity-based measures in Adam et al. (2002) by constructing a definition of an integrated financial market and introducing news-based measures of integration. In addition to building a methodological framework for financial market integration, Baele et al. (2004) are interested in the effects of local news versus global news on interest rates, and study integration in the government and corporate bond, credit, equity and money markets. Similarly to Adam et al. (2002), Baele et al. (2004) do not extend the measures of integration to the retail payments market. Korkeamäki (2009) studies the effect of introducing the euro on the relationship between interest rates and stock market returns, and estimates the convergence of interest rate sensitivity across EU countries. The results imply that the interest rate risk has decreased in the period since the introduction of the euro; companies have been able to protect themselves against risks more efficiently in a more complete and integrated European financial market. Moreover, the author finds evidence of sigma convergence for interest rate sensitivity across European countries.

A number of studies estimate the demand for different payment instruments. Humphrey et al. (1996) estimate a model of payment instrument demand in a cross-country panel data setting. The authors study five instruments: cash, paper giro, electronic giro, credit cards and debit cards. The price of a transaction, which the authors calculate based on several sources and definitions, is not an important determinant of demand. The significance of other variables, such as the availability of point-of-sale terminals, automated teller machines (ATMs) and institutional variables depends

3 A number of studies, which are not reviewed here, use survey methods to study consumers' choice between different payment instruments (see, for example, Stix (2004)). Furthermore, articles which concentrate on the determinants of cash demand, or focus on individual countries, or articles which study financial market integration without applying sigma or beta convergence methods, are excluded.

on whether lagged use of these payment instruments and country-specific dummies are included in the regression. When lagged use and country dummies are dropped, the availability of point-of-sale terminals increases the demand for debit cards, but decreases the demand for all other instruments. The number of ATM terminals is positively related to the growth in debit card and credit card use, and income is positively associated with non-cash payments. Violent crime increases the use of non-paper-based instruments and the concentration of the banking sector increases the use of debit cards. The authors also find some evidence of substitution between different payment instruments.

Guariglia and Loke (2004) estimate the demand for non-cash payment instruments for a panel of European countries using the generalised method of moments (GMM) estimator. The results emphasise the role of past habits in determining current payment behaviour, and the importance of distinguishing between the volume and the value of transactions. Humphrey et al. (2000) forecast the evolution of the use of cheques and electronic payments in the United States, while Snellman et al. (2001) study the substitution of cash for non-cash payments in Europe and develop a forecast for the use of cash.

Measures of integration for the retail payments market have been constructed in several financial integration reports produced by the ECB (see, for example, ECB (2010)). However, convergence in the retail payments market appears to have only been studied in Deungoue (2008), who uses retail payment data mostly covering the period before the introduction of the euro (1990-2002). In contrast, the payment data in the present study is more recent and allows the full effect of the adoption of the euro on the integration process to be estimated. The effect of introducing the euro on the sigma convergence process has not been estimated using retail payment data before. By adding euro-interaction terms to the sigma convergence estimations, the effects of the introduction of the euro on the speed of convergence can also be estimated. Moreover, the dataset used in this study allows us to make a distinction between the transactions made by debit card and credit card, and to study the convergence for e-money. Visually inspecting the data is an important first step but, as the estimation results indicate, visual inspection does not always provide enough information to analyse underlying data patterns or to quantify significant relationships between variables. Based on the results of this paper, some tentative conclusions can also be drawn regarding the way in which integration in retail payments market has developed during the recent economic crisis and since the introduction of SEPA.

3 DATA AND SUMMARY STATISTICS

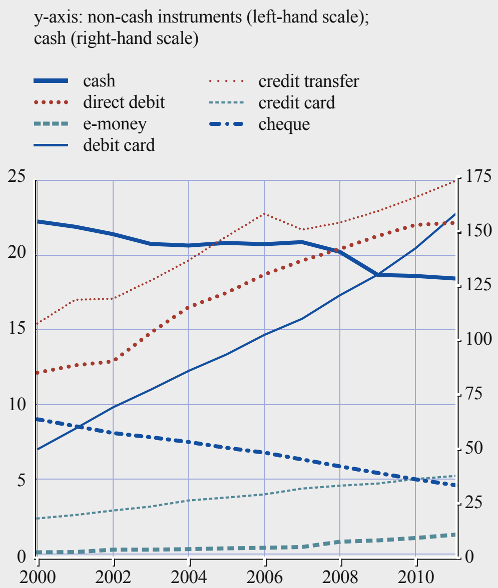
The present study uses annual data on the volume and the value of retail payment transactions for the current 27 EU countries for the period 1995-2011. The payment instruments studied are cash, debit card, credit card, direct debit, credit transfer, cheque and e-money. Mobile money is not included, since data on mobile money transactions are not available. Moreover, while mobile money is increasingly popular in some of the developing countries, it remains a marginal means of payment in Europe (see Hyytinen and Takalo (2009), and Leinonen (2010) for a discussion of the trends and future of the mobile money market). Payment data is provided by the ECB Statistical Data Warehouse. Macroeconomic variables are collected from the World Bank and Eurostat databases.

Data on cash transactions is not generally available. This study uses the method commonly employed in the literature to approximate the value of transactional cash demand (see, for example, Snellman et al. (2001); Sisak (2011); and Schmiedel *et al*. (2012)). Following Humphrey (2004) and Sisak (2011), the starting point is the notion that cash is mostly used in consumer point-of-sale transactions. To approximate the value of point-of-sale consumption, spending on education, financial services, health and housing is subtracted from the total private consumption. This is done because spending on education, financial services, health and housing forms the part of household consumption which does not take place at point-of-sale locations. The residual value (private consumption minus spending on education, financial services, health and housing) is then used as an approximation of the total value of consumption that takes place at point-of-sale locations. Point-of-sale purchases are then reasonably assumed to be made mainly in cash and by card. The value of transactions made by debit card and credit card is then subtracted from the total value of point-of-sale consumption. The resulting value is an approximation of the value of payments made in cash.[4] The number of transactions made in cash is obtained by dividing the value of payments made in cash by the average value of a cash transaction. The average value of cash transaction is taken from the study by Schmiedel et al. (2012); the value varies between countries but not between years.

Tables A1-6 present summary statistics for the retail payment instruments and other variables used in the estimations. Summary statistics are presented for selected sub-periods and for the total study period 1995-2011. On average, credit transfers and cash are the most popular payment methods in terms of value and volume of transactions, respectively. Chart 1 depicts

Chart 1 Total number of transactions for the 27 EU countries

(in billions)

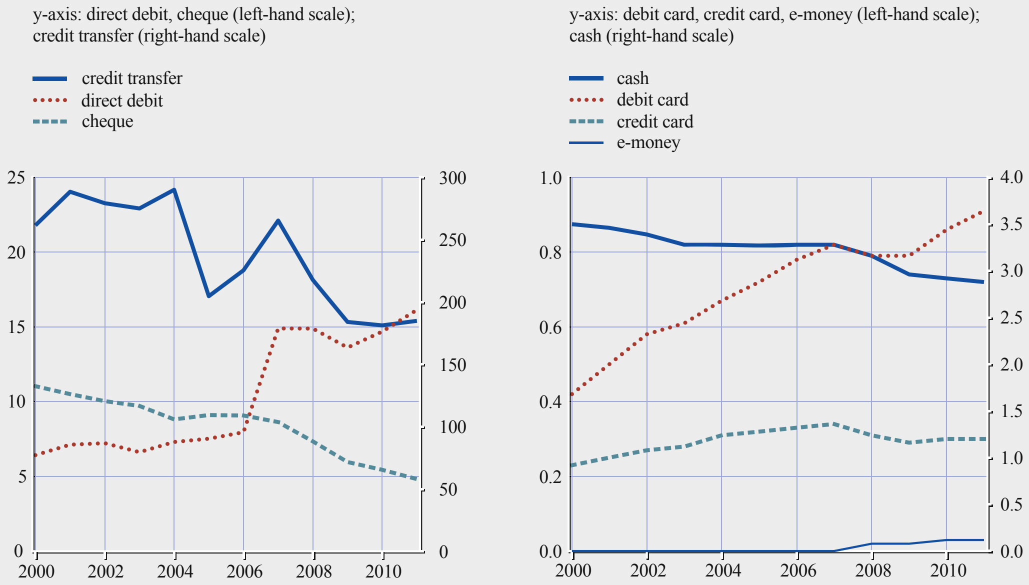


Source: ECB Statistical Data Warehouse.
Note: The yearly evolution of the total number of transactions made by different payment instruments in the 27 EU countries for 2000-2011.

4 Since separate data on debit and credit card transactions is not available for France, the value of "all cards", as reported inthe ECB Statistical Data Warehouse, has been used when calculating the value and the volume of cash transactions for France.

Chart 2 Real value of transactions for the 27 EU countries

(in trillions of euros)



Source: ECB Statistical Data Warehouse.
Note: The yearly evolution of the total real value of transactions made by different payment instruments in the 27 EU countries for 2000-2011.

the evolution of the total number of transactions in the 27 EU countries for the years 2000-2011.[5] The number of cheque transactions has been declining steadily, and was less than 5 billion in 2011. The number of debit and credit card transactions has been increasing and totalled approximately 28 billion in 2011. Debit cards are clearly a more popular payment medium than credit cards: over 80% of the combined debit and credit card transactions were made by debit card. The number of transactions made by credit transfer and direct debit has increased over the period studied. The number of cash transactions is measured on the right-hand scale and reaches over 155 billion. The downward trend in the number of cash transactions in the late 2000s should be interpreted with caution; since the measure of cash transactions is based on private consumption, it is very sensitive to the overall economic developments. Cash transactions are thus more likely to reflect the impact of the financial crisis on the economy than other instruments.

The real value of transactions is depicted in Chart 2, in separate panels for scaling reasons.[6] The value of debit card transactions increases, while the value of credit card transactions decreases slightly during the period coinciding with the financial crisis. According to the estimations, cash transactions reaches €3.5 trillion, and tends to decrease after the year 2000. The value for e-money payments increases significantly between 2007 and 2008 but e-money, in relation to other payment

5 Total reported numbers are an estimate, since there are some randomly missing observations, which have been replaced by our approximations in Charts 1–2. Total numbers for 2000-2011 are presented because the data are more complete starting from 2000. France does not report data on debit card and credit card transactions separately, so France is excluded in the total calculations for the 27 EU countries for debit and credit cards. Calculations presented in Charts 1 and 2 are, however, very close to ECB estimates (see http://www.ecb.europa.eu/press/pr/date/2012/html/pr120910.en.html).

6 There is a jump in the series in 2006 for credit transfers and direct debits owing to changes in data reporting methodology which took place in Germany at that time. The robustness of the results was checked by excluding Germany in the estimations;the conclusions were unaffected.

instruments, remains a marginal means of payment. E-money institutions such as Amazon and PayPal have their European headquarters in Luxembourg, and the high volume and value of e-money transactions originating in Luxembourg is of a different magnitude compared with other countries in our sample. The robustness of the results by excluding Luxembourg in the e-money estimations are discussed in Section 5. The total value of cheque transactions remains high, at almost €5 trillion in 2011. However, the diminishing role of cheques is clearly demonstrated in Chart 2: the value of transactions made by cheque halves during the ten-year period studied. Credit transfers and direct debits are the most important payment instruments in value terms: the value for credit transfers alone was close to €200 trillion in 2011.

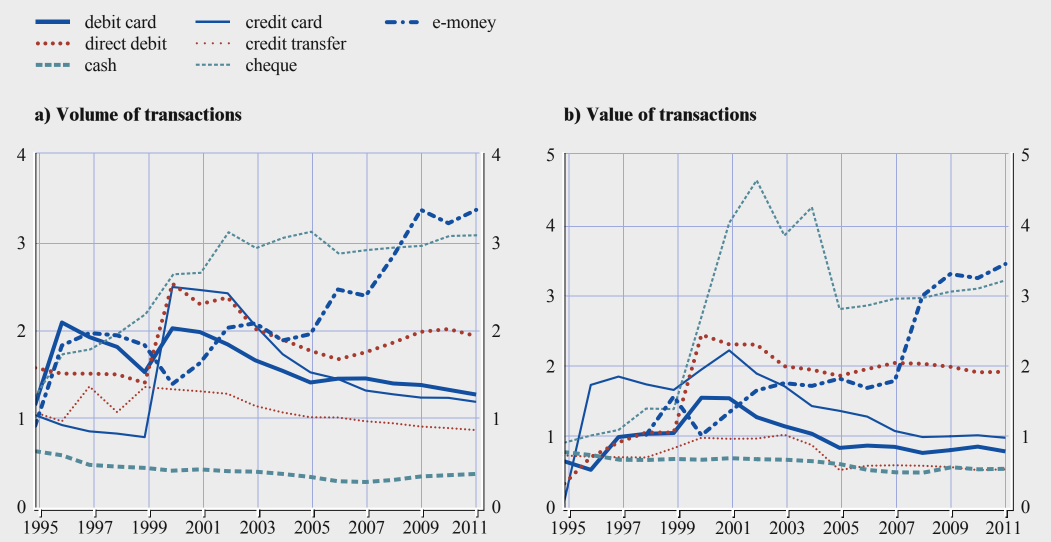
4 MEASURING THE CONVERGENCE OF RETAIL PAYMENTS

To study the convergence of retail payments and the evolution of different payment instruments used in different countries, two approaches are adopted: sigma convergence and conditional beta convergence. To avoid dynamic panel bias, the conditional beta convergence is estimated using the difference GMM estimation method. The two methods give different perspectives on convergence: sigma convergence measures how the cross-country dispersion in the distribution of transactions evolves over time, while beta convergence measures how countries move within the distribution and is used to investigate whether countries which start from a lower volume or value of transactions for a particular payment instrument catch up with countries which start from a higher volume or value of transactions (Sala-i-Martin (1996)).

4.1 SIGMA CONVERGENCE

In the presence of sigma convergence, the dispersion of payment instrument use across countries decreases over time (Sala-i-Martin (1996)). More specifically, sigma convergence implies that the standard deviation of the distribution of the volume and the value of transactions for different payment instruments decreases, making the observations increasingly centred on the mean over time. Chart 3 plots the evolution of the standard deviation of the volume and the value of different payment instrument transactions per capita across the 27 EU countries. For most of the payment instruments, the standard deviation of the volume of transactions peaks immediately after the introduction of the euro in 1999. After 2000, the standard deviation seems to decrease or remain stable for all instruments, except for cheques and e-money. The standard deviation of direct debits starts to increase slightly after 2006; however, for the most recent years, there is a decreasing trend. For the value of transactions, cheques have a very high and volatile standard deviation throughout the period studied.

Chart 3 Standard deviation for the volume and the value of transactions



Sources: ECB Statistical Data Warehouse, authors' calculations.
Note: The yearly evolution of the standard deviation for the log (real) value of per capita transactions for the 27 EU countries for 1995-2011.

To test empirically whether the standard deviation has a decreasing time trend, the following model is estimated:

$$(1) \quad S_t = \alpha_0 D_{PRE} + \beta_0 (D_{PRE} * trend) + \alpha_1 D_{POST} + \beta_1 (D_{POST} * trend) + \varepsilon_t,$$

where S_t is the standard deviation of the volume or the value of transactions (in logs and per capita terms) for a particular payment instrument across the 27 EU countries in year t, D_{PRE} is a dummy variable equalling one for the years before the introduction of the single currency in 1999,[7] D_{POST} is a dummy equalling one for the years after 1999, D_{PRE} * *trend* and D_{POST} * trend are the time trends for the before-euro and after-euro introduction periods respectively, and ε_t is the error term. Equation (1) is estimated separately for the volume and the value of all payment instruments in our data. The parameters to be estimated are intercepts α_0 and α_1 and the slope coefficients for the time trend before-euro and after-euro introduction, β_0 and β_1. The estimation allows us to directly compare the speed of convergence before and after the introduction of the single currency, by comparing the estimated slope coefficients β_0 and β_1. Since SEPA was introduced in 2008 and the time period after 2008 is too short to estimate time trend effects, equation (1) does not include variables indicating the introduction of SEPA.

4.2 BETA CONVERGENCE

Beta convergence takes place if countries that have a low initial volume or value of payment instrument use grow faster in the subsequent period than countries with a higher initial level of use of that payment instrument. The former are then seen as catching up with the more "evolved" latter. Thus, in the presence of beta convergence, the volume or value of payment instrument use for the preceding period is inversely related to the current growth rate for that payment instrument use. Beta convergence can be unconditional or conditional. If the convergence is unconditional, all countries are assumed to converge to the same steady state. If the convergence is conditional, countries are allowed to have different long-term levels of payment instrument use. The long-term levels of transactions are determined by control variables which include, for example, macroeconomic, technological and institutional variables.

Chart 4 depicts the relationship between the compound annual growth rate of transactions for 2000-2011 and the initial volume and value of transactions in 2000. If the catching-up process for payment instrument use does exist, the relationship between the level and the subsequent growth rate of transactions should be negative. For cash, cheques and e-money, there seems to be no such relationship. For debit and credit cards, direct debits and credit transfers, the charts suggest that there is indeed a negative relationship, but one which seems to be more non-linear than linear.

Beta convergence is estimated by regressing the growth rate of the interest variable on the lagged level of the variable, and in the case of conditional convergence, on a set of control variables. A negative and statistically significant coefficient on the lagged level variable is seen as evidence of beta convergence (Barro and Sala-i-Martin (1992); Sala-i-Martin (1996)).

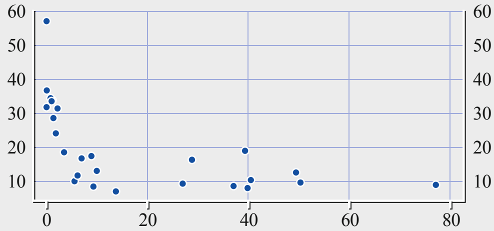
7 Equation (1) was estimated with the euro dummy equalling one for the years after 2002, when the euro notes and coins entered circulation, but this did not qualitatively change the results.

Chart 4 Correlation of compound annual growth rate (2000-2011) and the volume and value of transactions (2000)

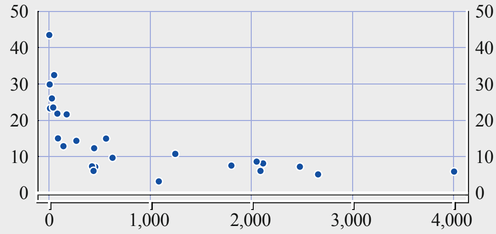
(percentages)

Debit card

x-axis: number of per capita transactions in 2000
y-axis: compound annual growth rate 2000-2011

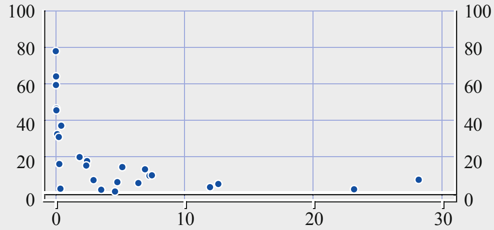


x-axis: real value of per capita transactions in 2000
y-axis: compound annual growth rate 2000-2011

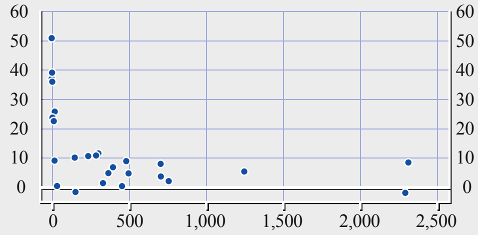


Credit card

x-axis: number of per capita transtions in 2000
y-axis: compound annual growth rate 2000-2011

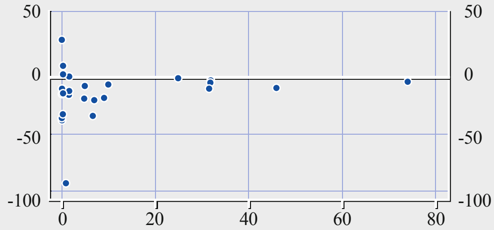


x-axis: real value of per capita transactions in 2000
y-axis: compound annual growth rate 2000-2011

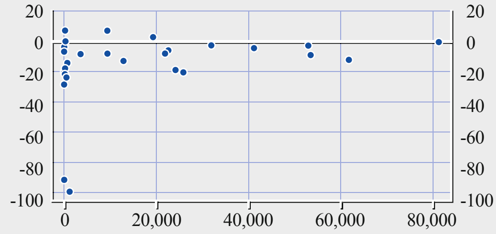


Cheque

x-axis: number of per capita transactions in 2000
y-axis: compound annual growth rate 2000-2011

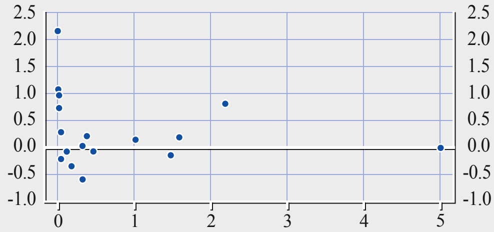


x-axis: real value of per capita transactions in 2000
y-axis: compound annual growth rate 2000-2011

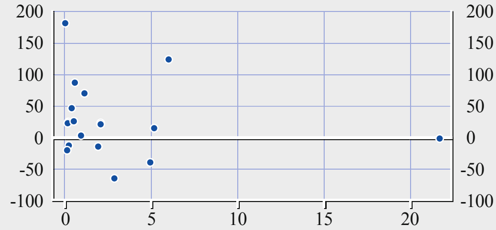


E-money

x-axis: number of per capita transactions in 2000
y-axis: compound annual growth rate 2000-2011



x-axis: real value of per capita transactions in 2000
y-axis: compound annual growth rate 2000-2011



Sources: ECB Statistical Data Warehouse, authors' calculations. Notes: Scatterplots of the compound annual growth rate of transactions in 2000-2011 and the initial volume and value of transactions in 2000. The compound annual growth rate is calculated as: ((end value/ starting value)^(1/number of years))-1.

Chart 4 Correlation of compound annual growth rate (2000-2011) and the volume and value of transactions (2000) (cont'd)

(percentages)

Sources: ECB Statistical Data Warehouse, authors' calculations. Notes: Scatterplots of the compound annual growth rate of transactions in 2000-2011 and the initial volume and value of transactions in 2000. The compound annual growth rate is calculated as: ((end value/starting value)^(1/number of years))-1.

The following dynamic panel data model is estimated:

$$(2) \quad \Delta y_{it} = \alpha + \beta y_{it-1} + \gamma X_{it} + v_i + \varepsilon_{it}$$

In equation (2), Δy_{it} is the growth rate of the volume or the value of transactions for a payment instrument in country i, α is a constant, y_{it-1} is the one-year lagged level of payment instrument use in country i, X_{it} is a set of time-varying control variables for country i, v_i is a country-specific fixed effect and ε_{it} is the error term.

Equation (2) is estimated separately for the volume and the value of transactions made in cash, by debit card, credit card, direct debit, credit transfer, cheque and in e-money. In the presence of beta convergence, the coefficient on the lagged level of payment instrument use (β) is negative and statistically significant. The bigger the beta (in absolute terms), the faster the economy is converging. The control variables in equation (2) are based on the determinants of demand for retail payment instruments in the empirical literature (see, for example, Guariglia et al. (2004); Humphrey et al. (1996); and Snellman et al. (2001)). To avoid variable and instrument proliferation, cross-substitution between different payment instruments is not controlled for in the estimations.

The control variables in X_{it} depend on the payment instrument studied. Since the use of cash is expected to be related to the opportunity cost of holding cash and the ease of acquiring cash, the deposit rate and the number of ATMs in a country are included as explanatory variables. However, the number of ATMs can have a negative effect on cash use, if the former is positively related to customers' awareness and acceptance of payment cards, or if the same cards are used to withdraw cash and make payments (Humphrey et al. (1996)). The volume of card payments depends on the technology and infrastructure available. For credit and debit cards, the number of electronic funds transfer at point-of-sale (EFTPOS) terminals and the number of ATMs in a country are included as explanatory variables. The use of cheques or e-money is not constrained by the availability of payment technology variables (ATMs or EFTPOS terminals), so no controls for technology are added in the estimations of cheque or e-money demand. Additionally, the real interest rate (lending rate) is expected to have a negative effect on credit card use. For all payment instruments, GDP is included to control for changes in macroeconomic conditions. All value variables are in logs and in real per capita terms. Volume variables are in logs and per capita terms. Finally, equation (2) is estimated with year dummies.[8]

Equation (2) is estimated by using the difference GMM method developed by Arellano and Bond (1991) and further elaborated on by Arellano and Bover (1995), and Blundnell and Bond (1998). For more details on the estimation method and robustness tests see the Annex to this paper.

8 The effects of euro adoption and the creation of SEPA were also tested by including euro and SEPA dummies and interactions in the estimated equation. The interaction terms turned out not to be statistically or economically significant and so were omitted from the model.

5 EMPIRICAL RESULTS

Sigma convergence results from estimating the volume of transactions for the period 1995-2011 using equation (1) are presented in Table A7. Our estimations of sigma convergence measure convergence within the 27 EU countries, without detailing the effects of individual countries or groups of countries, such as euro area or non-euro area countries, on the convergence process.[9] In the period after the euro was introduced, the standard deviation of cash use has a negative time trend. However, the coefficient is small, indicating that the speed of convergence is very slow. Countries diverge in terms of their debit card use before the introduction of the euro, but converge in the after-euro introduction period. The same is true for credit transfers. For credit cards, there is convergence both in the before-euro and after-euro introduction periods. The introduction of the euro has no effect on the speed of convergence: based on the F-test, the speed of convergence is equal before and after the introduction of the euro. For direct debits, the standard deviation has decreased in the after-euro introduction period; however, there is no difference in the speed of convergence between the before-euro and after-euro introduction periods. Countries seem to diverge in terms of the volume of cheque and e-money transactions, but the divergence is slower after the introduction of euro.

The estimation results for the value of transactions in the 27 EU countries for 1995-2011 are presented in Table A8. For cash, there is evidence of convergence in the before-euro introduction period. The slope coefficient in the period after the introduction of the euro is negative and statistically significant, but small, indicating that the speed of convergence is slow and has little economic significance. For debit and credit cards, the standard deviation has a positive time trend before the introduction of the euro; however, after, their use converges. The use of direct debits diverges in the before-euro period but, after the introduction of the euro, neither convergence nor divergence is found. Countries converge in terms of credit transfers in the period after the introduction of the euro. Cheque and e-money transactions diverge, but this slows down after the introduction of the single currency. Overall, the introduction of the euro has had a positive effect on the convergence process for all payment instruments.

Tables A9 and A10 present the results of estimating the sigma convergence equation for the sub-period 2000-2011, for which there are fewer missing observations on transactions across countries. The results for the volume of transactions in Table A9 reveal that there is sigma convergence for all payment instruments, except for cheques and e-money. For the value of transactions, countries are converging in terms of all payment instruments except for e-money, as is evident from Table A10. The results indicate that the convergence process has been faster and more comprehensive during the most recent years in the data. The overall results for sigma convergence are summarised in Tables 1 and 2.

The conditional beta convergence results from estimating equation (2) with the difference GMM method are presented in Tables A11 and A12. Cash shows no convergence for the number or the value of transactions. The sign of the coefficient on the deposit rate is consistently negative, and statistically significant for the value of transactions. The coefficient on GDP is positive and significant for the value of transactions, which is to be expected since cash transactions and consumption correlate owing to the method used to approximate cash transactions. The number of ATMs has no significant effect on the volume or the value of cash use.

9 Comparing, for example, the speed of convergence between euro area and non-euro area countries would require a relevant benchmark to which the groups of countries would be expected to converge. In estimating, for example, interest rate convergence, such a benchmark usually arises naturally, but for retail payments a meaningful benchmark is less easy to find.

Table 1 Summary of the sigma convergence results for the volume of transactions

Volume of transactions	Before-euro introduction full sample data	After-euro introduction full sample data	After-euro introduction sub-sample data
Cash	YES	YES	YES
Debit card	NO	YES	YES
Credit card	YES	YES	YES
Direct debit	NO	YES	YES
Credit transfer	NO	YES	YES
Cheque	NO	NO	NO
E-money	NO	NO	NO

Sources: ECB Statistical Data Warehouse, authors' estimations.
Notes: This table summarises the sigma convergence results for the value of transactions separately for the sub-period 2000-2011 and for the total period 1995-2011. "YES" indicates that there is sigma convergence;"NO" indicates there is no sigma convergence.

Debit cards converge in terms of volume, but not in terms of value. The number of EFTPOS terminals has a positive effect on the volume of transactions, but for the value of transactions, the effect is not statistically different from zero. The results for the volume and the value of credit card transactions are comparable to the results for debit cards. For the volume of transactions, the estimated beta is negative, statistically significant and of the same magnitude as the beta coefficient for debit cards. For the value of transactions, there is no evidence of convergence. Similarly to debit cards, the other control variables for credit cards are not statistically significant.

Direct debits converge in terms of the volume and the value of transactions, while credit transfers converge only in terms of the value of transactions. For the volume of the remote payment instruments, the significance of the beta coefficient seems to be sensitive to the number of lags used as instruments, and to the control variables included, and the results should thus be interpreted with caution. However, the results concerning the value of transactions seem to be resistant to changes in the instrument count. The number of EFTPOS terminals has a positive effect on the value of credit transfers. Even though the number of EFTPOS terminals is not directly related to the use of credit transfers, the number of terminals is likely to correlate with the overall technological readiness of a country (Columba (2009)). The relationship between EFTPOS terminals and the use of remote payment instruments is thus likely to reflect the underlying effect of the omitted technology variable on non-cash payment instrument use. For cheques and e-money, no evidence of convergence was found. The coefficient on the lagged level of use is not statistically different from zero for the volume or the value of transactions. The beta convergence results are summarised in Table 3.

Table 2 Summary of the sigma convergence results for the value of transactions

Value of transactions	Before-euro introduction full sample data	After-euro introduction full sample data	After-euro introduction sub-sample data
Cash	YES	YES	YES
Debit card	NO	YES	YES
Credit card	NO	YES	YES
Direct debit	NO	NO	YES
Credit transfer	NO	YES	YES
Cheque	NO	NO	YES
E-money	NO	NO	NO

Sources: ECB Statistical Data Warehouse, authors' estimations.
Notes: This table summarises the sigma convergence results for the value of transactions separately for the sub-period 2000-2011 and for the total period 1995-2011. "YES" indicates that there is sigma convergence;"NO" indicates there is no sigma convergence.

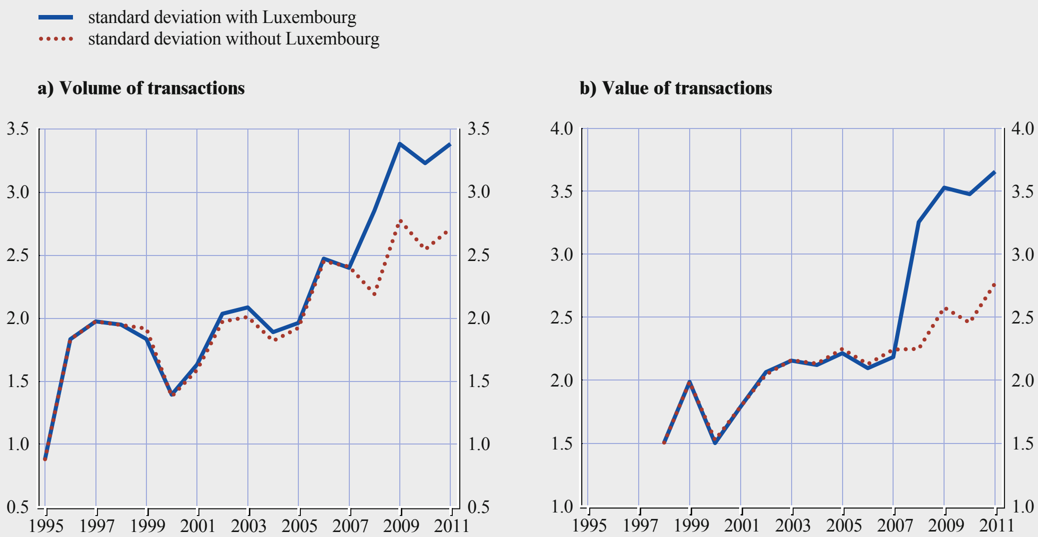
Table 3 Summary of the beta convergence results

Data: 1995-2011	Volume of transactions	Value of transactions
Cash	NO	NO
Debit card	YES	NO
Credit card	YES	NO
Direct debit	YES*	YES
Credit transfer	NO	YES
Cheque	NO	NO
E-money	NO	NO

Sources: ECB Statistical Data Warehouse, authors' estimations.
Notes: This table summarises the conditional beta convergence results for the volume and the value of transactions. "YES" indicates that there is beta convergence;"NO" indicates that there is no beta convergence.
* This result is not robust to changes in the instrument count or the model specification.

Finally, estimations for sigma and beta convergence for e-money exclude Luxembourg, for which the volume and the value of transactions increased substantially after 2007, owing to PayPal and other e-money institutions headquartered in the country. The sigma convergence results remain unchanged: countries diverge in terms of their e-money use, even when Luxembourg is excluded, but more slowly. The effect of Luxembourg on the cross-country dispersion is evident in Chart 5, where the standard deviations with and without Luxembourg are depicted. Both series have an increasing trend, but there is a clear jump in the standard deviation calculated with Luxembourg, which takes place after 2007, when PayPal started to operate from Luxembourg. For beta convergence results, there is no evidence of convergence for the volume of transactions, even when Luxembourg is excluded. For the value of transactions, the estimated beta is negative when the model is estimated without Luxembourg, but statistically significant only when the instrument count is high.

Chart 5 Standard deviation for the volume and the value of e-money transactions



Sources: ECB Statistical Data Warehouse, authors' calculations.
Note: The yearly evolution of the standard deviation for the log (real) value of per capita e-money transactions with and without Luxembourg.

To summarise, there is evidence of convergence for the volume of transactions made by debit card and credit card, and the results are resistant to different instrument counts and to changes in the model specification. The results concerning the volume of direct debits and of credit transfers are sensitive to the number of lags used as instruments, and to the set of control variables in the difference GMM estimations. In contrast, when transactions are measured in terms of value, there is evidence of convergence for the remote payment instruments.

6 CONCLUSIONS

Financial integration in the financial markets in Europe has progressed since the creation of the monetary union. However, the level of integration depends on the market segment and seems to be sensitive to the overall trends in economic development (ECB (2012)). In order to promote integration, policy-makers need tools and indicators to measure the level and progress of integration. For retail payments, the development of these indicators has been less straightforward than for other market segments. In this paper, methods which had been applied previously to measure integration in other segments of the financial markets have been applied to quantify integration in the retail payments market.

The convergence of payment behaviours across the 27 EU countries for the period 1995-2011 has been estimated. Two methods of estimating convergence have been employed: sigma convergence and beta convergence. There is strong evidence of sigma convergence, and the speed of convergence has accelerated for most of the payment instruments studied since the introduction of the single currency. The evidence concerning beta convergence is more varied. The estimation results for beta convergence suggest that countries have been catching up in terms of the volume of card payments, and the value of remote payment instruments.

Based on the findings in this paper, it can be argued that payment behaviours in the 27 EU countries have become more similar since the introduction of the single currency. However, the speed of sigma convergence for cash has been very slow. Moreover, cheques and e-money are exceptions, as countries diverge in their use of these two payment instruments. One possible reason for this lack of convergence could be that there is a negative overall trend in the volume and the value of transactions made by cheque. The divergence result reflects the fact that consumers are making fewer transactions by cheque in most of the 27 EU countries, while in the remaining EU countries, cheques are still relatively popular. For e-money, the overall number and value of transactions is increasing. This payment instrument is, however, still in its early stages of development and the total volume and value of transactions is relatively low. Countries differ in terms of the way in which they adopt payment innovations, and the dispersion in the use of e-money across countries is likely to reflect these different adoption patterns.

The recent financial crisis discouraged integration in many segments of the financial markets, especially in money, bond and equity markets. There is also evidence that in banking, cross-border activity declined during the period of financial turmoil (ECB (2012)). Even though payment behaviours are not likely to be affected by the same factors that led to disintegration in other financial market segments, namely mistrust and increasing differences in country-specific risks, it is nonetheless interesting to note that the convergence in retail payment behaviours has continued regardless of the Europe-wide crisis. However, it is hard to disentangle the effects of SEPA and those of the economic crisis on the convergence process, and the present study offers only some preliminary conclusions. Since economic theory and empirical findings support the fact that integration promotes competitiveness, efficiency and growth, the process of integration should be considered beneficial, even at times of extreme economic uncertainty. Regardless of our positive findings regarding financial integration, it should be noted that payment behaviours are slow to change, and the differences in payment habits across Europe remain significant. The single market for European retail payments has not yet fully materialised and neither have its benefits. This paper may serve as a useful tool for policy-makers and market stakeholders when predicting the future trajectories of the European retail payments market.

ANNEX

This annex presents more information on the estimation method, discusses robustness tests for empirical results and includes some of the statistical tables referred to in this paper.

1 THE DIFFERENCE GMM METHOD

Equation (2) is estimated by using the difference GMM method developed by Arellano and Bond (1991) and further elaborated by Arellano and Bover (1995), and Blundnell and Bond (1998). The dynamic panel methods, originating from Arellano and Bond (1991), Anderson and Hsiao (1982), Hansen (1982) and Holtz-Eakin et al. (1988), are used to estimate models with a relatively short time dimension, dynamic dependent variable, endogenous regressors, and which show evidence of heteroskedasticity and autocorrelation within cross-section units (Roodman (2006) and Bond (2002)). The lagged dependent variables on the right-hand-side of equation (2) generate the dynamic panel bias: the term y_{it-1} in equation (2) correlates with the country-specific fixed effect (Nickell (1981)). First-differencing equation (2) removes the fixed effect, but the first-differenced error term $\varepsilon_{it} - \varepsilon_{it-1}$ correlates with the lagged dependent variable y_{it-1} through the term ε_{it-1}. However, lags two and deeper of the dependent variable (y_{it-2}, y_{it-3}…) remain orthogonal to the first-differenced error, provided that the error term is not autocorrelated. All endogenous variables in equation (2) can be instrumented with lagged values of themselves (as before, lags two and deeper), while exogenous variables function as instruments for themselves. This is known as the difference GMM method (Arellano and Bond (1991)).

System GMM, however, estimates two equations: the first-differenced equation and the original equation in levels (Arellano and Bover (1995); and Blundnell and Bond (1998)). While the first-differenced equation is instrumented, as in the case of the difference GMM method, the endogenous variables in the level equation are instrumented with lagged first-differences of the endogenous variables.

There is some evidence that the system GMM method is more efficient than the difference GMM method in small samples (Soto (2009)). However, the validity of system GMM hinges on the assumption that changes in the instrumenting variable do not correlate with the fixed effect. In terms of instrument validity, the difference GMM estimations yielded more satisfactory results than the system GMM estimations in our sample. Thus the results are presented from estimating equation (2) with the difference GMM.

2 MODEL DIAGNOSTICS AND ROBUSTNESS TESTS

Based on the Arellano-Bond tests for autocorrelation, there is no evidence of second-order autocorrelation in the first-differenced errors, which suggests that the errors in levels are not serially correlated. The Sargan test, which is not robust to heteroskedasticity or serial correlation, suggests problems of instrument validity in the estimations concerning the value of cheques; the Sargan test statistic is relatively close to zero for the volume of direct debit transactions.[10] However, according to the Hansen test statistic, which is robust to heteroskedasticity and serial correlation, the null hypothesis that the instruments are jointly valid is not rejected in any of the estimations. The Hansen test statistic is known to weaken when the instrument count increases. However, the number of

10 For the volume of credit card transactions, the Sargan test statistic is relatively close to zero; however, if lags two to four are used as instruments, the Sargan test statistic is 0.156. The significance and magnitude of beta are unaffected.

instruments is kept moderate in all our estimations to avoid the problems caused by instrument proliferation. The instrument count is restricted in two ways: by restricting the number of lags used as instruments and by collapsing the instrument set, as suggested by Roodman (2006).[11] Only lags two to three for the endogenous regressors are include, and the effect of adding or removing lags on the significance and magnitude of the estimated coefficients is tested.

For the volume of transactions, the results for cheques and e-money are not sensitive to the number of instruments: the estimated beta remains statistically not different from zero, even when the maximum number of lags is used. For cash, the estimated beta is statistically significant only when the maximum number of lags is used; however, as discussed previously, when the maximum number of lags is used, the results are less reliable. For debit and credit cards, the point estimate of beta remains negative, significant and of the same magnitude when the instrument set is varied. For direct debits and credit transfers, the significance of beta is sensitive to the instrument count and to the set of control variables used. The results for direct debits and credit transfers should thus be interpreted with this caveat in mind.

The results for the value of transactions are also robust to the instrument count for cash, cheques and e-money, even though the estimate of beta for cash and cheques was negative and significant when the maximum number of lags was used. Similarly for the value of debit and credit cards, beta is negative and significant when the maximum instrument set is used. However, when the maximum number of lags used, the test statistics hint at problems of instrument validity. For the value of direct debits and credit transfers, beta remains negative and significant, even when the instrument count is varied.

Table A1 Summary statistics for debit card transactions in the 27 EU countries

Debit cards	Volume of transactions (millions)					Value of transactions (billions of euro, real)				
	N	Mean	Stand. dev.	Minimum	Maximum	N	Mean	Stand. dev.	Minimum	Maximum
1995-2000	103	351.00	565.00	0.30	2620.00	93	23.70	36.10	0.05	154.00
2001-2006	153	453.00	791.00	0.86	4650.00	156	24.70	49.00	0.06	292.00
2007-2011	130	729.00	1250.00	5.21	7610.00	130	32.10	61.20	0.24	335.00
1995-2011	386	519.00	938.00	0.30	7610.00	379	27.00	50.90	0.05	335.00

Source: ECB Statistical Data Warehouse.
Notes: Summary statistics for the volume and the value of debit card transactions. "N" stands for the number of observations. "Stand. dev." stands for standard deviation. "Minimum" and "Maximum" are the smallest and largest values of observations.

Table A2 Summary statistics for credit card transactions in the 27 EU countries

Credit cards	Volume of transactions (millions)					Value of transactions (billions of euro, real)				
	N	Mean	Stand. dev.	Minimum	Maximum	N	Mean	Stand. dev.	Minimum	Maximum
1995-2000	80	143.00	303.00	0.04	1,360.00	72	12.10	29.40	0.00	135.00
2001-2006	150	134.00	349.00	0.09	1,870.00	144	12.20	32.00	0.00	167.00
2007-2011	130	184.00	410.00	2.70	1,930.00	129	11.40	26.20	0.10	153.00
1995-2011	360	154.00	363.00	0.04	1,930.00	345	11.90	29.30	0.00	167.00

Source: ECB Statistical Data Warehouse.

11 There is no general rule regarding what is a good number of instruments in system and difference GMM estimations. One rule of thumb often used in the literature is that the number of instruments should not exceed the number of cross-sectional units. Since there are 27 cross-sections in our case, the choice of instrument count can be considered to be conservative.

Table A3 Summary statistics for direct debit transactions in the 27 EU countries

Direct debits	Volume of transactions (millions)					Value of transactions (billions of euro, real)				
	N	Mean	Stand. dev.	Minimum	Maximum	N	Mean	Stand. dev.	Minimum	Maximum
1995-2000	111	586.00	1,220.00	0.02	5,880.00	105	359.00	1,020.00	0.00	7,490.00
2001-2006	156	595.00	1,280.00	0.05	7,360.00	153	284.00	746.00	0.00	4,190.00
2007-2011	132	796.00	1,740.00	0.19	8,700.00	132	559.00	2,020.00	0.12	12,100.00
1995-2011	399	659.00	1,440.00	0.02	8,700.00	390	398.00	1,370.00	0.00	12,100.00

Source: ECB Statistical Data Warehouse.
Notes: Summary statistics for the volume and the value of direct debit transactions. "N" stands for the number of observations. "Stand. dev." stands for standard deviation."Minimum" and "Maximum" are the smallest and largest values of observations.

Table A4 Summary statistics for credit transfers in the 27 EU countries

Credit transfers	Volume of transactions (millions)					Value of transactions (billions of euro, real)				
	N	Mean	Stand. dev.	Minimum	Maximum	N	Mean	Stand. dev.	Minimum	Maximum
1995-2000	105	863.00	1,450.00	1.10	7,390.00	103	8,780.00	21,500.00	4.55	121,000.00
2001-2006	157	730.00	1,290.00	1.86	7,260.00	154	10,100.00	28,400.00	2.88	130,000.00
2007-2011	132	864.00	1,280.00	4.36	6,090.00	132	7,800.00	19,600.00	17.80	141,000.00
1995-2011	394	810.00	1,330.00	1.10	7,390.00	389	8,980.00	23,900.00	2.88	141,000.00

Source: ECB Statistical Data Warehouse.
Notes: Summary statistics for the volume and the value of credit transfers. "N" stands for the number of observations. "Stand. dev." stands for standard deviation. "Minimum" and "Maximum" are the smallest and largest values of observations.

Table A5 Summary statistics for cash (estimated) in the 27 EU countries

Cash	Volume of transactions (millions)					Value of transactions (billions of euro, real)				
	N	Mean	Stand. dev.	Minimum	Maximum	N	Mean	Stand. dev.	Minimum	Maximum
1995-2000	151	5,770.00	7,930.00	101.00	34,200.00	151	123.00	174.00	1.74	757.00
2001-2006	161	5,510.00	7,920.00	116.00	26,800.00	161	124.00	194.00	2.53	752.00
2007-2011	124	5,220.00	7,600.00	90.60	26,000.00	124	118.00	186.00	2.09	730.00
1995-2011	436	5,510.00	7,820.00	90.60	34,200.00	436	122.00	184.00	1.74	757.00

Source: ECB Statistical Data Warehouse.
Notes: Summary statistics for the volume and the value of cash transactions (estimated based on private consumption). "N" stands for the number of observations. "Stand. dev." stands for standard deviation. "Minimum" and "Maximum" are the smallest and largest values of observations.

Table A6 Summary statistics for the variables used in the beta convergence estimations

	N	Mean	Stand. dev.	Minimum	Maximum
ATMs per 1,000 inhabitants	423	0.59	0.32	0.01	1.66
Deposit rate	377	5.64	7.72	0.01	74.68
EFTPOS terminals per 1,000 inhabitants	415	11.71	7.60	0.00	37.68
Interest rate	332	4.54	7.89	-71.21	97.47
Real private consumption per capita	441	10,954.52	5,926.42	1,360.63	27,125.96
Real GDP per capita	453	19,661.61	13,402.51	1,895.71	70,563.15

Sources: Eurostat and the World Bank.
Notes: Summary statistics for the variables used in the beta convergence estimations (1995-2011)."N" stands for the number of observations. "Stand. dev." stands for the standard deviation."Minimum" and "Maximum" are the smallest and largest values of observations.

Table A7 Sigma convergence estimation results for the period 1995-2011 for the volume of transactions

	Cash	Debit card	Credit card	Direct debit	Credit transfer	Cheque	E-money
Time trend before-euro introduction	-0.064*** (0.003)	0.192*** (0.017)	-0.072* (0.035)	-0.022 (0.022)	0.040*** (0.007)	0.223*** (0.015)	0.335*** (0.021)
Time trend after-euro introduction	-0.009*** (0.000)	-0.051** (0.003)	-0.078*** (0.006)	-0.016*** (0.004)	-0.045*** (0.001)	0.044*** (0.003)	0.160*** (0.003)
Before-euro dummy	0.687*** (0.008)	1.261*** (0.045)	1.089*** (0.095)	1.580*** (0.060)	1.017*** (0.018)	1.119*** (0.041)	0.823*** (0.058)
After-euro dummy	0.451*** (0.006)	2.125*** (0.032)	2.484*** (0.067)	2.147*** (0.042)	1.580*** (0.013)	2.404*** (0.029)	0.587*** (0.041)
N	459	459	459	459	459	459	459
Adjusted R^2	0.99	0.99	0.93	0.98	0.99	0.99	0.99
F-test, H_0: β_0=β_1	0.000	0.000	0.881	0.791	0.000	0.000	0.000

Sources: ECB Statistical Data Warehouse, authors' estimations.
Notes: This table presents the ordinary least squares estimation results for equation (1) for the period 1995-2011. The dependent variable is the standard deviation of the log volume of per capita transactions. Standard errors are in parentheses. * Significant at the 5% level; ** Significant at the 1% level; *** Significant at the 0.1% level. "Time trend before-euro introduction" is estimated as β_0 in equation (1); "Time trend after-euro introduction" is estimated as β_1; "Before-euro dummy" is the estimated before-euro introduction intercept α_0 and "After-euro dummy" is the estimated after-euro introduction intercept α_1. The F-test tests the hypothesis that the slope of the time trend is the same before and after the introduction of the euro. The null hypothesis is that the slopes are equal. The *p*-value of the F-test is reported.

Table A8 Sigma convergence estimation results for the period 1995-2011 for the value of transactions

	Cash	Debit card	Credit card	Direct debit	Credit transfer	Cheque	E-money
Time trend before-euro introduction	-0.040*** (0.003)	0.144*** (0.012)	0.467*** (0.022)	0.215*** (0.021)	-0.009 (0.007)	0.135* (0.053)	0.376*** (0.015)
Time trend after-euro introduction	-0.017*** (0.000)	-0.050*** (0.002)	-0.086*** (0.004)	0.002 (0.003)	-0.039*** (0.001)	0.004 (0.009)	0.167*** (0.005)
Before-euro dummy	0.798*** (0.008)	0.952*** (0.032)	0.615*** (0.059)	0.726*** (0.059)	1.254*** (0.020)	1.241*** (0.146)	–
After-euro dummy	0.773*** (0.006)	2.061*** (0.022)	2.814*** (0.041)	2.328*** (0.041)	1.679*** (0.014)	3.402*** (0.103)	0.625*** (0.052)
N	459	459	459	459	459	459	378
Adjusted R^2	0.99	0.99	0.98	0.99	0.99	0.96	0.98
F-test, H_0: β_0=β_1	0.000	0.000	0.000	0.000	0.000	0.016	0.000

Sources: ECB Statistical Data Warehouse, authors' estimations.
Notes: This table presents the ordinary least squaresestimation results for equation (1) for the period 1995-2011. The dependent variable is the standard deviation of the log volume of per capita transactions. Standard errors are in parentheses. *Significant at the 5% level; *** Significant at the 0.1% level. "Time trend before-euro introduction" is estimated as β_0 in equation (1); "Time trend after-euro introduction" is estimated as β_1; "Before-euro dummy" is the estimated before-euro introduction intercept α_0 and "After-euro dummy" is the estimated after-euro introduction intercept α_1. The F-test tests the hypothesis that the slope of the time trend is the samebefore and after the introduction of the euro. The null hypothesis is that the slopes are equal. The *p*-value of the F-test is reported.

Table A9 Sigma convergence estimation results for the period 2000-2011 for the volume of transactions

	Cash	Debit card	Credit card	Direct debit	Credit transfer	Cheque	E-money
Time trend	-0.008*** (0.001)	-0.067*** (0.001)	-0.137*** (0.003)	-0.046*** (0.003)	-0.045*** (0.001)	0.024*** (0.002)	0.181*** (0.003)
Constant	0.436*** (0.007)	2.331*** (0.018)	3.279*** (0.032)	2.549*** (0.039)	1.578*** (0.008)	2.672*** (0.026)	0.317*** (0.038)
N	324	324	324	324	324	324	324
Adjusted R^2	0.34	0.86	0.89	0.39	0.93	0.28	0.91

Sources: ECB Statistical Data Warehouse, authors' estimations.
Notes: This table presents the ordinary least squares estimation results for equation (1) for the period 2000-2011. The dependent variable is the standard deviation of the log volume of per capita transactions. Standard errors are in parentheses. *** Significant at the 0.1% level.

Table A10 Sigma convergence estimation results for the period 2000-2011 for the value of transactions

	Cash	Debit card	Credit card	Direct debit	Credit transfer	Cheque	E-money
Time trend	-0.018*** (0.001)	-0.063*** (0.002)	-0.100*** (0.002)	-0.034*** (0.002)	-0.045*** (0.001)	-0.068*** (0.008)	0.191*** (0.005)
Constant	0.785*** (0.008)	2.231*** (0.022)	3.004*** (0.024)	2.814*** (0.021)	1.768*** (0.017)	4.367*** (0.096)	0.306*** (0.056)
N	324	324	324	324	324	324	324
Adjusted R^2	0.70	0.79	0.88	0.55	0.76	0.18	0.84

Sources: ECB Statistical Data Warehouse, authors' estimations.
Notes: This table presents the ordinary least squares estimation results for equation (1) for the period 2000-2011. The dependent variable is the standard deviation of the log value of real per capita transactions. Standard errors are in parentheses. *** Significant at the 0.1% level.

Table A11 Difference GMM results for conditional beta convergence

	ΔCash		ΔDebit card		ΔCredit card	
	Volume	Value	Volume	Value	Volume	Value
β	-0.325 (0.280)	-0.425 (0.238)	-0.633** (0.188)	-0.533 (0.684)	-0.513*** (0.129)	-0.101 (0.459)
Deposit rate	-0.052* (0.019)	-0.047* (0.019)	-	-	-	-
Interest rate	-	-	-	-	-0.082* (0.039)	0.040 (0.070)
EFTPOS	-	-	0.801** (0.245)	0.658 (0.605)	1.187*** (0.136)	0.273 (0.341)
ATMs	-0.047 (0.034)	-0.042 (0.027)	-0.196 (0.175)	0.022 (0.628)	-0.472 (0.248)	0.106 (0.451)
GDP	0.486 (0.274)	0.535* (0.261)	0.256 (0.376)	0.600 (1.336)	0.414 (0.657)	0.672 (2.230)
Hansen p	0.154	0.309	0.776	0.072	0.187	0.888
Sargan p	0.586	0.701	0.718	0.179	0.054	0.911
AR(2)	0.125	0.147	0.069	0.619	0.595	0.599
N	274	264	327	320	171	163
Instruments	19	19	20	20	21	21

Sources: ECB Statistical Data Warehouse, authors' estimations.
Notes: The table shows the two-step difference GMM estimation results for equation (2). The dependent variable is the growth rate of transactions for payment instrument *i*. Year dummies are included (the results have been omitted for space reasons). Windmeijer-corrected standard errors are in parentheses. The null hypothesis for the Hansen and the Sargan over-identification tests is that instruments are jointly valid. AR(2) is the *p*-value of the Arellano-Bond test for second-order autocorrelation for first-differenced residuals; the null hypothesis is no autocorrelation. All continuous variables are in per capita terms and in logs. Value variables are in logs, in per capita terms and have been adjusted for inflation. * Significant at the 5% level; ** Significant at the 1% level; *** Significant at the 0.1% level. Lags twotothree for the endogenous variables are included as instruments or,wherespecification tests suggest problems, lags two to four. The robustness of the results is discussed in the Annex.

Table A12 Difference GMM results for conditional beta convergence

	ΔDirect debit		ΔCredit transfer		ΔCheque		ΔE-money	
	Volume	Value	Volume	Value	Volume	Value	Volume	Value
β	-0.657*	-0.818***	-0.605	-1.118**	-0.622	-1.213	0.079	-0.624
	(0.294)	(0.214)	(0.764)	(0.402)	(0.761)	(1.846)	(0.392)	(1.183)
EFTPOS	0.347	0.418	0.496	0.569**	-	-	-	-
	(0.456)	(0.448)	(0.306)	(0.200)				
GDP	-0.164	0.571	-0.508	0.294	0.871	0.993	-2.864	-4.250
	(0.712)	(0.689)	(0.520)	(0.760)	(1.194)	(2.984)	(2.383)	(5.657)
Hansen p	0.152	0.175	0.238	0.615	0.580	0.119	0.614	0.490
Sargan p	0.078	0.283	0.175	0.556	0.573	0.003	0.716	0.642
AR(2)	0.105	0.407	0.501	0.956	0.555	0.319	0.873	0.515
N	331	324	325	323	328	305	134	122
Instruments	20	19	20	20	19	19	15	15

Sources: ECB Statistical Data Warehouse, authors' estimations.
Notes: The table shows the two-step difference GMM estimation results for equation (2). The dependent variable is the growth rate of transactions for payment instrument *i*. Year dummies are included (the results have been omitted for space reasons). Windmeijer-corrected standard errors are in parentheses. The null hypothesis for the Hansen and the Sargan over-identification tests is that instruments are jointly valid. AR(2) is the *p*-value of the Arellano-Bond test for second-order autocorrelation for first-differenced residuals; the null hypothesis is no autocorrelation. All continuous variables are in per capita terms and in logs. Value variables are in logs, in per capita terms and have been adjusted for inflation. * Significant at the 5% level; ** Significant at the 1% level; *** Significant at the 0.1% level. Lags two to three for the endogenous variables are included as instruments or,wherespecification tests suggest problems, lags two to four. The robustness of results is discussed in the Annex.

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