Narrow money and transaction technology: new disaggregated evidence

Columba, Francesco

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Francesco Columba*

Banca d'Italia, Economic Research Department, via Nazionale 91, 00184 Rome, Italy

Abstract

This paper analyses the effect of transaction technology innovation on narrow money using Italian data disaggregated at provincial level. In particular, this study assesses the impact of the diffusion of ATMs (automated teller machines) and of POS (points of sale), on the demand for currency and on the demand for M1 using a unique data set. We find that transaction technology innovation has a negative effect on the demand for currency in circulation, while its effect on M1 is positive; additionally, heterogeneity in the use of cash within Italy is detected.

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E-mail address: francesco.columba@bancaditalia.it. Tel. +39 06 4792 5599.

Introduction

Money demand is intensively studied due to the relevance of a precise estimation of its parameters to better inform a number of crucial economic policy decisions. First, from a consumer finance perspective a quantification of the money demand parameters, in particular of the interest elasticity of the demand for money, is essential to estimate the welfare cost of inflation (Attanasio, et al., 2002, Lucas, 2000). Second, a careful evaluation of money demand elasticity to the scale variable, product or consumption, is relevant to grasp the long run relation between money, inflation and output (Friedman, 1969). Third, in order to evaluate monetary policy stance it is relevant to detect possible shifts in money demand parameters due to financial innovation or to the introduction of new means of payments, such as debit cards, credit cards, electronic money. This third argument in support of the relevance of the study of money demand is well exemplified by the length and intensity of the debate on the stability of US money demand (Duca, 2000, Duca and Van Hoose, 2004, Teles and Zhou, 2005).

This paper studies the effect of the deployment of two types of terminal that innovated transaction technology, ATMs (automated teller machines) and POS (points of sale, the terminals where debit cards are used to settle transactions), on the demand for currency and on the demand for narrow monetary aggregate M1.[1] The analysis takes advantage of a unique data set that tracks heterogeneity in the distribution of cash across provinces. We attempt at attenuating the problems stemming from a possible instability of money demand parameters or from an endogeneity of the parameters to the monetary policy with the exploitation of the cross-section variability.[2] Estimates at the regional level of an area identified by a single currency and monetary policy are more precise than time-series estimates, since changes in the monetary policy reaction function can lead to changes in both money and nominal income over time, but not across regions.

The first goal of this paper is to ascertain the effect of the diffusion of ATMs and of POS on the demand for currency. It is worthwhile pursuing this objective, not only because of the need of understanding movements in money demand for the economic policy reasons above mentioned, but

also because of the unsettled empirical evidence on the effect of lower transaction costs stemming from the adoption of new technologies on currency demand. The decrease in transaction costs that we exploit empirically is represented by the diffusion of ATMs and POS that leads to a reduction in the shoe-leather cost of withdrawing currency. Moreover, while the effects of the diffusion of ATMs was widely investigated, the effects of the diffusion of POS, that enhances the use of debit card as alternative to cash to settle transactions, to our best knowledge, was not analyzed thoroughly in theoretical models. Intuitively, however the increase in the spread of POS, analogously to that of ATMs, should lead to lower transaction costs, inducing a decrease in the average holding of cash.

The second objective is to evaluate the overall effect of ATM and POS diffusion on the demand for a more ample monetary aggregate, M1 (i.e. currency and demand deposits), to assess how the negative effect of transaction technology innovation on currency in circulation compares with the positive effect on demand deposits that arises from a decrease in the opportunity cost of holding a positive balance on the account.[3] Partly due to a lack of disaggregated data for currency in circulation, the effect of the spread of new transaction technologies on M1 was not studied before.

To achieve the two objectives above enunciated, we take advantage of the natural experiment represented by the introduction of the euro that let us build a unique measure of the currency in circulation at the provincial level. The data set comprises data on the daily inflows and outflows of lira and euro banknotes in Italy through the branches of the Bank of Italy, that acted as cash offices. We cumulated all the euro banknotes put in circulation in all the working days since January 2 to March 29, 2002 (subtracting the notes that during the period were withdrawn from circulation), province by province, and we obtained stocks of euro increasing through the period observed. To derive the euro stocks we therefore exploited 5,985 observations, each constituted of the net flow of euro banknotes for the province i (ranging between 1 and 95) and for the date t (ranging between 1 and 63). Our assumption is that in the first three months of 2002 the flows of euro banknotes between the different provinces were negligible so that the stocks built are reliable enough.

This data set enables us to assess the impact of the diffusion of ATMs and POS on currency with actual cross-section data allowing us to address heterogeneity in financial development that is

relevant to Italy, especially regarding currency and payments. To our knowledge, data on currency with such a degree of disaggregation were not used before. In Italy the remarkable differences between the areas of the country with regard to two of the traditional determinants in the use of cash, the alleged "greyness" of economy and the degree of financial sophistication,[4] provides a strong motivation for analyzing cash with provincial data. Moreover census data on currency disaggregated by province were not available until now. Only data derived from sample surveys were available and they may suffer from not being representative of the stock of currency in all the provinces we consider. The data set we build is derived from first-hand data used to construct the monetary aggregates that we are interested in. Nevertheless to avoid relying only on one cross-section of data at the point in time when the euro was introduced, and to check for the robustness of our results to heterogeneity in the degree of financial development across Italy we also estimate panel regressions with fixed provincial effects, assuming that the distribution of currency observed in 2002 was similar in nearby years.[5]

The empirical analysis is driven by the idea that ATMs allow households to economize cash balances held. According to Baumol's theory of the transaction demand for money and the McCallum and Goodfriend (1989) extension with the shopping time model, lower shoe-leather and transaction costs arising from the availability of ATMs should reduce the demand for cash. Nevertheless, from an empirical point of view, the effect of the diffusion of ATMs on the demand for cash is mixed (see Drehmann, Goodhart and Krueger, 2002 and Amromin and Chakravorty, 2009, for the effect on small notes). The expected sign of the overall effect of ATM on M1 therefore depends on how the possible negative effect on currency and the positive effect on demand deposits compare.

The POS allows cards' holders to buy goods and services by debiting immediately their bank accounts with electronic fund transfers that reduce the cost of a transaction. Purchases at a POS with a debit card are an alternative to cash, given the finality of the payment likewise that of cash payment, therefore the sign of the effect on demand for currency of an increase in POS availability should be negative (see Raa and Shestalova, 2004 and Whitesell, 1989, 1992) . As for

the effect of ATM also the expected sign of the overall effect of POS on M1 depends on how the negative effect on currency and the positive effect on demand deposits compare.

The rest of the paper is organized as follows. In section 2 the related literature is reviewed. Section 3 describes the econometric specification and section 4 discusses the data. Section 5 presents the results for currency in circulation and M1 in comparison with those of other studies. Section 6 reports on robustness checks. Conclusions are outlined in the final section.

2 Related literature

The theoretical motivation of this paper hinges on models of money demand rooted in the seminal ones of Baumol (1952) and Tobin (1956) that assign a key role to transaction technology. In this class of models, reviewed in a comprehensive survey by Duca and Van Hoose (2004), money demand is positively related to the transaction costs and so, implicitly, inversely related to the improvements in transaction technology that lower transaction costs. McCallum B. T. and Goodfriend M. (1987), in particular, extend the Baumol-Tobin model of money inventory considering more explicitly the role of money as medium of exchange that lets people save time to manage a transaction.

An empirical model that tests the validity of the general implications descending from the models of money demand is derived by Attanasio et al. (2002). The model stresses the importance of transaction technology innovation for money demand, obtaining precise estimates of the parameters of the money demand with the use of microdata and finding that the interest rate elasticity is sensibly lower for individuals who have access to ATMs than those lacking. Moreover Attanasio et al. (2002) have results consistent with the view that cash holding is considerably higher in Central and in Southern Italy, where the underground economy and criminal activities are deemed to be more widespread than in Northern Italy.

With regard to models with empirical predictions concerning the relation between monetary aggregates and the objects of interest in this work, ATM and POS, the first, to our knowledge, is that by Paroush and Ruthemberg (1986).[6] Their model predicts that the introduction of ATMs

should increase the share of demand deposits at the expense of currency holdings, under the assumption that the cost of holding demand deposits is reduced by the introduction of ATMs. Lower costs should arise, in a Baumol-Tobin framework, from reducing the time costs of transactions from drawing on demand deposit balances. The empirical findings, based on Israeli data, are in line with theoretical priors: more ATMs lead to a higher level of demand deposits and lower currency holdings. Zilberfarb (1989) presents empirical results for Israel supporting those findings. Daniels and Murphy (1994a, 1994b) show, using data on two households samples in the United States in the mid-1980s, that ATMs shift households demand from currency to transaction accounts.

Snellman, Vesala and Humphrey (2001) study the pattern of the share of cash transactions for ten European countries over the period 1987-1996. The authors argument that the diffusion of POS made it convenient to use payment cards instead of cash for low value payments at a point of sale, since the finality of the settlement typical of cash is coupled with the possibility to keep earning interest on demand deposits (on this see also Raa and Shestalova, 2004). They suggest that the diffusion of POS is one of the key determinant of the substitution of non-cash payments for cash. The diffusion of ATM has instead an ambiguous effect on the substitution for cash; on the one hand it becomes easier to withdraw cash therefore increasing its demand, while on the other hand, the use of payment cards is enhanced and it is possible to save on the average cash balance held (see also Alvarez and Lippi, forthcoming). The main results are that, controlling for standard money demand influences, the nature of the substitution of card payments for cash is similar across countries and that the development stage of each country in the substitution process depends crucially on the diffusion of the card payment infrastructure, particularly POS. The evidence provided supports the view that in Italy the substitution process away from cash due to POS payments was very slow, between 1987 and 1996, and that, ceteris paribus, the use of cash in the near future should have continued to be above that in other European countries.

Also Drehmann et al. (2002) investigate the effects of modern payment technologies on the demand for cash. They find, using annual data from 1980 to 1998 for 18 OECD countries, that POS

terminals have a significant negative effect on the demand for small banknotes and that ATMs seem to increase the demand for small notes, while the effects on large notes are unclear. The authors argue that cash will not loose its role in favor of more technologically sophisticated instruments, such as e-money, because the characteristics of cash will continue to be unchallenged.

Raa and Shestalova (2004) test the empirical predictions of the model of money demand with respect to payment technologies and have results consistent with the restrictions imposed on Whitesell's model (1989, 1992). They find, assessing cash and debit cards relative convenience with Dutch data, that currency has a lower fixed cost and is preferred to debit cards for small value transactions, while debit cards, that bear a lower variable cost, are chosen for large value transactions.

As for census currency data disaggregated at a sub-national level, to our best knowledge only Judson and Porter (2004), who estimate the dollars circulating outside the United States,[7] use data comparable to our.

3 Econometric specification

The econometric specification is based on the Baumol-Tobin inventory approach and extensions, such as that of McCallum and Goodfriend (1987). After measuring the stocks of currency in circulation for the 95 provinces at the end of March 2002 we were in the position to estimate a demand for currency in circulation exploiting the remarkable cross-section variability of our data set (Table 1). We used a traditional specification, comprising a scale variable and an opportunity cost, to which we added two regressors accounting for the diffusion of ATM and POS terminals. The benchmark equation we estimated with OLS is the following:

$$(1) \qquad \log(CC/P)_j = b_0 + b_1 \log(GDP/P)_j + b_2 (i_{dd})_j + b_3 \log(ATM)_j + b_4 \log(POS)_j + \varepsilon_j$$

where CC denotes currency in circulation (net euro flows put in circulation from Bank of Italy from the introduction of the euro to the end of March 2002), GDP denotes nominal gross domestic product, P is the consumer price index used as deflator, i_{dd} is the interest rate on demand deposits (the relevant opportunity cost for currency in circulation since demand deposits represent the closest

substitute to cash[8]), ATM is the number of automated teller machines, POS is the number of terminals for electronic fund transfer at points of sales, j indexes the 95 Italian provinces and ε_j is the error term.

To deal with the possibility that the cross-section results of a negative effect of ATM and POS on currency demand may be driven by differences in provincial availability of other kinds of financial technology such as credit card, store of value card or other electronic payment devices, we also ran panel regressions with fixed effects at the provincial level to control further for the cross-section heterogeneity, as specified in equation 2, where t indexes years since 1991 to 2003.[9]

(2) $$\log(CC/P)_{jt} = b_0 + b_1 \log(GDP/P)_{jt} + b_2 (i_{dd})_{jt} + b_3 \log(ATM)_{jt} + b_4 \log(POS)_{jt} + \varepsilon_{jt}$$

We then estimated with OLS a demand for M1 with the same specification used for the demand for currency in circulation, except for the opportunity cost now represented by ($i_{3m} - i_{orM1}$), the interest rate on 3-month Treasury bill (the alternative asset for demand deposits), minus the own rate of return on M1 (i.e. the interest rate on demand deposits times their share of M1):

(3) $$\log(M1/P)_j = b_0 + b_1 \log(GDP/P)_j + b_2 (i_{3m} - i_{orM1})_j + b_3 \log(ATM)_j + b_4 \log(POS)_j + \varepsilon_j$$

We then estimated a demand for M1 with panel regressions with fixed provincial effects (see equation 4) with the goal, like for currency demand, of checking for cross-section financial technology heterogeneity with t spanning from 1991 to 2003.

(4) $$\log(M1/P)_{jt} = b_0 + b_1 \log(GDP/P)_{jt} + b_2 (i_{3m} - i_{orM1})_{jt} + b_3 \log(ATM)_{jt} + b_4 \log(POS)_{jt} + \varepsilon_{jt}$$

4 Data

It is generally difficult to estimate the stocks of currency circulating in sub-areas of a currency area, particularly in our case because we consider data very disaggregated, at the level of Italian provinces (comparable in size to US counties). Once put in circulation banknotes and coins circulate within an area according to tourism, trade and hoarding patterns, making it unfeasible to detect their movements. For this reason, only indirect measures of the stocks of currency in sub-areas are available.

The European System of Central Banks (ESCB), after a thorough internal analysis of the impact of banknote migration after the euro introduction[9], chose the Capital Share Mechanism (CSM) as conventional measure of circulation in the euro-area countries to distribute among the central banks the seigniorage revenues resulting from euro circulation. The CSM allocates the capital of the European Central Bank (ECB) to the National Central Banks (NCBs) using as weights the averages of population and GDP national shares over the euro-area aggregates. The rationale for this allocation is that population and GDP are two of the key factors determining the level of cash needed for transaction purposes. Of course, this method represents a compromise between feasibility, costs considerations and accuracy of measurement, partly because it ignores currency demand arising from the hoarding of currency for speculative, illegal or other motivations. The method also disregards heterogeneity in financial technology.

Trying to measure currency in circulation within provinces, we determined the quotas of currency in circulation to be attributed to the provinces exploiting the natural experiment arising from the introduction of the euro. Instead of the CSM method used by the ESCB, we used an original method based on data on banknotes inflows and outflows from Bank of Italy's provincial branches, that, among numerous other functions, are also cash offices. The stocks of currency in circulation in sub-areas, whose measurement is highly questionable at any moment of time, are instead quite reliable if we can measure all the new banknotes introduced in the monetary circuit from the very beginning. Of course the stocks of currency in circulation are reliable only if we sum

the banknotes introduced for a very short period of time, after which the notes begin to migrate between the sub-areas disrupting the informational content of the initial stocks.

The introduction of a new legal tender, in January 2002, is one of the extremely rare, if not unique, cases in which it is possible to know the initial stocks put in circulation in each sub-areas of a currency area. We also take advantage of a circumstance that preserved the informational content of disaggregate stocks of currency in Italy more than in the majority of the other euro-area countries. The circumstance is that the length of the dual circulation period, that spanned since January 1, 2002 to February 28, 2002, in which the Italian lira and the euro coexisted as legal tenders, was the longest among those of euro area countries with the aim to mitigate the inconvenience of the changeover for the citizens with a smooth transition to the euro.[11] This possibly led to a negligible migration of the euro banknotes between the Italian provinces in the first months, because the demand for cash was still partially absorbed by lira banknotes. Finally the main determinant of the banknotes migration, tourism, had not its traditional sizeable start until Easter (March 31, 2002). For these reasons, we could build provincial stocks of euro currency in circulation cumulating the net flows of euro banknotes introduced through the branches of the Bank of Italy, since the 1st of January to the end of March with the assumption of the irrelevance of banknote migration not being a overly strong one.

The data set we built is unique because it comprises data on the daily inflows and outflows of lira and euro banknotes through the 95 Italian branches of the Bank of Italy that act as cash offices. We cumulated all the euro banknotes put in circulation in all the working days since January 2 up to March 29 (subtracting the ones withdrawn from circulation), province by province. To derive the euro stocks we therefore exploited 5,985 observations, each constituted of the net flow of euro banknotes for one of the 95 provinces in one of the 63 days.[12] As above mentioned, having assumed that in the first three months of 2002, the flows of euro banknotes between the different provinces were negligible, the stocks built are largely reliable. The other variables used in the cross-section regressions refer to the end of December 2001.

An alternative method we experimented to disaggregate currency at the provincial level is to determine the weights on the basis of currency in Italian micro-data on families' cash holdings reported by the Bank of Italy Survey on Households Income and Wealth (SHIW). Due to the lack of sufficient observations per province this procedure does not yield significant weights for all the provinces. For this reason, we believe our data set may be preferable from a macro perspective while SHIW is tailored for micro analyses. Furthermore, our data set directly measures currency in contrast to the indirect data from SHIW, which may suffer from under-reporting of financial assets.

5 Results

5.1 Currency in circulation

We report the results of the cross section regressions for the demand for currency based on cash data constructed with the method described in section 4 and using daily observations on the net flows of euro (table 2). To evaluate the effect of the introduction of ATM and POS we estimate four different specifications: first without terms accounting for transaction technology, second with ATMs, third with POS and finally with both ATMs and POS.

We find that after a 1 per cent increase in the number of ATMs, currency demand decreases by -0.34 per cent and by -0.28 when considered jointly with POS; following a 1 per cent increase in the number of POS, currency in circulation decreases 0.20 percent and by 0.11 percent, but not significantly, when ATMs are considered jointly with POS. The estimated income elasticity is 1.30 when both ATM and POS technologies are included; the coefficient for interest rate on demand deposits is negative but not significant.

The effect of ATMs on the demand for currency are negative, as expected on the basis literature, those for POS accord with those of Snellman et al. (2001), of Drehmann and Goodhart (2000) and of Amromin and Chakravorti (2009) who find a negative impact on cash holdings.

For the income elasticity our results are in line with the empirical literature on demand for currency. As for theoretical models our estimated income elasticities are more in line with the

value, 1, found by Brunner and Meltzer (1967) who improved on Miller and Orr (1966), while they differ from the Baumol-Tobin model's income elasticity of ½.

The concern that different levels of financial development and hence of financial technology across provinces may drive the reported results of the cross-section regressions was addressed with panel regression with fixed effects at the provincial level. The panel regression results in table 3 reassured us that the negative effect of ATM and POS on currency demand still holds, even if with smaller coefficients, while we can not confirm that of POS when considered jointly with ATM.

We also controlled, exploiting supervisory data on the quantity of the deposits of a province held by depositors of other provinces, both in the cross-section regression and in the panel regressions, for the possibility that wealthier provinces attracting more out of province depositors could blur our results. Indeed the results for the effects of ATM and POS and for the income elasticity are weakened but still hold in the cross-section (equation 5 of table 2) and panel estimates, with an exception for ATM in the panel estimates (equation 5, table 3).

Another issue we tackled was the possibility that the euro issuance could be driven by people exchanging euro for lira and that this could lead to correlation between euro issuance and wealth. We therefore inserted in our regressions a term accounting for the amount of financial wealth held by households in a province (derived from the 2002 SHIW, the closest survey to the euro changeover). Our results hold in the cross-section and panel estimates, with the exception of a positive effect of ATM due possibly also to the problems of the SHIW data on wealth linked to underreporting described in Cannari and D'Alessio (1993) or to the extension of our currency weights obtained in 2002 to previous years.[13]

5.2 M1

We report the results of the estimates of the demand for M1 to evaluate the overall net effect of transaction technology innovation on M1 resulting from the effects on its two components of M1.

Table 4 reports the results for M1 demand with the same four specifications used for currency demand: first without terms accounting for transaction technology, second with ATMs, third with POS and finally with both ATMs and POS.

Estimates indicate that a 1 per cent increase in the number of ATMs boosts M1 by 0.27 per cent in the absence of POS, and by a smaller 0.14 per cent in the presence of POS. The effect of POS is of the same sign: a 1 per cent increase in the number of POS increases demand deposits by 0.24 per cent, without controlling for the number of ATMs and by a smaller 0.18 per cent controlling for the number of ATMs. The elasticity to the opportunity cost is negative and equal to -0.14 per cent. The income elasticity through the four formulations decreases as more terms accounting for transaction technologies are introduced. Elasticity estimates range from 1.14 when no transaction technology is considered to a low of 0.81 when ATMs and POS are taken into account.

From panel regression with fixed provincial effects (table 5), as in the regressions for currency in circulation, we are reassured of the positive effect of POS on M1 demand while that of ATM turns out to be negative perhaps due to problems in the reconstruction of the provincial currency stocks moving away from the actual observations gathered in 2002.

For the income elasticity our results, that in the cross-section locate our coefficient close to one when all terms for transaction technology are introduced, may be compared with those of Mulligan and Sala-i-Martin (1992), who used demand deposits and conducted a cross-section analysis, finding a income elasticity larger than one. Comparisons can be done also with studies of broader monetary aggregates. Angelini, Hendry and Rinaldi (1994) estimate elasticities with respect to real domestic demand less than one (0.6 to 0.7 per cent). For euro area M3 Dedola, Gaiotti and Silipo (2001) find (with pooling with fixed effects and with long-run coefficients constrained to be equal only across 5 countries) a real GDP elasticity between 1.2 and 1.26, while Focarelli's (2005) estimates of income elasticity range between 1.4 and 1.6.

As with currency demand adding also a term accounting for the amount of deposit held from residents of other provinces the results still hold with one exception (the ATM term becomes

insignificant in equation 5 of table 4, but negative in equation 5 of table 5). Inserting the term for financial wealth the results still hold both in the cross-section and the panel estimates for POS while the ATM coefficient turns negative in the panel estimate (equation 6 in table 4 and 5) possibly pointing to the problem already mentioned of the quality of the estimates of currency.[12]

Following a general to specific approach we also checked if other variables relevant to currency demand could explain heterogeneity in the spread of euro through Italy. These included percentage of graduates in the population, the percentage of people with only a primary school degree, the unemployment rate, an index of criminality and a variable reflecting the danger of having high holdings of cash (the number of cases of pick-pocketing). We also checked if the amount of banknotes frontloaded and sub-frontloaded (that is, respectively, the banknotes delivered to post offices and banks before January 1, 2002 and the banknotes distributed by the latter to commercial chains and retailers before the same date) had an impact. None of the variables were significant and did not alter the qualitative results with respect to the specifications shown in the tables. Finally we also checked for interactions between ATM and POS, but the term introduced in the equation was not significant.

6 Robustness checks

As robustness check for our method of constructing currency stocks, we also estimated currency with weights derived from regional data (in Italy there are twenty regions) on average cash holdings reported in Bank of Italy's Survey on Households Income and Wealth (see section 4). The results are qualitatively similar to those using data constructed under our "direct" method. Results differ mainly with regard to the income elasticity that becomes extremely high without declining in the presence of transaction technology terms. It is important to note that these results may be biased from the typical under-reporting of the financial assets of the families interviewed.

To check for the robustness of our results for both currency and M1 equations, besides controlling for outliers, we performed the Breusch-Pagan test finding no evidence of heteroskedasticity. We inspected the distribution of residuals, standardized and studentized too, and

we calculated distance statistics to check for influential data points without detecting significant anomalies. We ran regressions with White robust standard errors, robust regressions, regressions weighted with the population and gdp, respectively, of the provinces, quantile regression models (least absolute deviations), stepwise regressions. The results commented in section 5 were not significantly altered neither qualitatively neither quantitatively.[13]

We also controlled for correlation of our variables with the population and we ran regressions with all the variables in the equations for currency and for M1 in per capita terms; the results of section 5 were not significantly altered. We also introduced in our specification of the equation also the population variable itself and again the results were not significantly changed.

Finally to take into account possible structural differences between Italian areas we also inserted in the equations five geographical dummies, for North-West, North-East, Centre, South and the Islands respectively, without having significant alterations of our results.

Conclusions

This study makes two contributions to the literature on money demand. First, it provides an unprecedented estimate of currency at a very disaggregate level taking advantage of the natural experiment represented by the introduction of the euro in Italian provinces. Second, using disaggregated data the study estimates the effect of transaction technology innovation on currency and M1 demand.

One major finding for currency demand, on the basis of cross-section results, is that ATM technology has significantly negative effects, with a 1 percent rise in ATM reducing currency by 0.28 percent. Another result is that estimates of the income elasticity decrease in magnitude when ATM and POS are accounted for. Lastly, the effect of the opportunity cost is generally not statistically significant while the effects of an increase of 1 per cent of the number of POS on currency is negative by 0.20 percent, but loses its significance when estimated jointly with the ATM term.

The analysis of M1 yields the following results; the estimated effect on M1 of increasing the number of ATM is positive, at 0.14 per cent, when considered jointly with POS; that of an increase of the number of POS is positive, at 0.18 per cent; income elasticity estimates are smaller in size and decreases when ATM and POS are accounted for, while the effect of the opportunity cost is negative and significant.

These findings suggest that ATM and POS diffusion has overall a negative effect on currency in circulation. The total effect on M1 of the two forms of transaction technology innovation considered is positive. The overall effect on M1 may have to be considered with caution due to the particular period examined, the cash changeover, and to a not clear support of theory due to the difficulty of finding an empirical counterpart of the theoretical aggregate "transaction money"; nevertheless, support for the positive effect on M1 could be provided, in a portfolio demand approach, where alternatives to M1 may be found in the larger aggregate M3. The payment innovations induce shifts in the composition of M1 away from cash towards demand deposits. The empirical evidence is consistent with the hypothesis that not accounting for transaction technology innovation may result in a serious omitted variables bias for traditional money demand elasticity estimates as well as in a poorer model fit when estimating money holdings.

The results provide insights into the effects of new payment technologies on the monetary aggregates of concern to central banks. Moreover the possible offsetting effects of the payment technology innovation on the currency and demand deposit components of narrow monetary aggregates are relevant to assess the velocity of money. The findings imply that estimating the trend of money velocity should take account of the diffusion of new payment technologies.

Consistently with money demand theory, the spread of transaction technology innovations has the anticipated effects on the currency and demand deposits components of M1. The total net effect on M1 is positive, with the negative effects of POS and ATMs terminals on currency more than offset by positive effects on demand deposits.

Further research on this topic may be relevant for the analysis of money demand in the euro area. First, the introduction of the euro likely affected the attractiveness of cash and reduced the need to hold several European currencies. Second, the ongoing process of financial innovation is likely to continue altering the empirical behavior of money demand not only in the euro area, but also elsewhere. Given the generally more advanced state of transactions technology in Europe and the heterogeneity of technology adoption within the single currency euro area, findings in Europe may provide insights on the impact of technology on money demand outside of Europe.

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Appendix

The data set comprises variables for 95[9] Italian provinces.

Automated tellers machines: number of ATMs; source, supervisory banking statistics data set collected by Bank of Italy.

Currency in circulation: cumulated net inflows of euro banknotes in the economy through the branches of Bank of Italy, daily frequency (working days); the source is a banknote statistics data set of Bank of Italy.

Demand deposits: source, supervisory banking statistics data set collected by Bank of Italy.

Gross domestic product: gross nominal value added per province: source Istat (National Institute of Statistics).

Interest rate on demand deposits: interest rate for demand deposits higher than 10,000 euro, the only one for which the data are available with provincial detail; source, Credit Register data set collected by Bank of Italy.

Interest rate on 3-month Treasury bill (BOT): source, monetary statistics collected by Bank of Italy.

Own rate of return of M1: it is equal to the sum of the rate of return of each of the two components of the aggregate M1, currency in circulation and demand deposits, times their relative weights over M1. It is therefore equal to interest rate on demand deposits times the share of demand deposits over M1, since the rate of return of currency may be assumed to be zero.

Points of sale: number of POS; source, supervisory banking statistics data set collected by Bank of Italy.

Prices: the index of prices used is the consumer price index source with base equal to 100 in 1995, elaborations on Istat data.

Wealth: Survey on Households Income and Wealth, Bank of Italy.

Footnotes

(1) The two components of the Italian aggregate M1, currency in circulation and demand deposits, in the period examined, averaged 15% and 85% of M1 respectively.
(2) See Mulligan and Sala-i-Martin (1992).
(3) The theoretical model of Paroush and Ruthenberg (1986) suggests that the introduction of ATMs increases the share of total money constituted by demand deposits at the expense of currency holdings, under the assumption that the cost of holding demand deposits is reduced with the introduction of ATMs. In a Baumol-Tobin framework, the lower cost arises from reducing the time, and hence the transaction cost, necessary of drawing on a demand deposit. Indeed, Paroush and Ruthenberg (1986) empirical findings are in line with the hypothesis that more ATMs lead to a higher level of demand deposit holdings and a lower level of currency holdings; see also Columba (2003).
(4) See European Central Bank (2001) and Attanasio et al. (2002).
(5) We used the distribution of currency across provinces detected in 2002 to extend the time-span of our circulation data applying the cross-section distribution to the national aggregate. We acknowledge of course that this is a rough proxy, but it is the best available for the robustness check of our main results.
(6) For an extensive survey of the payment literature see Hancock and Humphrey (1998).
(7) Fischer, Kohler and Seitz (2004) address the issue of measurement of the euros in circulation out of the euro area.
(8) In Italy demand deposits traditionally paid a positive interest rate.
(9) See note 4.
(10) See Signorini and Cannari (1999).
(11) See Columba (2008) on the transition to euro in Italy.
(12) The distribution of the branches of Bank of Italy, and hence data on currency, follow the province structure in place until 1996. For the other variables of the data set we aggregated the data of the new eight provinces constituted in 1996 with the data of the provinces of which were part before 1996.
(13) Income elasticity and POS coefficients become statistically insignificant.
(14) The ATM coefficient in the cross-section estimate becomes statistically insignificant.
(15) Results are available upon request.

Figure 1

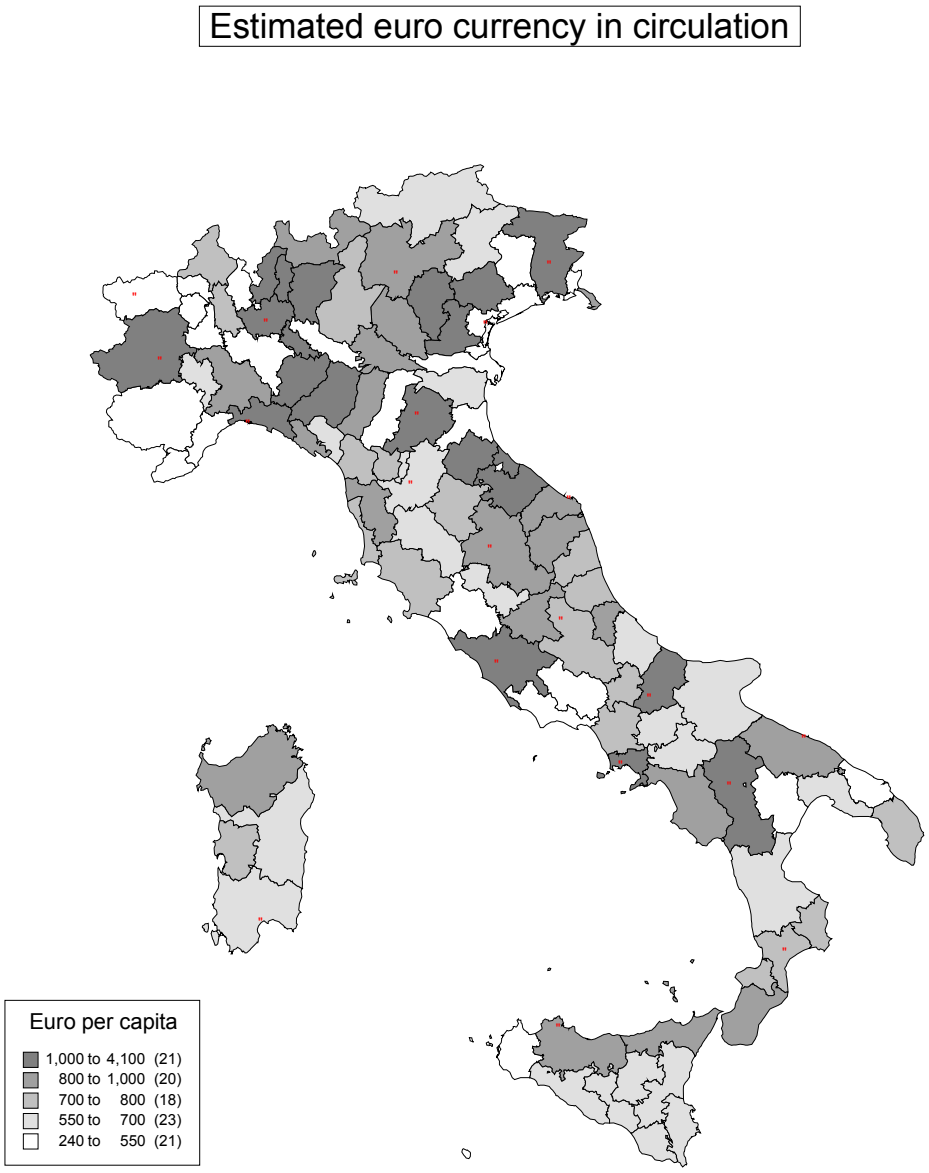
Estimated euro currency in circulation
Euro per capita
1,000 to 4,100 (21)
800 to 1,000 (20)
700 to 800 (18)
550 to 700 (23)
240 to 550 (21)

Table 1

Summary statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
Population	0,59	0,62	0,01	3,80
GDP	12,00	16,30	1,48	122,00
Currency	0,54	0,75	0,04	4,43
M1	5,30	11,10	0,33	87,30
ATM	362	419	38	3.060
POS	7.873	10.121	493	68.551
Prices	115,43	2,02	111,90	118,80
Interest rate on demand deposits	1,37	0,26	0,96	2,77

Sources: Bank of Italy, Institute of National Statistics (ISTAT).
Data refer to Italian provinces at the end of 2001. Population is expressed in millions, GDP, currency and M1 in billions euro. ATM and POS are absolute numbers. The interest rate on demand deposits is expressed as percentage. Prices are expressed in term of consumer price index with base 1995=100.

Table 2

OLS regressions of currency in circulation on GDP, interest rate on demand deposits, ATM, POS and non-resident held deposits.

Explicative variables	Equation 1	Equation 2	Equation 3	Equation 4	Equation 5
GDP	0,93 ***	1,27 ***	1,13 ***	1,30 ***	1,27 ***
	0,02	*0,08*	*0,06*	*0,08*	*0,08*
Interest rate on demand deposits	-0,05	-0,03	-0,01	-0,02	0,00
	0,07	*0,06*	*0,07*	*0,06*	*0,06*
ATM		-0,34 ***		-0,28 ***	-0,23 **
		0,23		*0,09*	*0,09*
POS			-0,20 ***	-0,10	-0,06
			0,06	*0,06*	*0,06*
non-resident held deposits					-0,03 **
					0,01
R^2 adjusted	0,94	0,94	0,94	0,95	0,95
Number of observations	95	95	95	95	95

Currency in circulation, GDP, ATM, POS, non-resident held deposits and financial wealth variables are in log form. Currency and GDP are deflated with consumer price index. Robust standard errors in italics. *** Significant at 1% level. ** Significant at 5% level. * Significant at 10% level.

Panel regressions with group fixed effects (95 provinces) of currency in circulation on GDP, interest rate on demand deposits, ATM, POS, non-resident held deposits and financial wealth.

Explicative variables	Equation 1	Equation 2	Equation 3	Equation 4	Equation 5	Equation 6
GDP	0,07 ***	0,07 ***	0,08 ***	0,07 ***	0,02 **	-0,04
	0,01	*0,01*	*0,17*	*0,01*	*0,01*	*0,00*
Interest rate on demand deposits	-0,02 ***	-0,03 ***	-0,03 ***	-0,03 ***	-0,03 ***	-0,03 ***
	0,00	*0,00*	*0,00*	*0,00*	*0,00*	*0,00*
ATM		-0,02 **		-0,02 *	0,02 *	0,03 ***
		0,01		*0,01*	*0,01*	*0,01*
POS			-0,01	0,00	-0,01	0,00
			0,00	*0,01*	*0,01*	*0,00*
non-resident held deposits					0,00	0,00
					0,00	*0,00*
financial wealth						0,00
						0,00
R^2	0,55	0,55	0,55	0,55	0,65	0,95
Number of observations	1.235	1.235	1.235	1.235	1.235	1.235

Currency in circulation, GDP, ATM, POS, non-resident held deposits and financial wealth variables are in log form. Currency and GDP are deflated with consumer price index. Robust standard errors in italics. *** Significant at 1% level. ** Significant at 5% level. * Significant at 10% level.

Table 4

OLS regressions of M1 on GDP, opportunity cost (i_{3m}-i_{orM1}), ATM and POS and non-resident deposits

Explicative variables	Equation 1	Equation 2	Equation 3	Equation 4	Equation 5
GDP	1,14 ***	0,87 ***	0,90 ***	0,81 ***	0,86 ***
	0,02	*0,07*	*0,05*	*0,07*	*0,06*
Opportunity cost (i_{3m}-i_{orM1})	-0,19 ***	-0,17 ***	-0,14 ***	-0,14 ***	-0,12 **
	0,06	*0,06*	*0,05*	*0,05*	*0,05*
ATM		0,27 ***		0,14 **	0,06
		0,07		*0,07*	*0,07*
POS			0,24 ***	0,18 ***	0,13 ***
			0,04	*0,05*	*0,05*
non-resident held deposits					0,05 ***
					0,01
R^2 adjusted	0,96	0,97	0,97	0,97	0,98
Breusch-Pagan chi^2 test					
Number of observations	95	95	95	95	95

M1, GDP, ATM, POS, non-resident held deposits and financial wealth variables are in log form. M1 and GDP are deflated with consumer price index. Robust standard errors in italics. *** Significant at 1% level. ** Significant at 5% level. * Significant at 10% level.

panel regressions with group fixed effects (95 provinces) of M1 on GDP, interest rate on demand deposits, ATM, POS, non-resident deposits and financial wealth.

Explicative variables	Equation 1	Equation 2	Equation 3	Equation 4	Equation 5	Equation 6
GDP	0,11 *** *0,01*	0,11 *** *0,01*	0,10 *** *0,09*	0,09 *** *0,01*	0,03 *** *0,01*	-0,07 *0,01*
Interest rate on demand deposits	-0,03 *** *0,00*	-0,03 *** *0,00*	-0,02 *** *0,00*	-0,02 *** *0,00*	-0,03 *** *0,00*	-0,04 *** *0,00*
ATM		0,02 ** *0,01*		-0,02 ** *0,01*	0,01 *0,01*	0,02 ** *0,02*
POS			0,02 *** *0,00*	0,03 *** *0,01*	0,03 *** *0,01*	0,02 *** *0,01*
non-resident held deposits					-0,01 *0,00*	0,00 *0,01*
financial wealth						0,01 *** *0,00*
R^2	0,53	0,53	0,54	0,54	0,60	0,90
Number of observations	1.235	1.235	1.235	1.235	1.235	1.235

M1, GDP, ATM, POS, non-resident held deposits and financial wealth variables are in log form. M1 and GDP are deflated with consumer price index. Robust standard errors in italics. *** Significant at 1% level. ** Significant at 5% level. * Significant at 10% level.