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THE DEMAND FOR MONEY, FINANCIAL INNOVATION, AND THE WELFARE COST OF INFLATION: AN ANALYSIS WITH HOUSEHOLDS' DATA

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ABSTRACT

How far can shoe-leather go in explaining the welfare cost of inflation? Using a unique set of microeconomic data on households, we estimate the parameters of the demand for money derived from the generalized Baumol-Tobin model. Our data set contains information on average holdings of cash, on deposits and other interest bearing accounts, on the number of trips to the bank, on the size of withdrawals and on the ownership and use of ATM cards. We model the adoption of new transaction technologies and use these estimates to correct for the selectivity bias induced by some households choosing to hold no interest bearing assets and some to use an ATM card. The interest rate and expenditureflow elasticities of the demand for cash are close to the tehoretical values implied by standard inventory models. However, we find significant differences between the individuals with an ATM card and those without. The estimates of the demand for cash allow us to calculate a measure of the welfare cost of inflation analogous to Bailey's triangle, but based on a rigorous microeconomic framework. The welfare cost of inflation varies considerably within the population, but never turns out to be very large (about 0.1 percent of consumption or less). Our results are robust to various changes in the specification. In addition tot eh main results based on the average stock of cash held, we provide some evidence based on the number of trips to the bank and on the average withdrawals that confirm our basic findings.

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1. Introduction

The generalized move towards lower inflation in both the United States and Europe has stimulated considerable interest in the welfare gains from price stability. Bailey (1956) first measured the welfare cost of inflation as the distortion in the allocation of real resources induced by positive nominal interest rates and the associated higher opportunity cost of holding money. His study shows that the welfare cost is equivalent to the area of the triangle beneath the money demand curve, and estimates such costs using evidence from hyperinflations. Lucas (1994) reviews general equilibrium models with money in the utility function and computes substantial welfare costs of inflation using parameter estimates from time series studies. Feldstein (1997) also finds substantial welfare gains from reducing inflation (a perpetual gain of 1 percent of GDP), but argues that most of the benefits arise from the interaction between inflation and tax rules. Thus, the magnitude of the welfare cost of inflation is still an unresolved question, especially at low levels of inflation.

Evaluating welfare costs requires estimates of the interest and transaction sensitivity of money demand. The theoretical framework behind most money demand functions is that of models of cash management in the tradition of Baumol (1952), Tobin (1956) and Miller and Orr (1963). Although these theories have long been available, very little is known about their empirical relevance, particularly at the level of households and firms. This is partly because the concept of cash balances or 'money' in the theoretical models of the Baumol-Tobin variety does not obviously correspond to any of the monetary aggregates, such as M1, that are used in time series studies, especially over periods of time when large components of the money stock become interest-bearing. This is one area in which aggregate time series are unlikely to be very informative, because the costs of cash management vary across different consumers and firms. For instance, if the heterogeneity in costs induces non-linearities, one cannot easily aggregate individual money demands.

Cost heterogeneity is most likely to arise when there are fixed costs in the adoption of interest-bearing financial instruments or when financial innovation brings new financial instruments and means of payment, which are themselves costly to adopt. If new instruments alter the costs involved in cash management they also affect the parameters of the demand for money and bias the parameters estimated with time series data. At the micro level, however,

there is virtually no evidence, partly because data sets containing information on cash holdings are few and far between. Even when available, they lack information on interest rates on assets alternative to money, preventing any estimate of one of the relevant parameters of the money demand, i.e. the interest rate elasticity. The empirical literature on money demand has therefore lagged behind that on consumption and investment, where empirical studies routinely address aggregation issues and use household or firm-level data extensively. Only very recently have some papers sought to estimate the elasticity of cash with respect to transaction variables using household or firm data sets (Mulligan and Sala-i-Martin, 1996; Mulligan, 1997); but none has provided definitive estimates of the interest rate elasticity. Yet, this parameter is crucial to assessing the welfare gains from low inflation.

In this paper we present evidence from a unique data set which contains direct information, at the household level, on cash holdings and cash management activities (such as the number and size of withdrawals), interest rates, various financial assets, the adoption and use of new technology, as well as consumption and income flows, income sources, demographic and occupational variables. In short, the data set we use appears tailor-made for estimating a sophisticated version of the Baumol-Tobin model of the demand for money.

Our empirical specification controls for corner solutions in the use of interest-bearing assets and for the adoption of new transaction technologies, such as that offered by ATM cards, on which we have detailed information. The richness of the data set and the variability observed across households and over the sample period allow us to identify the structural parameters of the demand for money and present methodologically sound estimates of the demand for cash and of the implied welfare cost of inflation.

The data is drawn from a household survey run by the Bank of Italy every two years. We use the surveys collected between 1989 and 1995 and merge them with two additional data sets on interest rates on checking and saving accounts and measures of financial innovation. Using Italy as a case study is of particular interest for a variety of reasons. The most important is that in Italy a large portion of (M1) money, including all checking accounts, is interest bearing. This implies that demand deposits, on which we have detailed information both in terms of amounts held and interest rates paid, represent the natural interest-bearing asset to be considered alternative to cash in models of the Baumol- Tobin variety. This institutional feature allows us to cut through a number of definitional issues that plague other

studies of money demand using either time-series or cross-sectional data. Second, nominal interest rates on deposits display a remarkable degree of regional and provincial variation that can be exploited to estimate the relevant elasticity of cash. In addition to the cross-sectional variability, during our period inflation (and nominal interest rates with it) declined significantly in Italy, from about 6 to 4 percent. Third, the payments system underwent considerable change and modernization, notably (and most significantly for our purposes) the diffusion of ATM cards, whose ownership tripled during the sample period. As we have information both on the holding of ATM cards and on the number of ATM points in the province of residence, we can explicitly model the process of adoption of the new technology and hence the effects of technological progress on the demand for money and on the welfare cost of inflation.

We obtain precise estimates of the parameters of the demand for money. We find an interest rate elasticity of between -0.3 (for non-ATM users) and -0.6 (for ATM users), and substantial economies of scale in cash management (a consumption elasticity well below unity). Our estimates are robust with respect to changes in the empirical specification and to the methodology used to correct for selectivity biases and potential endogeneity of the adoption of new transaction instruments. The welfare cost of inflation varies considerably within the population but is never very large (0.1 percent of consumption or less). The reason is that inflation carries low welfare costs in economies in which a large portion of the money stock is interest-bearing. We argue that our results extend to environments with many interest-bearing assets with different degrees of liquidity. We also find that the welfare loss of inflation is, ceteris paribus, considerably greater among households with a more sophisticated transaction technology, as the latter raises the interest sensitivity of the demand for money.

In Section 2 we present a theoretical framework that allows us to derive an empirically tractable demand for money nesting the most popular models of cash management. We place particular emphasis on the connection between the demand for money and the welfare cost of inflation in the presence of innovations transaction technology. We also argue that only the non-interest-bearing portion of money affects the welfare cost of inflation. The data on real money balances, deposit rates, spread of the ATM technology and other variables are set forth in Section 3. In Section 4 we present separate estimates for the demand for currency for ATM users and non-ATM users. Section 5 discusses the implications of the estimates for the

computation of the welfare cost of inflation. In Section 6 we exploit additional information available in the data set and find that the estimated equations for the size of withdrawals, the fraction of income received in cash, and the number of trips to the bank are all consistent with inventory models of money demand. Section 7 concludes.

2. Theoretical framework

In this section we provide a theoretical framework to help in modeling the demand for money while accounting for new transaction technology. We also illustrate the procedure for computing the welfare cost of inflation and survey previous literature. We conclude that if deposits are interest-bearing, the welfare cost of inflation is independent from the demand for deposits.

2.1. The model

Like McCallum and Goodfriend (1987), we assume that people need time to make transactions and that money is a way to save on transaction time. Real money holdings, m, transaction time, τ, and flow consumption (or income), c, are linked by the following transaction technology

$$\tau = Ac^{\gamma} L\left(\frac{c}{m}\right), \tag{1}$$

where A measures improvements in the technology, i.e. technical progress in the transaction industry; $L(\cdot)$ is a non-decreasing function and γ a parameter that allows departure from zero-degree homogeneity of money demand with respect to consumption and interest rates, as predicted, for example, by the Baumol-Tobin inventory models of the demand for money. One interpretation of (1) is that τ represents the time needed for trips to the bank, as in Baumol (1952), Tobin (1956) and Miller and Orr (1966). Following this interpretation, transaction time, τ, and the number of trips to the bank, n, are linked by the relation

$$\tau = k \cdot n \ , \tag{2}$$

where k is the average time per trip. In turn, k might be a function of time if technical progress reduces the time of a trip. The consumer optimization problem is to choose m in order to trade the time-cost of transactions off against the cost of holding money instead of an interest-bearing asset yielding a nominal return of R per period:

$$\begin{aligned} &\min \quad w\tau + Rm \\ &\text{s.t.} \ \ \tau = Ac^{\gamma} L\left(\frac{c}{m}\right) \ , \end{aligned} \tag{3}$$

where w, the time-cost of transactions, results from the shadow value of time and, possibly, from the fixed cost of withdrawing cash balances (a brokerage fee); and R is the nominal rate of interest.

Depending on the shape of $L(\cdot)$ and on the value of γ, problem (3) conveniently nests various models of the transaction demand for money. For example, if $L(\cdot)$ is linear and $\gamma = 0$, the optimization problem yields the Baumol-Tobin solution. If $\gamma = 0$ and $L(\cdot)$ is quadratic, the solution is the same as in Miller and Orr (1966). If $\gamma = 0$ and $L(c/m) = (c/m)^{\beta}$ one obtains various intermediate cases, all featuring the property that the consumption and the interest rate elasticity of the demand for money sum to zero. Finally, if $\gamma \neq 0$ the demand for money is not homogeneous of degree zero in consumption and in the interest rate.

Assuming $L(c/m) = (c/m)^{\beta}$, the optimization problem delivers a closed-form solution:

$$m = \left(\frac{wA\beta}{R}\right)^{\frac{1}{1+\beta}} c^{\frac{\beta+\gamma}{1+\beta}} \tag{4}$$

It is easy to verify that one obtains the Baumol-Tobin square root formula by setting $\gamma = 0$ and

$\beta=1$ and the Miller and Orr solution by setting $\gamma=0$ and $\beta=2$.[1] With our data it will be possible to test the restriction that the sum of the consumption and interest rate elasticities equals zero, as predicted by classical inventory models. Substituting (4) in (1) and the resulting expression in (2), one obtains the optimal number of transactions:[2]

$$n=\left(\frac{A}{k}\right)\left(\frac{wA\beta}{R}\right)^{\frac{-\beta}{1+\beta}} c^{\frac{\gamma+\beta}{1+\beta}} \tag{5}$$

While the consumption elasticity in the trip equation is the same as in the demand for money, the interest rate elasticity is positive and, except for the Baumol-Tobin case, different in absolute value.

2.2. *Financial innovation*

The decisions to hold an interest-bearing asset and an ATM card are discrete choices and therefore involve similar conceptual (and econometric) issues. But there is one important difference. The adoption of a new technology such as an ATM card, while it can affect the parameters of the demand for cash, does not change the qualitative nature of that demand. For individuals who do not hold interest-bearing assets at positive interest rates, however, there is no immediate opportunity cost of holding cash. This is why in Section 4 we will estimate the demand for cash only for households that hold the relevant alternative assets, correcting for selection bias. At the same time, we allow the parameters of our model to differ across regimes according to ATM ownership.

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[1] Lucas (1994) shows that the estimates of the welfare costs of inflation at low levels of the interest rate are sensitive to the shape of the demand for money. He argues that a log-log specification fits the US aggregate data better than a log-level specification. The specification of the transaction technology used in the text leads to a log-log demand for money. However, one can test for this functional form and/or allow for functional forms that have the property that as the nominal rate of interest goes to zero so does the interest elasticity. Mulligan and Xala-i-Martin (1996) suggest $L(c/m)=L(z)=H(z-\bar{z})^2/z$ for $z\geq\bar{z}$ and H constant, which has the property that the interest rate elasticity goes to zero as R approaches zero. As will be seen, in our case welfare costs are small, and would not change much allowing for a small interest rate elasticity at low levels of interest rates.

[2] This result is obtained ignoring that n can only takes integer values and may not generalize to the case in which n is restricted to be an integer.

One advantage of the McCallum-Goodfriend framework is its easy generalizability to take into account innovations in the transaction technology and the fact that many consumers do not hold interest-bearing assets. If ownership of such assets and adoption of new payment technologies are endogenous (perhaps because of transaction and/or adoption costs), they should be properly modeled to obtain consistent estimates of the demand for cash. One approach is to compare the costs and the benefits of ownership of interest bearing-assets and adoption of the new technology. The consumer will choose to open a checking account if the benefits (less interest foregone) exceed its adoption costs. These issues have been discussed recently by Mulligan and Sala-i-Martin (1996). Conditional on holding a checking account, similar considerations apply to the adoption of new technologies, such as ATM cards.[3]

As the conceptual issues are similar, here we focus only on the slightly more complex problem of adopting a new technology and on how money demand is modified by the possibility of ATM withdrawals (the alternative to withdrawing cash at the bank's counter). Equation (1) contains an exogenous technical progress term, A, which may be a function of time. But technical progress in the transaction technology also occurs because consumers choose to adopt new time-saving ways to make withdrawals.

Let B denote an indicator variable that equals 1 if the consumer has an ATM card, 0 if not. To take the different technology available to each consumer into account, one can specify technical progress in equation (1) as

$$A = (1 - \delta B) A_0; \quad \text{with} \quad A_0 = De^{-gt}$$

where $0<\delta<1$ measures the proportional gain in units of time from adopting the technology (B=1), D is a constant and g the growth rate of exogenous technical progress in the transaction industry. This specification of technical progress implies that adopting the card shifts only the intercept of the money demand function, leaving the parameters β and γ unchanged. Here we focus on this case, but in the empirical specification we generalize by allowing all the

[3] Some banks do not provide ATM cards, others do but charge a fixed annual fee and, possibly, a fee for each transaction. Finally, other banks provide them free of charge. It is likely that different consumers will have different incentives to search for a bank that provides an ATM card, so that access to this type of technology is effectively endogenous.

parameters of the demand for money to change between ATM users and non-users.

If adoption has a cost, a consumer will switch to the ATM only if the benefit exceeds that cost. Let the cost of adoption $Z(x)$ depend on a vector x of consumer characteristics and on other variables affecting the adoption decision, such as the availability of the ATM technology and the share of consumers that have already adopted it(as a measure of network externalities). The benefit from adoption is then the sum of two terms: the increase in consumption that the consumer enjoys because less time is spent transacting, and the reduction in forgone interest thanks to lesser need for money balances for transaction purposes. That is:

$$Benefit = w(\tau_{m|B=0} - \tau_{m|B=1}) + R(m_{|B=0} - m_{|B=1}),$$

where $m_{|B=i}$ and $\tau_{m|B=i}$ denote, respectively, optimal money balances and transaction time conditional on $B = i$ ($i = 0, 1$). Using (1) and (4), benefits equal to

$$w(1-(1-\delta)^{\frac{-\beta}{1+\beta}})A_0^{\frac{-\beta}{1+\beta}}\left(\frac{w\beta}{R}\right)^{\frac{-\beta}{1+\beta}}c^{\frac{\gamma+\beta}{1+\beta}} + R\left(1-(1-\delta)^{\frac{1}{1+\beta}}\right)A_0^{\frac{1}{1+\beta}}\left(\frac{w\beta}{R}\right)^{\frac{1}{1+\beta}}c^{\frac{\gamma+\beta}{1+\beta}}$$

Adoption of the new transaction technology will thus take place if

$$w(1-(1-\delta)^{\frac{-\beta}{1+\beta}})A_0^{\frac{-\beta}{1+\beta}}\left(\frac{w\beta}{R}\right)^{\frac{-\beta}{1+\beta}}c^{\frac{\gamma+\beta}{1+\beta}} + R\left(1-(1-\delta)^{\frac{1}{1+\beta}}\right)A_0^{\frac{1}{1+\beta}}\left(\frac{w\beta}{R}\right)^{\frac{1}{1+\beta}}c^{\frac{\gamma+\beta}{1+\beta}}$$
$$\geq Z(x) \qquad (6)$$

Not surprisingly, the decision to adopt depends on the value of time, w, and on the interest rate, R: an increase in either makes adoption more likely. Furthermore, since all variables affecting the demand for money also affect the benefit from adoption, they all affect the decision in (6). In particular, an increase in the volume of transactions, c, raises both money holdings and the time spent transacting thus increasing the benefit from adopting a superior technology. Finally, the decision to adopt the new technology depends on the vector

of variables that affect the cost of adoption, x. This second group of variables is crucial for identification, as discussed further in Section 4.1.

Once it is recognized that B is endogenous, it is clear that the interest rate affects optimal cash holdings both through the traditional channel and through the adoption decision. Thus ignoring the endogeneity of alternative moneys, especially in periods of financial innovation, can lead to biased estimates of the interest rate elasticity and of the welfare costs of inflation.

Technical progress affects also the optimal number of trips. Equation (5) indicates that people who have adopted the ATM card, for instance, will make more trips than those who have not as their technology requires less time per transaction, hence allowing more withdrawals and economizing on cash holdings. However, equation (5) also shows that, other things being equal, technical progress (the term A) will reduce the number of trips.

In the empirical application we are mainly interested in estimating the demand for money controlling for selection bias in the adoption of an interest-bearing asset and in the adoption of the new technology. For this purpose there is no need to use equation (6) explicitly. The two decisions can be modeled as probit models affected by the relevant variables, where the two probits should be interpreted as reduced forms derived from an equation like (6).

2.3. *The welfare cost of inflation*

One of the purposes of this paper is to estimate the welfare cost of inflation and to see how it varies with innovation in the transaction technology. Here we discuss how the theoretical framework sketched out above can be used to obtain alternative measures of the welfare cost of inflation, all of which lead, in principle, to the same result.

Following Bailey (1956), the welfare cost of inflation corresponding to any given nominal interest rate R, $W(R)$, can be measured as the area under the (inverse) money demand function in the interval $m(R)$ - $m(0)$. This measure of the welfare cost implicitly assumes that the socially optimal cash balances $m(0)$ are those of an economy in which monetary policy induces a steady deflation at the Friedman optimal rate, so that $R = 0$. Using (4), the welfare cost is given by

$$W_m(R) = \int_0^R m(R) - Rm(R) = (wA\beta)^{\frac{1}{1+\beta}} \beta^{-1} c^{\frac{\gamma+\beta}{1+\beta}} R^{\frac{\beta}{1+\beta}} \tag{7}$$

The first term in equation (7), $(wA\beta)^{\frac{1}{1+\beta}}$, is the (exp) of the constant term in a log-log estimate of money demand; $\beta/(1+\beta)$ and $(\gamma+\beta)/(1+\beta)$ are, respectively, the interest rate and consumption elasticity. Thus, having estimated the parameters of the money demand, one can readily compute (7) and obtain an estimate of the welfare cost of inflation. Note that this equation truly measures welfare costs only if one assumes that the government can finance its expenditures by non-distorting taxes (Fisher, 1981).

Alternatively, the welfare cost of inflation can be defined as the value of the time spent transacting when the nominal interest rate exceeds that corresponding to the Friedman optimal deflation rate, so that money balances fall below their optimal level. From equation (1), and noting that $[c/m(0)]^{\beta} = 0$ so that $\tau(0) = 0$, the value of the time spent in transactions is given by:

$$W_\tau(R) = w\left[\tau(R) - \tau(0)\right] = w\tau(R) = wAc^{\gamma}\left(\frac{c}{m(R)}\right)^{\beta} = (wA\beta)^{\frac{1}{1+\beta}} \beta^{-1} c^{\frac{\gamma+\beta}{1+\beta}} R^{\frac{\beta}{1+\beta}} \tag{8}$$

where the last equality is obtained by substituting in the optimal money balances from equation (4). If one could observe τ and w, computing the welfare cost associated with the current interest rate would not require knowledge of the parameters of the money demand function.

Finally, one could define the welfare cost in terms of the cost of the extra trips to the bank entailed by a rate of inflation higher than the social optimum, or $W_n(R) = w \cdot k \cdot \left[n(R) - n(0)\right]$. Noting that $n(0) = 0$ one immediately obtains an expression for the welfare cost similar to (7) or (8). Obviously, $W_m(R) = W_\tau(R) = W_n(R)$.

Expression (7) is the welfare cost of inflation for an individual with a deposit account and access to a given technology, provided that the changes in the interest rate do not induce a

change in discrete choices. In order to allow for the possibility that some households choose not to hold interest-bearing assets and that, among those who do, some have access to different payment technologies, one must take into account the effects of interest rate changes on the asset ownership and on the selection of the technology.

The overall welfare cost is thus a weighted average of the welfare costs of the households with and without ATMs, the weights given by the proportion having a card. In turn, the welfare cost must be multiplied by the proportion of households having a bank account:

$$Welfare\ cost = F(\bar{R})[L(\bar{R})W(\bar{R})_{ATM=1} + (1 - L(\bar{R}))W(\bar{R})_{ATM=0}] \qquad (9)$$

where $F(\bar{R})$ is the probability of owning a deposit evaluated at the interest rate $\bar{R}$, and $L(\bar{R})$ the probability of having an ATM card evaluated at $\bar{R}$. Equation (9) highlights the fact that the interest rate has three effects on the welfare cost of inflation: two indirect effects, because changing the interest rate changes the fraction of people who have a bank account and the fraction using ATMs through the $F(.)$ and $L(.)$ functions; and a direct effect, because changing the interest rate changes the demand for money (differently in the two regimes).

To study the effects of changes in the interest rate on money demand and on the welfare cost one has to take into account the indirect effects, which in principle can be important, since $F(\bar{R})$ and $L(\bar{R})$ may be powerfully affected by interest rate changes. This will be taken up in Section 4.

2.4. The definition of money and the welfare cost of inflation with interest-bearing moneys

As checking and saving accounts in Italy are interest-bearing, our definition of "money" includes only cash. However, it should be recognized that the interest on checking and saving accounts (at banks or at the post office) is lower than on Treasury Bills. On the other hand, saving and especially checking accounts are certainly more liquid than T-Bills.

The McCallum-Goodfriend framework can be extended to take the presence of different assets and different types of moneys offering different liquidity services into account. Let us assume that the liquidity technology depends not only on the ratio of the consumption flow to cash but also on the ratio of the consumption flow to the total of deposit and cash:

$$\tau = A_1 c^{\gamma_1}\left(\frac{c}{m}\right)^{\beta_1} + A_2 c^{\gamma_2}\left(\frac{c}{m+d}\right)^{\beta_2} \tag{10}$$

where m and d denote currency and deposits, respectively. The specification in equation (10) captures the idea that cash and deposits are not perfect substitute (which would be the case if A_1 was equal to zero. Its main drawbacks are that the same measure of consumption enters the two components and that these are additive. The only justification we have is in terms of the empirical specification. We only have very aggregated information on consumption. Furthermore this form of additivity is the only way to avoid having two separate (and highly collinear) interest rates in the demands for cash.

Given the specification in equation (10), the maximization problem (3) becomes that of minimizing the following equation:

$$\min w\left[A_1 c^{\gamma_1}\left(\frac{c}{m}\right)^{\beta_1} + A_2 c^{\gamma_2}\left(\frac{c}{m+d}\right)^{\beta_2}\right] + R^b m + (R^b - R)d \tag{11}$$

where R and R^b indicate, respectively, the interest rate on interest-bearing money (deposits), and the interest rate on assets alternative to money (say, short-term government bonds). It is immediate to check that the equations for optimal currency and for the total of deposit and currency are:

$$m = \left(\frac{wA_1\beta_1}{R}\right)^{\frac{1}{1+\beta_1}} c^{\frac{\gamma_1+\beta_1}{1+\beta_1}} \tag{12}$$

$$d+m=\left(\frac{wA_2\beta_2}{R^b-R}\right)^{\frac{1}{1+\beta_2}} c^{\frac{\gamma_2+\beta_2}{1+\beta_2}} \tag{13}$$

Note that the demand for cash (12) is identical to that derived in Section 2 (see equation (4)). The demand for the sum of deposits and currency (13), however, depends only on the spread between the nominal interest rate on bonds and the nominal interest rate on deposits. An implication of this equation is that if inflation changes both nominal interest rates by the same amount, the demand for currency falls and that of deposits increases by the same amount, so as to leave their sum unchanged.

In principle, the evaluation of the welfare cost of inflation should take into account the distortions involved in the management of cash as well as of deposits. In the absence of frictions and non-neutralities it is reasonable to assume that a change in the rate of inflation is reflected into a proportional change in the nominal interest rate (which enters equation 12). However, the interest rate differential (R^b-R) depends on technology parameters as well as on the competitive structure of the banking sector and it is not clear how it will be affected by a change in the rate of inflation.[4] If one assumes that (R^b-R) is independent from inflation, from the computation of the welfare cost of inflation it is sufficient to consider only equation (12) and the effect of changes in the nominal interest rate on the demand for currency.

3. Data description

The main aim of this paper is to estimate the model illustrated in Section 2 with household level data. This requires information on cash balances, consumption, the opportunity cost of holding money, as well as information on the use of financial technology (such as ATM cards) and its determinants.

Because of the special institutional features of its payment system, estimating the demand for money in Italy has several advantages. Checking accounts are interest-bearing assets, so that the nominal interest rate on deposits provides a proper measure of the

[4] Marimon, Nicolini and Teles (1997) present a general equilibrium model with multiple means of payments and show that the equilibrium interest rate differential depends on the cost of providing "electronic money" and on the market structure of the financial sector.

opportunity cost of holding cash. Given the limited development of the Italian financial system, its transaction and information costs, and the fact that deposits pay interest, for the vast majority of the sample checking or saving accounts effectively represent the relevant alternative to cash. Almost everybody in the sample reports cash balances and about 85 percent hold either a checking or a saving account in all survey years. The fraction of households holding assets other than cash or deposits ranges between a fourth and a third, depending on survey year. Furthermore, a negligible fraction of those without a checking or saving account report having some other interest-bearing asset. Thus, it is reasonable to assume, as we do, that deposits are the effective interest-bearing alternative to cash.

To estimate the interest elasticity of the demand for currency we need a sample with enough variability in the opportunity cost of holding cash. For such purpose we use surveys from several different years. We also document below that due to the characteristics of the Italian financial intermediaries, the nominal interest rate on deposits presents substantial geographical variation across regions.[5]

3.1. Data sources

In what follows we use three data sets. Detailed information on cash balances and other characteristics of the payment system are available in the 1989-1995 Survey of Household Income and Wealth (SHIW), a collection of four large cross-sections of Italian households (1989, 1991, 1993, and the newly available 1995). Each cross-section is representative of the Italian population. The survey provides a truly unique set of data to estimate the demand for cash. Households supply information on consumption, financial wealth and several variables describing their cash management: average cash balances, ATM and credit card use, average size of withdrawals (separately at ATMs and bank counters), amount of bank or postal deposits, average number of trips to the bank (distinctly for withdraws at ATMs or at bank counters), minimum amount of cash balances before making a

[5] The main reason why deposit rates vary in the cross-section is the geographical variability of the cost of intermediating funds and of the degree of competition between banks in local markets. We take these characteristics as given, and do not try to model the behavior of the banking system in this paper. For the empirical estimates this implies, for instance, that people do not change there place of residence in order to reduce the cost of trips to the bank or to economize on cash balances.

withdrawal, fraction of income received in cash. The Appendix reports variables' definitions, the main features of the survey, and averages and standard deviations of the variables used in estimation.

Data on nominal interest rates on deposits is drawn from the Monetary Statistics collected by the Bank of Italy. which include the average interest rate on checking and saving accounts on a quarterly basis, aggregated by province (there are 95 provinces in Italy). We can thus impute to each household in the sample an interest rate that varies by year and province. The third data set, also collected by Bank of Italy, gives the number of ATM points, again available in each sample by province. As is discussed below, this is one of our instruments in estimating the decision to switch to a more sophisticated transaction technology and identifying the demand for cash balances.

3.2. Descriptive analysis

Table 1 reports sample means of consumption, cash balances, deposits, financial wealth and several other variables related to cash management from 1989 to 1995. All variables are deflated by the Consumer Price Index and expressed in 1995 thousand lire. The exchange rate between the lira and the dollar is currently around 1,800.

Average non-durable-consumption falls from 33 million lire in 1989 to 30 million in 1995, an average decline of 1.5 percent per year. This decline is only partly corroborated by national accounts data, which show a substantial drop during the 1993 recession but a gradual recovery since then.

The table also indicates that while in 1989 average deposits represent almost half of average financial wealth, in subsequent years this fraction declines to about one third. About 85 percent of households have a checking account. There is some evidence that the 1989 survey samples, on average, richer households. The exclusion of this first year of data, however, does not affect our results.

The increased use of ATM cards was the crucial innovation in cash management during our sample period. In 1989 the fraction of ATM users was only 15 percent (Table 1). By 1995 that fraction had risen to 40 percent. Even so, the fact the majority of households still did not have access to ATMs is a confirmation of the comparative backwardness of the Italian

payment and banking system. Figure 1 reports the frequency of ATM users by year and province. The Northern provinces are coded with numbers going from 1 to 40; the Central provinces have codes from 41 to 60, and the Southern provinces have codes over 60. Geographical differences are quite persistent. While in the North the use of ATMs is relatively widespread even in the earlier part of the period, the financial sophistication of the South lags considerably behind even in recent years. It is the time-series and cross-sectional variability in the diffusion of technology that allows us to estimate the adoption decision as well as the effect of financial innovation on money demand.

The decision to use an ATM is likely to depend not only on demographic characteristics, transaction variables and the opportunity cost of using cash but also on the use made by other people, and ultimately on the availability of ATM points in each location. Table 2 indicates that there has been a substantial increase in ATMs between 1989 and 1995, (from 100 to 280 per million). Figure 2 signals that installation of ATMs has proceeded at a much quicker pace in the Northern regions.

In the empirical estimates we do not take into account the possibility that ownership or use of credit cards may affect the transaction technology available to households. As of 1995 credit cards were held by less than 15 percent of the population, and this fraction has not exhibited strong trend during the sample period. Although certainly important for other countries, we ignore the effect of credit cards. In the context of the Italian economy, the increased use of ATM cards between 1989 and 1995 is a much more important development in cash management.

An important feature of the data is the high level of average cash balances "usually held at home" (over 1 million lire in 1989, or about $650 at the current exchange rate between the lira and the dollar).[6] In real terms, currency declines until 1993 to 0.6 million lire (about $385), and then rebounds slightly in 1995. On average, the decline of cash balances is 7 percent per year. The fall in consumption can only explain a small portion of the reduction in cash balances. In fact, the ratio of the two falls considerably, from almost 4 percent in 1989 to 2.8 in 1995. Other factors must therefore be at work in explaining the shrinking cash balances. The amount of cash as a percentage of non-durable consumption is considerably higher for

[6] Humphrey et al. (1997) show that by international standards Italy has a high cash-income ratio.

households with no bank account and, among those with a bank account, for those who do not hold an ATM card. Over time, the pattern of this variable is similar across different groups.

In addition to cash balances, the survey contains information on the amount of cash that triggers a withdrawal. Starting in 1991 the survey also contains information on amounts withdrawn (both at a bank counter and, for those who hold a card, at an ATM point) and the annual number of trips to banks and to ATMs.

On average, minimum cash balances before withdrawals (at banks or ATMs) is about constant between 1989 and 1993 and declines in 1995. The variable is slightly higher for households with no ATM card. Strictly speaking, a positive level of cash before withdrawing contradicts traditional inventory models of cash management of the Baumol-Tobin type that implicitely assume that a withdrawal occurs when the cash balance hits zero. However, uncertainty in the flow of expenditures and high transaction costs at very low levels of cash can justify a positive level for the "minimum cash" variable.[7] These issues are discussed again in section 4.3.

The average withdrawal at bank counters increases considerably between 1991 and 1993 and declines slightly in 1995. Withdrawals at ATMs are substantially smaller, a reflection of the fact that this transaction technology is cheaper and (perhaps) of daily limits on withdraws at ATMs. The total number of trips to banks or ATM is between 26 and 30 (between 2 and 3 trips per month). However, this average hides different patterns: trips to banks fall, while the number of withdrawals at ATMs increase.

Data on withdrawals, deposits, average and minimum cash balances, number of withdrawals, and consumption flows allow one to check informally if information on these variables is roughly consistent in the data. To perform this exercise, one needs of course to make some assumptions. According to standard inventory models of cash management, two quantities should roughly match the average stock of cash. The first is the sum of cash before withdrawals and cash held for transaction purposes:

$$S_L = \frac{c}{2n} + \min cash \quad , \tag{14}$$

[7] This would be the case, for instance, if banks are closed during some times of the day or some days of the week, if ATM cards are subject to daily limits or if there is some probability that the ATM machines don't work.

where c, n, and min *cash* are consumption, number of trips and the minimum cash balances. The second quantity is the sum of the ratios of withdrawals to trips, plus minimum cash balances:

$$S_2 = \frac{W_a}{2n_a} + \frac{W_b}{2n_b} - \frac{D_b}{2n_d} + \min cash, \tag{15}$$

where W_a, W_b, and D_b, are withdrawals at ATMs, withdrawals at tellers, and average amount of deposits; n_a, n_b, and n_d denote the corresponding average number of withdrawals and deposits.

In the sample the medians of S_1 and S_2 are 868 and 550 thousand lire, respectively. These should be compared with 675 thousand lire, the median of reported cash balances. Equation (14) converts consumption flow in cash balances. However, not all purchases are made with cash. In 1993 and 1995 we have data on the fraction of total expenses paid with cash. Since this fraction is about 70 percent of non-durable consumption, we adjust S_1 by multiplying consumption in equation (14) by 0.7. In this case we obtain a median for the adjusted S_1 that is almost the same as the median of cash balances. We conclude from these experiments that the variables in our data set are remarkably consistent with each other and with standard inventory models of money demand.[8]

The last row of Table 1 reports that, on average, almost 50 percent of income is received in cash. This high fraction indicates, alone, how important cash still is in the Italian payment system. However, the average tells only part of the story. The fraction is very high for some population groups, such as pension recipients (pensions are typically paid in cash) or households headed by self-employed individuals (for instance, shopkeepers'income is typically in the form of cash). There are also substantial geographical differences. In Figure 3 we plot, for each of the four surveys, the average fraction in each province against the province code. The higher level of this variable in the South is likely to reflect the higher fraction of pension recipients and self-employed, and the importance of the underground economy.

[8] Recall that our definition of consumption does not include durable goods. To the extent that part of durable

Table 2 reports summary statistics on the pattern of nominal interest rates and other bank characteristics in Italy over the sample period. Nominal after-tax interest rates on deposits are imputed to each household, as explained above.[9] Although in Italy nominal interest rates on checking and saving accounts are rather sticky, partly reflecting imperfect competition in the banking sector, they do vary considerably across years, provinces and deposits size (being substantially larger for larger deposits). The table shows that nominal interest rates declined from 4.6 percent in 1989 to 3.5 in 1995, or 1.1 points. In any given year, the standard deviation of the interest rate is between 0.3 and 0.4, or about 10 percent of the mean. The average reduction in after-tax nominal interest rates on deposits almost matches the reduction in after-tax nominal interest rates on short-term government bonds (1.08 against 1.27). This implies that the spread between the two interest stays roughly does not vary much over time, lending support to our procedure of computing the welfare cost of inflation (see section 2.4 above).

Figure 4 reports the cross-sectional distribution of the nominal interest rate from 1989 to 1995.[10] The most interesting feature of Figure 4 is that from 1989 to 1993 interest rates are substantially lower in the South, whereas in 1995 interest rates are more equal across provinces, although in the South remain lower than in the rest of the country.

As mentioned, interest rates vary over time and with province and class of deposit. This last source of variability could possibly be endogenous and correlated with unobservable components of the demand for cash. To avoid this problem, we estimate the model taking averages across different deposit size classes, and therefore using only the time and geographical variability. Factoring in the variability of interest rates across classes of deposit alters the results only slightly different. [11]

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consumption is paid with cash, S_t underestimates cash balances.

[9] During the sample period nominal interest rates on deposits are subject to a 30 percent flat rate with-holding tax which is therefore netted out to obtain after-tax measures.

[10] It should be kept in mind that interest rates vary also by deposit amounts. Thus in Figure 4 each point in the graphs represents the average interest rate in each province over all deposits.

[11] Since there are 95 provinces, 4 years and 4 classes of deposits, we have potentially 1,520 different interest rates in the sample. Given that in some years households from some provinces are not interviewed and that the highest class of deposits are seldom observed in the data set, we have 893 interest rate values. Excluding the variability of interest rates across deposit size, we have 380 interest rate values.

4. The Demand for Money

The data set described above is well suited to estimate an empirically tractable version of the model of money demand discussed in Section 2. In order to estimate the parameters of the demand for money, bank account possession and acquisition of an ATM card, we pool the four cross-sections. This allows us to exploit both the cross-sectional and the time series variability in the interest rate and in the other variables.

The simplest specification of the demand for cash can be obtained by log-linearizing equation (4) in Section 2.1. Assuming that the terms wA can be represented only by a function of time, one can regress the log of average cash balances on that of non-durable consumption,[12] the log of the interest rate[13] and a time trend:

$$\ln m = \underset{(0.177)}{1.000} - \underset{(0.008)}{0.172}\, t + \underset{(0.001)}{0.008}\, t^2 - \underset{(0.047)}{0.709}\, \ln R + \underset{(0.008)}{0.368}\, \ln c, \qquad (16)$$

where standard errors are reported in parenthesis. The estimated consumption and interest rate elasticities are not too far from the values implied by Tobin's model, though the assumption that they are equal to ½ is strongly rejected. These parameters correspond to a value of β of 0.410 and a value of γ of 0.109. According to equation (7), the welfare cost of a 5% nominal interest rate varies from 106,000 lire in 1989 (about $62) to 54,000 lire in 1995 ($32), or from 0.3% to 0.2% of annual non-durable consumption.[14]

This simple regression ignores several important problems. First, as is stressed by Mulligan and Sala-i-Martin (1996), equation (4) is the relevant equation of the demand for cash only for households that have interesting-bearing deposits. In commenting Table 1 we pointed out that about 15 percent of households do not hold any such deposit. Estimation of

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[12] There are several justifications for using consumption as the measure of transactions. Models with cash-in-advance constraints suggest that the demand for money depends on planned consumption, not income. Other theoretical models suggest that the demand for money depends on permanent income, and consumption is certainly a better proxy for permanent income than current income. Portfolio models stress instead that money depends on assets, not flow consumption, although this might apply to deposits, more than to cash.

[13] As noted, about 15 percent of the households in the sample do not hold a checking account. To estimate equation (16) in the text, we impute to households with no checking account the average interest rate in each province.

[14] If one allows transaction costs to depend on various observed characteristics, such as education, family and earners composition, the welfare cost is slightly reduced.

the demand for money must tackle this classic selection problem. Second, transaction costs and even the parameters of the transaction technology may differ between households with and without access to ATMs. Given the increased use of ATMs over time, it is therefore important to control for this factor while recognizing that, in all likelihood, card-holding is an endogenous decision. Finally, the time cost of transactions is likely to differ across individuals according to education, employment and demographic variables. Before presenting our estimates, we address the econometric problems and our identification strategy.

4.1. Econometric and identification issues

An endogenous switching regression framework with a selectivity correction can address the two problems mentioned above. We first correct for the selection bias introduced by the fact that not all households hold a bank account, and then estimate a switching regression model with an additional selection correction for the decision to take an ATM card. This is equivalent to first estimating a probit model for the decision to hold a bank account. The probit estimates can be used to compute the Mills Ratio to be used in the demand for cash equation. *Conditional on having a bank account*, we then estimate an additional probit for ATM card-holding and compute two additional Mills Ratios, one for the households with an ATM card and one for those without.[15] Finally, using the sample of households with a bank account, we can estimate two demand-for-cash equations: one for ATM households and one for the non-ATM households. Each of these equations will include the Mills Ratio from the bank account probit and the relevant Mills Ratio for the ATM probit.

If one does not want to rely on the non-linearity of the Mills Ratio alone to reach identification, the latter requires that some variables affecting the decision to have a bank account and the decision to have an ATM card not directly affect the demand for cash. While two variables are sufficient for identification, we use several (their selection is discussed in

[15] To correct for the selectivity problem in the money demand equation for households with an ATM one must compute the expected value of the residuals, conditional on the household having a bank account and an ATM card. A similar computation must be performed for the demand for cash of households without an ATM card. The computation of these expectations conditional on the two events can be simplified by estimating the unconditional probability of having a bank account and the probability of having an ATM card conditional on having a bank account. This is why we estimate the probit for the ATM choice only on the households with a bank account.

the next subsection). In addition to the identifying variables, as suggested by the discussion in Section 2.2, we introduce in the probit regressions all variables that affect the demand for cash, such as the flow of consumption, the interest rate, the time trend and variables proxying for the different cost of transaction time for different individuals.

4.2. The demand for cash

Table 3 gives our main results. The first two columns report the estimates of the probit models for the decision to have a bank account and the decision to have an ATM card, conditional on having a bank account. The last two columns contain the coefficients of the demand for cash for households with and without an ATM card.

As discussed above, all variables that enter the demand for cash are also likely to determine the choice of using a transaction technology. Furthermore, identification of the money demand equation requires that some variables that affect the choices of having a bank account and an ATM card do not affect the average stock of currency. Ideal candidates for this type of variables are fixed costs associated with these discrete choices. Unfortunately, a direct measure of these costs is problematic. We rely, instead, on variables that are likely to be related to such costs. In particular, we consider the number of ATM points in the area of residence at the end of the past year. If there are network externalities, the cost of adoption declines with the fraction of the population that has already adopted the technology and, especially, with the availability of ATM points in the area of residence. In particular, we expect that network externalities increase the probability of becoming ATM card-holder. We discuss this variable further below.

We also consider dummies for the area of residence (city center, semi-central, outskirts),[16] which are meant to capture the notion that households living in rural areas face different costs and benefits of opening and operating a bank account or holding an ATM card. Finally, total financial wealth is a variable that, according to our model, should not affect the demand for cash (once we condition on consumption), but is likely to affect portfolio choice

[16] The connotation of residence areas in Italy (and more generally in Europe) is different from North America. Often what we define as 'outskirts' are equivalent in terms of social status to the American inner cities. Vice-versa, the "city center" is often the most exclusive residential area.

and the fixed cost incurred when operating a new transaction technology.

Table (3) indicates that the nominal interest rate and consumption coefficients are positive in both probit equations, consistent with the model of Section 2. The consumption coefficient is precisely estimated in both equations, while the interest rate coefficient is small and not significantly different from zero in the equation for the decision to use an ATM. The education dummies indicate that consumers with higher education are more likely to own a bank account and to use an ATM card. Finally, all variables that identify the model (number of ATM points, area of residence and financial wealth) are generally significantly different from zero and with the expected signs. [17]

There are two objections that can be raised against the use of the number of ATM points as an identifying instrument: a) that it can be endogenous if the installation of ATM points is demand driven; b) that it also affects the demand for cash directly, perhaps because it reduces precautionary holdings at least among card-holders. To address the first problem, we replace the number of ATMs in the first stage with two indicators of the structure of the banking sector, the share of deposits held by the 5 largest banks in the province and the share of deposits in the province held by cooperative banks. Both correlate with the introduction of ATMs and are significant in the probits.[18] The results of the second stage regressions are substantially unaffected.

Regarding the second objection, it should be stressed that it is unlikely to be relevant for the individuals not holding an ATM card. Furthermore, as the model is still formally identified, we have tried adding the number of ATMs to the second stage regressions of the demand for cash, obtaining an insignificant coefficient. Finally, the use of the industry structure variables discussed above as an alternative to the number of ATM also addresses this problem.

Columns (3) and (4) of Table 3 report the estimates of the endogenous switching

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[17] Several other demographic variables, such as famnili composition variables, occupation dummies and so on, are also significant and with the expected signs. The interpretation of these coefficients, however, is not always obvious.

[18] We find that banking concentration discourages adoption of both deposits and ATM cards, consistent with the idea that market power (as measured by market concentration) raises adoption fees for deposits and ATMs. The share of cooperative banks, on the other hand, favors ATM card adoption. This is because cooperative banks, which are linked by their association, can more easily internalize the network externalities from faster installation of ATMs. Results are available upon request.

regressions for the demand for cash. Column (3) refers to the sub-sample of households with a bank account and an ATM card. In column (4) the sample is restricted to households with a bank account but no ATM card.[19] The consumption and the interest rate elasticities have the expected sign and are precisely estimated in both equations. However, important differences between the two regimes emerge. While the consumption elasticity is larger for households with no ATM cards compared to card-holders (0.437 and 0.347 respectively) the interest rate elasticity differs markedly, being more than twice as large (in absolute value) for households with an ATM card (-0.59 compared to -0.27). If one computes the coefficients of the transaction technology (β and γ in our model) implied by these estimates, one finds β=0.69 and γ=-0.10 for the group with ATM card, and β=2.69 and γ=-1.07 for the group without ATM card, leading to the following transaction technology:

$$\tau = A_{ATM=1}\frac{c^{0.347}}{m^{0.69}} \quad ; \quad \tau = A_{ATM=1}\frac{c^{0.437}}{m^{2.69}} \tag{17}$$

Note that in the group with ATMs transaction time is closer to being homogenous of degree zero with respect to consumption and money balances (γ is close to zero). This implies that cash holdings are closer to being homogeneous of degree zero with respect to consumption and the interest rate, as in the Baumol-Tobin model. In the group without ATM cards, the homogeneity property does not hold, but the parameter β is very close to the theoretical value of 2 of the Miller and Orr model. The difference between the two groups implies that there are significant non-linearities in the aggregate demand for money.

Substituting the optimal value of cash balances for the two groups in equation (15) one can also derive an expression for optimal transaction time for ATM and non-ATM users as a function of c, R, technological change and all the other terms that appear in the money demand equation. The ratio between transaction time of ATM users and non-users is a useful measure of the efficiency gain entailed by the ATM technology. It is equal to:

[19] For completeness, we have also estimated the model for the individuals that do not hold a bank account (using the appropriate Mills Ratio). For them we obtain a negative (-0.01) and insignificant coefficient on consumption and a coefficient of -1.49 (s.e. 0.07) on the interest rate.

$$\frac{\tau_{ATM=1}}{\tau_{ATM=0}} = \frac{Z_{ATM=1}^{-0.35}}{Z_{ATM=1}^{-0.44}} \frac{1}{R^{0.32} c^{0.09}} \tag{18}$$

where $Z_{ATM=i} = (wA\beta)_{ATM=i}$ for i=0,1 as estimated in the two equations for cash holdings for ATM holders and non-holders.[20] This expression can be calculated for each individual in the sample, and implies an average reduction in transaction time of 47 percent by adopting an ATM technology.

The specifications in columns (3) and (4) include also several demographic variables: dummies for the education of the household head (the reference group is individuals with a college degree), number of adults and children in the household, number of income recipients, gender and age of head, dummies for employees and for self-employment, and a dummy for retired head. These variables proxy for differences in the value of time, and more generally in transaction costs across different population groups. Most of them are important determinants of money demand. As they reflect several factors, the interpretation of these coefficients is not always straightforward. In some cases, like with the education dummies, their relative magnitude is consistent with their interpretation as proxies of the cost of time.[21] The Mills Ratios in both equations are highly significant, showing that ignoring selection problems might bias the estimated coefficients.

The finding that the demand for cash responds to consumption, interest rates and economic incentives in general is important because very little is known about cash demand at the microeconomic level. Sprenkle (1993) presents descriptive evidence drawn from the 1984 Federal Reserve Bulletin. He suggests that household demand for transaction balances is largely independent of income and interest rates, because people follow rule-of-thumb behavior, such as making a withdrawal when their cash on hand falls to some minimum level, say $20 (p. 181). Our empirical results strongly contradict this view.

The results we obtain are robust to different specifications than that reported in Table

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[20] The term wA is the exponent of all the terms in the demand for cash equation except for consumption and the interest rate and represents both changes in technology and cross sectional differences in the cost of time .

[21] Unfortunately our data set does not contain a variable that measures with precision the hourly wage and therefore the cost of time. Furthermore, for households with multiple earners or out of the labor force, it would not be easy to proxy for the cost of time even if wage rates were available. For similar reasons, it is difficult to give a straightforward interpretation of the coefficients on these demographic variables.

3. For instance, we consider alternative definitions of consumption; we exclude from our sample retired household heads; we replace the time trend with year dummies. This specification search does not affect the main results reported in Table 3. In particular, we consistently find small differences in consumption elasticities between the two regimes, and that households with ATM cards show a much higher elasticity to the interest rate than households with no cards. These differences are reflected in different transaction technologies between the two groups.

To take into account the possibility of regional fixed effects, we have also included dummies for the region of residence (South and Centre of the country) both in the probits and in the demand for cash. These variables might proxy for the relevance of the underground economy and delinquency, which might raise the demand for cash.[22] The sign and magnitude of the coefficients on consumption and interest rates are robust to the inclusion of these variables.

5. The welfare cost of inflation

5.1. Previous studies

The welfare cost of inflation has usually been computed relying on parameter estimates of the demand for money obtained from time-series data. Bailey's (1956) original work focused on hyperinflation periods, when the nominal interest rate is well approximated by the inflation rate. During hyper-inflations people try to reduce cash balances to a minimum and engage in inefficient forms of transactions, even including barter. This argument is not necessarily relevant at low levels of the interest rate.

Lucas (1994) has recently evaluated the welfare cost of inflation deriving the money demand equation from two general equilibrium models (the Sidrauski and a general equilibrium version of the McCallum and Goodfriend model). He calibrates various welfare cost functions using estimates of the interest rate elasticities based on low-frequency time

[22] The sign of the coefficients we obtain are consistent with this interpretation: cash holding is considerably higher in the Center and in the South where the underground economy and criminal activities are deemed to be widespread compared to the North).

series data. Assuming a constant elasticity money demand function of the form $m = AyR^{-0.5}$, where y is real income and A a constant term, Lucas estimates that the welfare cost of a 6 percent nominal interest rate is in the order of 1 percent of GDP. Lucas further shows that the specific functional form (logarithmic or semi-logarithmic) of the money demand equation affects the welfare cost computations. For instance, using a semi-log functional form he obtains a welfare cost of about 0.3 percent.

Several studies provide estimates of the welfare cost of inflation in general equilibrium models. Cooley and Hansen (1989) simulate a real business cycle model with a cash-in-advance constraint and measure the welfare cost of inflation as the increase in consumption that an individual would require to be as well off as under the Pareto optimal allocation (that is, in an economy without cash-in-advance constraint). Their simulations suggest that the welfare cost of inflation is 0.38 percent of consumption using a monetary aggregate similar to M1, and 0.11 percent using an aggregate equivalent to currency plus reserves. Recent studies (Gomme, 1993; Dotsey and Ireland, 1996; Bullard and Russel, 1997) obtain higher welfare costs of inflation because they combine cash-in-advance constraints or costly financial intermediation with features of the economy that give rise to auxiliary costs of inflation (such as distortions caused by non-neutralities in the tax system).

Feldstein (1997) evaluates the welfare gain of moving from 2 percent inflation to price stability at about 1 percent of GDP. He finds that most gains from price stability do not derive from an increase in money demand (unlike Lucas, he uses a narrow concept of money), but from the reduction in inflation-induced tax distortions in the intertemporal allocation of consumption and in the demand for housing.

Simulated models are usually calibrated using evidence from time series data, but some recent papers have attempted to estimate the demand for money by both households and firms using microeconomic data. In this context, if the population is heterogeneous in some important dimension affecting the demand for money, aggregation issues are crucial. Corner solutions are also extremely important and can be expected to introduce systematic biases in aggregate money demand equations.

The analysis of microeconomic data allows one to address these problems directly. This is the most promising avenue of empirical research on the demand for money. Two recent studies using microeconomic data are Bomberger (1993) for households and Mulligan

(1997) for firms. Both concentrate on the estimation of the elasticity of money demand with respect to transaction variables, such as income or wealth for households and sales for firms. Mulligan, using the Compustat panel on firms, finds that the elasticity of cash balances with respect to sales is about 0.8. Bomberger, using the 1983 Survey of Consumer Finances, finds that the cross-sectional variation in deposits explained by wealth is greater than that explained by income. In both studies the opportunity cost of money is assumed to be constant across all households in any given cross-section, or its effect is absorbed by time dummies in panel data.

Some progress in pinning down the effect of the interest rate elasticity has been made by Mulligan and Sala-i-Martin (1996). They note that the welfare cost of inflation depends on the shape of the money demand function at low levels of the interest rate. The welfare cost is relatively large if money demand is very interest-sensitive at low levels of the interest rate, as in the log-log specification. Furthermore, because low levels of the interest rate are seldom observed, there is no reliable inference that can be extracted from the aggregate data for the overall shape of the money demand function. They also note that almost 60 percent of US households hold no interest-bearing assets, perhaps because of transaction and information costs. They evaluate the elasticity of money demand at low interest rates by looking at the elasticity of the decision to hold interest-bearing assets at small quantities of assets, which is found for many people. Their empirical specification requires data on the nominal interest rate on alternative financial assets, which they proxy with the marginal tax rate. The latter, however, is never significantly different from zero. The estimates, performed using the US Survey of Consumer Finances, suggest that the interest rate elasticity is indeed small at low levels of interest rate. Even though Mulligan and Sala-i-Martin do not provide explicit calculations for the welfare cost of inflation, their study implies that the welfare cost of inflation is low, at least to households.

5.2. Our evidence

By comparison with previous studies, the main advantage of our data set and approach is that we can estimate the interest rate elasticity of money demand addressing not only the selection problem signaled by Mulligan and Sala-i-Martin but also the endogeneity of the adoption of new transaction technologies. Our computations of the welfare cost, based on

equation (9), are therefore consistent with the theoretical framework sketched out in Section 2. They take into account not only the effect of changes in interest rates on cash balances but also the effect on the prior decision as to *whether* and *how* (i.e. with which technology) cash should be managed.

The welfare costs for the two regimes and for the population as a whole are reported in the upper panel of Table 4. postulating an interest rate of 5 percent for each household ($\bar{R}$=0.05) and that the socially optimal inflation rate requires $\bar{R}$=0. For households with ATMs the welfare cost is considerably larger than for the other group. There are two reasons for this difference. First, the interest rate elasticity for this group is larger in absolute value than for the group with no ATM (-0.59 versus –0.27, see Table 3). Second, the ATM group includes a larger number of people with more education and, more generally, higher value of time, corresponding to higher transaction costs.[23]

The welfare cost generally declines over time, particularly in the sample with ATM cards, reflecting the negative time trend affecting the money demand equation. Note that the aggregate welfare cost is fairly constant, reflecting the offsetting impact of a declining time trend and an increase in the fraction using ATMs. This highlights the importance of aggregation issues during periods of financial innovation.[24]

The issue of aggregation also emerges in the lower panel of Table 4 where we tabulate the welfare cost by education and region of residence for two levels of the interest rate (5 and 10 percent). It is seen that the welfare cost is considerably greater for households with better education and living in the Center or in the North. This probably reflect the higher shadow value of time for these individuals.

Overall we find that the welfare gain of a 5 point reduction in inflation is 19,000 lire ($11), or 0.06 percent of non durable consumption (0.10 percent for a 10-point reduction in inflation). Why is the welfare cost in our sample so small, while Lucas (1994) put it at 1

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[23]Evaluating the welfare cost for the two groups at the sample means of the variables (i.e. holding constant the characteristics across the groups), shows that the welfare cost of ATM users is larger than for non users. This difference reflects only the differences in the transaction technology between the two groups.

[24]The previous experiment computed the welfare cost assuming a nominal interest rate of 5 percent for each household, about the level prevailing at the beginning of the sample period. But in fact we know that interest rates vary across provinces and years in our sample. Thus, we compute the welfare gain from reducing the nominal interest rate by 5 percent for each household in the sample starting from a level of 5 plus its sample value. The pattern of welfare costs is similar to that of the upper panel in Table 6.

percent of GDP? Lucas' estimates refer to the whole economy and are therefore not directly comparable with ours.[25] Only a small part of the disparity can be explained by differences in consumption and interest rate elasticities, or in functional form. Nor is the gap between Lucas' and our estimates significantly diminished when we consider interest rates other than 5 or 10 percent. The main source of the difference is that Lucas uses a much broader monetary aggregate (cash and deposits), while we use cash only, as in Feldstein (1997).[26]

A possible objection to the procedure we follow is that it ignores the distortion induced by the presence of a differential in the return on deposits and government bonds. In the presence of different types of interest bearing assets, with different degrees of liquidity, the simple exercises described above cannot be performed. To assess the welfare effect of a reduction in the level of inflation would require knowing the relation between inflation and the wedge between the return on deposits and bonds (R_b - R). Without a full-fledged model this is not possible. As is mentioned in Section 2.4, it is possible to construct models where the differential is not affected by a reduction of inflation, so that our welfare cost computations should be correct. Given the size of the existing interest rate differentials and the reported elasticities in the demand for deposits, it is difficult to imagine situations in which the consideration of these factors could make a substantial difference.

6. Withdrawals and trips

As we discussed in Section 3, in addition to the data on average cash holdings, the SHIW contains additional information on various aspects of cash management. In section 3 we have illustrated the extent to which the reported figures on average cash holdings, average withdrawals, minimum cash, number of trips and consumption flows are internally consistent. It is interesting to establish the extent to which these variables react to changes in interest rates and consumption flows. While the interpretation of the results that follow is not at times as straightforward as that for the average cash holding, they provide useful information on the

[25]By focusing on households, we neglect the effect of inflation on cash balances held by firms and financial intermediaries.

[26] Even though the welfare costs of inflation are bound to be low in monetary economies in which a substantial portion of the money stock is interest-bearing, it should be kept in mind that the welfare gain from reducing inflation is a permanent benefit. This argument is stressed by Feldstein (1997).

way in which individual households change their cash-management behavior as a consequence of inflation.

6.1. *Average withdrawals*

Inventory models of the demand for money, such as the Baumol-Tobin and the Miller and Orr models, imply that the average cash holding is a constant fraction of the size of withdrawals (or cash deposits). Thus, in these models, one should obtain the same parameter estimates if withdrawals amounts are used instead of average cash holdings as a left-hand side variable. In practice, however, the two sets of estimates need not deliver the same results. First, the restrictions imposed by inventory models may not hold in practice. For instance, if a withdrawal is made when the cash balance hits some *positive* lower bound rather than when it is completely depleted (as in Baumol and Miller and Orr), then the proportionality between average holdings and the size of withdrawals may fail.[27] Second, average cash balances are self-reported, and there is no guarantee that households report the *mean* cash balances rather than some other index of central tendency.[28]

In Table 5, we report estimates of the determinants of the size of withdrawals. We retain the same specification as in the demand for average cash balances. In this case, however, we report estimates for three types of withdrawal: withdrawals at the bank's counter by ATM card-holders (column 1), withdrawals at the counter for by non-ATM card-holders (column 2), and ATM withdrawals. The pattern of coefficients is similar across equations. In all cases the interest rate elasticity is negative, significantly different from zero and somewhat larger (in absolute value) for non-holders of ATM cards. The transaction variable is positive and its elasticity is similar in size to that reported in Table 3 except for the size of withdrawals at an ATM: for this group the elasticity with respect to the scale of transactions is only 0.12, revealing substantial economies of scale.

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[27] In the inventory models of Baumol and Miller and Orr, withdrawals of cash take place only when cash balances drop to zero. This is a consequence of the assumption that withdrawals can be made instantaneously albeit at a cost. If it takes time to obtain cash following a large cash drain, than people make withdrawals when cash nears some positive lower bound. These "minimum" cash holdings serve the purpose of cushioning against cash needs during the lead-time. Thus, average cash balances are a convex combination of the amount withdrawn and of minimum cash balances. This implies that the empirical estimates of transaction and interest rate elasticities of average cash balances can differ from those of the size of withdrawals.

[28] In a simple Baumol-Tobin framework it is still true that median holdings of cash are proportional to the size of the withdrawal, with a factor of proportionality equal to $1/\sqrt{2}$.

While the elasticity to the interest rate for the group of non-holders is comparable to (and it is not dramatically different from) that reported in Table 3, the elasticities for the groups of card holders are conceptually different as they correspond to different types of withdrawal.

6.2. *The number of trips to the bank and income received in cash*

At the root of the welfare cost discussed in the previous section is that households shift their use of time from productive purposes to cash management in order to shield themselves from inflation. Faced with high nominal interest rates, consumers reduce cash balances and substitute time for money. In fact, the transaction technology specified in equation (1) implies that time spent transacting and money holdings should be negatively correlated. For the same reason, an increase in the nominal interest rate should increase the time spent transacting.

But this is not the only channel through which consumers reduce their exposure to inflation. The results in Table 3 show that as the nominal interest rate increases, more households find it optimal to hold interest-bearing assets (deposits) and also to use more efficient technologies (ATM cards). In this section we extend the evidence in two directions. We use information available in the survey on the number of trips to the bank that households make to deposit or withdraw cash to complement the evidence on cash management discussed in Section 4.2. Also, we show that an additional channel to protect against inflation is to alter the way income is received.

Figure 5 plots the yearly number of trips to the bank, either to withdraw or to deposit cash, against the ratio of average cash holdings to consumption. Data are aggregated by province and for the four sample years and show a marked negative correlation, as implied by a transaction technology where money and time can both provide liquidity services. In Table 6, we present estimates of an equation for the number of trips analogous to equation (5). To account for the integer nature of trips we use an ordered probit estimator, with trips coded in 8 groups (0 trips, less than 1 trip per month, 2, 3,4,5,6 and more than 7 per month)[29].

Column (1) reports estimates for the total number of trips. Since questions on trips

[29] The category 0 trips includes households who do not hold a bank account. Analogously, the category 0 trips to ATM includes households who do not have an ATM card.

were not asked in 1989, estimates refer only to 1991-95. Consistent with inventory models of the demand for money, the number of trips increases with the volume of transactions and with the interest rate with elasticities equal to 0.244 and 0.511, respectively. These estimates are broadly consistent with those obtained from the overall cash holdings equation, reported in Section 4.

One problem with these estimates is that the total includes both trips to the bank to make withdrawals and deposits and those to an ATM, while the two types of trip are different objects, as trips to the ATM require less time. Therefore, in column (2), we report separate estimates for the number of trips to ATMs. Even though the overall pattern of the estimated coefficients is similar to that for total trips, trips to the ATM are more responsive to the interest rate, with an elasticity which is about two times as greater as that for total trips.[30] Overall, these results are qualitatively similar to those obtained estimating the equation for cash and provide additional, independent support for inventory models of the demand for money.

The results for the number of trips, particularly those for the total number of trips, should be taken with caution. The variable "trips to the bank" is not clearly defined and might differ substantially from the theoretical concept in equation (5). Furthermore, because of the discrete nature of the variable and the use of an ordered probit model, we do not take proper account of the selectivity problem that might arise if the equation were estimated using only information for households with a bank account and, in the case of the equation in column 2, for those with an ATM card.[31] The evidence we present, however, is generally consistent with that presented in the previous sections.

The share of income received in cash is also a signal of the development of the payment system. In 1989 the sample average was 52 percent. Paralleling the other developments in cash management, this fraction declined to about 40 percent by 1995. Figure 6 again suggests substantial geographical variability in the share of income received in cash.

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[30] Notice that these elasticities are not directly comparable with those reported in Table 4, column 3, which refer to average cash holdings among holders of an ATM card. These balances are the reflection of both trips to the bank and to the ATM among ATM holders. The estimates in Table 6 refer instead to trips to ATM alone.

[31] The ordered probits are estimated on the entire sample. Obviously individuals who do not have a bank account (or an ATM card for the second equation) will have zero trips. We include on the right-hand side variables that are determinants of the choice to have a bank account and an ATM card.

Note that by to this indicator as well the South is financially less developed than the North.

The last column of Table 6 reports a two-limit Tobit estimate for the share of income received in cash. Our hypothesis is that when the nominal interest rate is high, individuals seek protection against inflation by altering the way they receive payments, opting for channels that minimize time of cash-in-hand. The estimates reported are consistent with this conjecture. In particular the interest rate has a strong and highly significant negative effect on the fraction of income received in cash.

7. Conclusions

The welfare cost of inflation we consider in this paper arises from the increased effort to manage cash balances in periods in which the nominal interest rate deviates from Friedman's optimal monetary rule. One way to measure such a cost is to integrate the area under the money demand curve. This requires information on its parameters, in particular the transaction and interest rate elasticities. As in Lucas (1994), these parameters have been generally inferred by aggregate money demand functions estimated on time-series data. Recently Mulligan and Sala-i-Martin (1996) have pointed out that the aggregate interest rate elasticity depends on the fraction of households holding interest-bearing assets. If this fraction is small, the interest rate elasticity is low, particularly at low levels of the nominal interest rate.

We estimate the demand for money in an economy in which deposits bear interest. This feature allows us to exploit the cross-sectional and time variability of nominal interest rates and estimate a version of the Baumol-Tobin model with microdata. We model both the access to interest bearing assets and the choice of ATM technology and find significant interest rate and transaction effects both in the equation for the ownership of an interest bearing checking account and for the ownership of an ATM card.

The parameters of the demand for cash are estimated precisely. We find an interest rate elasticity of around -0.5, and substantial economies of scale in cash management (a consumption elasticity well below unity). Furthermore, we find substantial differences in the equations for ATM card holders and non-holders. The demand for money of the households who choose to have an ATM card is considerably more elastic to the interest rate than that of the households who do not hold such a card. These non linearities can, in principle, be

important in evaluating the aggregate welfare cost of inflation.

Our estimates of the welfare cost of inflation varies considerably within the population, but turns out to be small. On average the yearly welfare cost of inflation is around 0.1 percent of non durable consumption.

If intensive cash management is the only distortion induced by inflation, and if a large portion of the money stock is interest-bearing, consumers are able to shield themselves against the inflation tax, and reducing inflation would result in limited welfare gains. But in reality there are also several other inflation-induced distortions that we have not considered in this paper and that make the goal of price stability even more desirable.

References

Bailey, J. (1956), "The welfare cost of inflationary finance", *Journal of Political Economy* 64, 93-110.

Baumol, William J. (1952), "The transaction demand for cash: an inventory theoretical approach", *Quarterly Journal of Economics* 66, 545-56.

Bomberger, William A. (1993), "Income, wealth, and the demand for deposits", *American Economic Review* 83, 1034-44.

Brandolini, Andrea, and Luigi Cannari (1994), "Methodological Appendix: The Bank of Italy Survey of Household Income and Wealth", in *Saving and the accumulation of wealth. Essays on Italian households and government behavior*, edited by Albert Ando, Luigi Guiso and Ignazio Visco. Cambridge: Cambridge University Press.

Bullard, James, amd Steven Russell (1997) "How costly is sustained low inflation for the US economy?", paper presented at the Conference on Macroeconomic Theory and Monetary Policy, Federal Reserve Bank of Philadelphia, October 23-24.

Dotsey, Michael, and Peter Ireland (1996), "The welfare cost of inflation in general equilibrium", *Journal of Monetary Economics* 37, 29-48.

Feldstein, Martin (1997), "The costs and benefits of going from low inflation to price stability", in *Reducing Inflation: Motivation and Strategy*, Christina D. Romer and David H. Romer eds. Chicago: The University of Chicago Press.

Fischer, Stanly (1981), "Towards an understaning of the costs of inflation", *Carnegie-Rochester Conference on Public Policy* 15, 5-42.

Gomme, Paul (1993), "Money and growth revisited: Measuring the cost of inflation in an endogenous growth model", *Journal of Monetary Economics* 32, 51-78.

Humphrey, David B, Lawrence B. Pulley, and Jukka M. Vesala (1997), "Cash, paper, and electronic payments: a cross-country analysis", *Journal of Money, Credit, and Banking*.

Lucas, Robert E. (1994), "On the welfare cost of inflation", The University of Chicago, February, mimeo.

Marimon, Ramon, Juan Pablo Nicolini, and Pedro Teles (1997), "Electronic money: the end of inflation?", paper presented at the Conference on Macroeconomic Theory and Monetary Policy, Federal Reserve Bank of Philadelphia, October 23-24.

McCallum, Bennett T., and Marvin S. Goodfriend (1987), "Demand for money: theoretical

studies", in *The New Palgrave: a Dictionary of Economics"*. P. Newman, M. Milgate and J. Eatwell eds. London: Macmillan, 775-81.

Miller, Merton H. and Orr, Daniel (1966), "A model of the demand for money by firms", *Quarterly Journal of Economics* 80, 413-35.

Mulligan, Casey B. (1997), "Scale economies, the value of time, and the demand for money: longitudinal evidence from firms", *Journal of Political Economy* 105, 1061-79.

Mulligan, Casey B., and Xavier Sala-i-Martin (1996), "Adoption of financial technologies: implications for money demand and monetary policy", NBER Working Paper n. 5504.

Mulligan, Casey B., and Xavier Sala-i-Martin (1997), "The optimum quantity of money: theory and evidence", *Journal of Money, Credit, and Banking*, forthcoming.

Sprenkle, Case M. (1993), "The case of the missing currency", *Journal of Economic Perspectives* 7, Fall, 175-84.

Tobin, James (1956), "The interest elasticity of the transactions demand for money", *Review of Economics and Statistics* 38, 241-47.

Appendix

Variables' Definition

Information on the sample design and response rates of the Survey of Households Income and Wealth can be found in Cannari and D'Alessio (1994). In the empirical estimates all demographic variables - age, education, occupation, and sector - refer to the head of the household (the husband, if present). If instead the person who would usually be considered the head of the household works abroad or was absent from the household at the time the interview took place, the head of the household is the person responsible for managing the household's resources. All monetary variables are deflated using the Consumer Price Index and expressed in 1995 lire.

ATM ownership
In each year, the SHIW asks respondents to report ownership of an ATM card. The surveys also contain information about use of ATMs.

Cash
The following question was asked of household heads in each of the surveys: "What is the average amount of cash held in your family?"

Minimum amount of cash
The following question was asked to household heads in each of the surveys: "Usually, what is the amount of cash that you have before you choose to make a cash withdrawal?"

Number of withdrawals and average withdrawal
The following questions were asked to household heads in each of the surveys: "Think about a normal month. How many cash withdrawals are made by you or a member of your household? What is the average cash withdrawn?" These questions are asked separetely for withdrawals at a bank, at a Post Office or at an ATM point.

Consumption
Consumption is the sum of the expenditure on food consumption, entertainment, education, clothes, medical expenses, housing repairs and additions, and imputed rents. Expenditures on durable goods (vehicles, furniture and appliances, art objects) are therefore not included in the definition of consumption.

Deposits
Include checking accounts, savings accounts and postal deposits.

Education of the household head
This variable is originally coded as: no education (0); completed elementary school (5 years); completed junior high school (8 years); completed high school (13 years); completed college (18 years); graduate education (more than 20 years). The variable is coded according to the values given in parenthesis. For the highest class we assume a value of 20 years.

Financial wealth
Sum of cash balances, checking accounts, savings accounts, postal deposits, government paper, corporate bonds, mutual funds and investment fund units, stocks. In 1989 total financial wealth is readily available. For other years it must be estimated because the categories of financial assets (except cash holdings) were provided in 15 bands; the average value between the lower and the upper band was used in determining the level of each asset.

Interest rate on deposits
We have data on the average interest rate on checking accounts by year (1989, 1991, 1993, 1995), size of deposit (between 0 and 49 million lire and between 50 and 99 million) and 95 provinces. The source of the data set is the Monetary Aggregates collected by the Bank of Italy. This data set is then merged with the 1989-1995 SHIW and an interest rate imputed to each household according to year, province of residence and size of bank account. The size of deposits is estimated multiplying the share of financial wealth in deposits with the level of financial assets (in 1989) or directly measuring the level of deposits (in 1991, 1993 and 1995). In 1991-95 deposits are provided in 15 bands; the average value between the lower and the upper band was used in determining deposits. For households with no bank account, the interest rate on the smallest deposit class in each year/province was imputed to estimate equation (14) in the text.

Interest rate on government paper
In order to compute the interest rate differential used in estimating the demand for deposits, we use as reference asset the average after-tax interest rate on Treasury bills.

Number of ATMs per province
Data on the number of ATM points in each year/province is provided by a special survey of the Bank of Italy. This data set is then merged with the 1989-1995 SHIW.

Summary statistics

Table A1 presents weighted sample averages of the demographic variables that are used in the estimation. The developments of these demographic variables matches that of population surveys, as documented by Brandolini e D'Alessio (1994). To the extent that demographic variables affect the demand for money, population aging, the decline in the number of children per household, and the increase in the number of income recipients should all be taken into account. The last raw of the table indicates that with respect to the original sample, 828 observations (2.5 percent of the original sample) are lost due to missing values, mainly because some households do not report information on cash balances, ownership of an ATM or of a bank account. The sample is therefore reduced from 32,691 potential observations to 31,863. Since the number of missing observations is relatively low, we do not attempt at modeling the probability of non-response.

Table 1. Money, consumption and financial innovation: 1989-1995 SHIW

Variable	1989	1991	1993	1995
Non-durable consumption	33,118	31,920	30,722	30,240
Deposits	18,807	12,999	12,894	13,207
Financial wealth	39,630	28,337	33,324	33,589
% with a bank account	86.83	85.77	84.87	84.60
% using ATMs	14.93	29.31	34.42	39.97
% using credit cards	9.57	13.85	10.88	14.29
Cash balances	1,122	919	654	724
No bank account	1,104	963	592	719
With bank account	1,124	912	664	725
No ATM card	1,106	953	679	769
With ATM card	1,209	837	606	657
Cash/consumption (%)	3.88	3.52	2.52	2.78
No bank account	5.66	5.41	3.56	4.10
With bank account	3.63	3.22	2.34	2.54
No ATM card	4.04	4.02	2.94	3.37
With ATM card	2.98	2.30	1.74	1.89
Average withdrawal at a bank	-	831	1,054	934
No ATM card	-	822	1,066	925
With ATM card	-	854	1,034	945
Average withdrawal at an ATM	-	425	400	383
Minimum cash balances	243	240	233	174
No ATM card	234	232	239	183
With ATM card	290	258	224	165
Total number of trips	-	28	26	30
To the bank (no ATM card)	-	18	13	13
To the bank (with ATM)	-	14	12	11
To the ATM	-	34	36	39
% of income received in cash				
Mean	52.19	46.29	45.60	44.85
Standard deviation	0.44	0.44	0.44	0.45
Sample size (total)	8,271	8,188	8,097	8,135
Sample size used in the estimation	7,973	8,127	7,663	8,100

Notes: All averages are computed using sample weights. Non-durable consumption and cash balances are deflated by the Consumer Price Index and expressed in thousands of 1995 lire. See Appendix for variables' definition.

Table 2. Interest rate variation and characteristics of the payment system

Variable	1989	1991	1993	1995
After-tax interest rate on T-Bills	9.19	9.15	7.72	7.92
After-tax interest rate on deposits				
Mean	4.62	4.37	4.27	3.54
Standard deviation	0.38	0.39	0.32	0.27
Number of ATM (per million people)				
Mean	100	170	240	280
Standard deviation	70	110	130	150
Share of deposits of the 5 largest banks				
Mean	0.502	0.503	0.505	0.511
Standard deviation	0.150	0.144	0.140	0.130
Share of deposits of cooperative banks				
Mean	0.129	0.130	0.130	0.132
Standard deviation	0.064	0.064	0.064	0.064
Difference between interest rate on loans and interest rate on deposits				
Mean	10.57	10.61	10.74	10.56
Standard deviation	1.21	1.12	1.06	1.16

Note: Source: Bank of Italy.

Table 3.The determinants of bank accounts, ATM use and the demand for cash balances for separate regimes

Variable	Probit for bank account (1)	Probit for ATM (2)	Cash balances: bank account and ATM card (3)	Cash balances: bank account and no ATM card (4)
Log(Consumption)	0.173	0.532	0.347	0.437
	(0.040)	(0.026)	(0.026)	(0.020)
Log(Interest rate)	0.923	0.397	-0.592	-0.271
	(0.171)	(0.122)	(0.105)	(0.070)
Time	0.153	0.291	-0.115	-0.034
	(0.029)	(0.019)	(0.019)	(0.013)
Time squared	-0.015	-0.020	0.007	0.002
	(0.004)	(0.002)	(0.002)	(0.001)
Less than elementary school	-0.714	-1.033	-0.132	-0.254
	(0.100)	(0.067)	(0.076)	(0.037)
Elementary schooling	-0.569	-0.726	-0.108	-0.136
	(0.094)	(0.037)	(0.032)	(0.027)
Junior high school	-0.235	-0.362	-0.070	-0.057
	(0.094)	(0.034)	(0.025)	(0.024)
High school	0.096	-0.081	-0.080	-0.057
	(0.097)	(0.033)	(0.023)	(0.024)
Male head	-0.006	0.095	0.046	0.114
	(0.037)	(0.026)	(0.022)	(0.014)
Number of children	-0.083	-0.095	0.018	0.017
	(0.081)	(0.012)	(0.010)	(0.007)
Number of adults	-0.126	-0.042	0.081	0.046
	(0.019)	(0.013)	(0.011)	(0.008)
Age	0.026	0.003	-0.002	0.001
	(0.006)	(0.005)	(0.004)	(0.002)
Age squared	-0.0003	-0.0002	0.0000	-0.00004
	(0.0001)	(0.00005)	(0.0004)	(0.00002)
Number of income recipients	0.068	0.101	0.042	0.036
	(0.024)	(0.015)	(0.012)	(0.009)
Employed head	0.220	0.014	0.052	0.046
	(0.045)	(0.029)	(0.024)	(0.017)
Self-employed head	0.273	-0.341	-0.038	-0.115
	(0.055)	(0.033)	(0.030)	(0.022)
Retired head	-0.113	-0.430	-0.129	-0.098
	(0.052)	(0.039)	(0.038)	(0.022)
Living in rural areas	-0.138	-0.288	-	-
	(0.063)	(0.049)		
Living in the suburbs	-0.092	0.066	-	-
	(0.064)	(0.023)		
Living in semi-center	-0.197	0.092	-	-
	(0.065)	(0.024)		
Log(Financial wealth)	0.918	0.073	-	-
	(0.013)	(0.007)		
Number of ATM in the province	1.911	2.326	-	-
	(0.149)	(0.086)		
Mills' Ratio: Bank account	-	-	0.150	0.137
			(0.008)	(0.006)
Mills' Ratio: ATM card	-	-	-0.603	0.377
			(0.043)	(0.030)
Constant	-5.632	-5.868	0.998	0.346
	(0.700)	(0.479)	(0.393)	(0.264)
R squared	0.596	0.250	0.177	0.184
Sample size	31,863	26,922	9,334	17,588

Note: In the probit estimates the dependent variable equals 1 if the household holds a bank account (an ATM card), 0 otherwise. In columns 3 and 4 the dependent variable is the logarithm of cash balances.

Table 4. The welfare cost of inflation

A. The welfare cost for households with and without ATM card

	5 percent nominal interest rate								
	With ATM			No ATM			Total sample		
	Group size	Welfare cost	% of consum.	Group size	Welfare cost	% of consum.	Group size	Welfare cost	% of consum.
1989	1,212	56.71	0.13	5,729	16.82	0.05	7,973	21.42	0.07
1991	2,321	41.14	0.10	4,612	13.65	0.04	8,127	19.50	0.06
1993	2,608	32.81	0.08	3,801	12.13	0.04	7,663	18.51	0.06
1995	3,193	28.63	0.07	3,446	11.37	0.04	8,100	17.49	0.06
Total	9,334	36.56	0.09	17,588	13.91	0.05	31,863	19.23	0.06

B. The welfare cost by education and area of residence

	5% interest rate		10% interest rate	
	Welfare cost	% of consumption	Welfare cost	% of consumption
Less than elementary school	9.46	0.05	18.32	0.10
Elementary schooling	14.80	0.06	25.93	0.10
Junior high schooling	20.40	0.06	33.26	0.10
High school	25.21	0.07	38.91	0.10
College	27.65	0.06	41.79	0.08
Resident in the North	22.34	0.07	35.11	0.10
Resident in the Center	20.21	0.06	32.79	0.10
Resident in the South	14.97	0.05	26.35	0.09
Total sample	19.23	0.06	31.46	0.10

Note. Welfare costs are computed on the basis of the estimated coefficients of Table 3 and are expressed in thousand of 1995 lire.

Table 5. The determinants of the size of withdrawals

	Withdrawal at a bank (with ATM card)	Withdrawal at a bank (no ATM card)	Withdrawal at an ATM (with ATM card)
	(1)	(2)	(3)
Log(Consumption)	0.213	0.304	0.130
	(0.033)	(0.025)	(0.019)
Log(Interest rate)	-0.361	-0.392	-0.161
	(0.137)	(0.095)	(0.081)
Time	0.314	0.436	0.003
	(0.057)	(0.041)	(0.032)
Time squared	-0.031	-0.043	-0.003
	(0.006)	(0.004)	(0.003)
Less than elementary school	0.107	0.009	0.000
	(0.085)	(0.047)	(0.051)
Elementary schooling	0.082	0.015	-0.066
	(0.040)	(0.036)	(0.023)
Junior high school	0.083	-0.008	-0.022
	(0.032)	(0.034)	(0.018)
High school	-0.046	-0.017	-0.025
	(0.029)	(0.034)	(0.016)
Male head	0.053	0.046	0.050
	(0.028)	(0.018)	(0.018)
Number of children	0.032	0.023	0.048
	(0.013)	(0.009)	(0.007)
Number of adults	0.056	0.031	-0.008
	(0.014)	(0.010)	(0.008)
Age	0.016	0.006	0.017
	(0.005)	(0.004)	(0.003)
Age squared	-0.0001	-0.00002	-0.0001
	(0.00005)	(0.00003)	(0.00003)
Number of income recipients	-0.053	-0.027	-0.040
	(0.016)	(0.012)	(0.009)
Employed head	0.032	0.024	0.017
	(0.029)	(0.023)	(0.019)
Self-employed head	0.025	0.038	-0.062
	(0.039)	(0.028)	(0.024)
Retired head	0.059	0.003	0.054
	(0.045)	(0.028)	(0.029)
Mills' ratio:	0.075	0.064	0.040
Bank account	(0.010)	(0.007)	(0.005)
Mills' ratio:	-0.008	-0.101	-0.076
ATM card	(0.052)	(0.031)	(0.029)
Constant	1.551	0.853	3.597
	(0.573)	(0.416)	(0.332)
R squared	0.087	0.133	0.067
Sample size	5,132	8,910	7,196

Note: The dependent variable is the logarithm of the average withdrawal at a bank or at an ATM. The sample excludes observations for 1989.

Table 6. The determinants of the number of trips and of the fraction of income received in cash

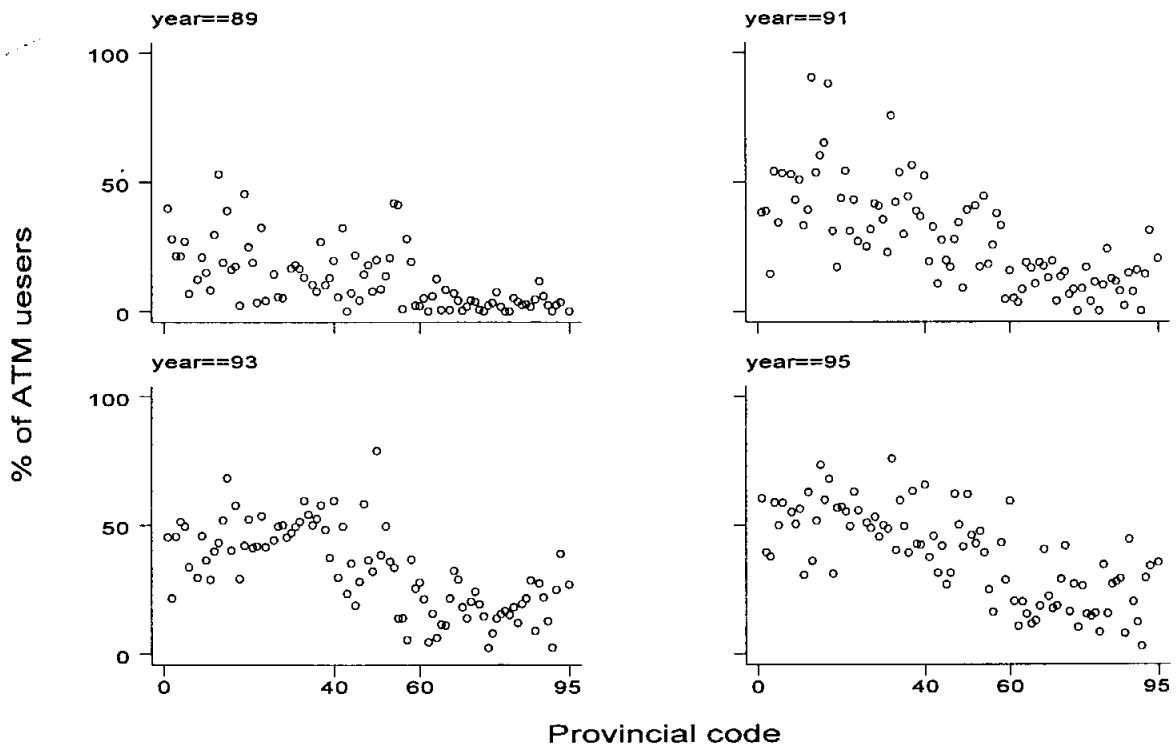
	Number of trips (total)	Number of trips at ATM	Fraction of income received in cash
	(2)	(3)	(1)
Log(Consumption)	0.511	0.642	-0.455
	(0.020)	(0.025)	(0.024)
Log(Interest rate)	0.244	0.655	-0.913
	(0.097)	(0.126)	(0.108)
Time	-0.521	-0.139	-0.085
	(0.040)	(0.051)	(0.017)
Time squared	0.049	0.022	0.006
	(0.004)	(0.005)	(0.002)
Less than elementary school	-0.748	-1.041	0.828
	(0.042)	(0.068)	(0.049)
Elementary schooling	-0.564	-0.764	0.550
	(0.032)	(0.036)	(0.037)
Junior high school	-0.309	-0.385	0.239
	(0.030)	(0.033)	(0.035)
High school	-0.092	-0.133	0.056
	(0.029)	(0.031)	(0.035)
Male head	0.042	0.071	-0.093
	(0.019)	(0.025)	(0.023)
Number of children	-0.054	-0.098	0.001
	(0.009)	(0.011)	(0.010)
Number of adults	-0.029	-0.018	0.023
	(0.010)	(0.013)	(0.012)
Age	0.005	-0.006	-0.025
	(0.003)	(0.005)	(0.004)
Age squared	-0.0001	-0.0001	0.0003
	(0.00003)	(0.00005)	(0.00004)
Number of income recipients	0.054	0.099	0.148
	(0.012)	(0.014)	(0.014)
Employed head	0.164	0.053	-0.331
	(0.022)	(0.028)	(0.027)
Self-employed head	-0.247	-0.417	0.574
	(0.026)	(0.033)	(0.030)
Retired head	-0.148	-0.403	0.353
	(0.028)	(0.040)	(0.033)
Living in rural areas	-0.094	-0.241	-0.103
	(0.034)	(0.048)	(0.040)
Living in suburbs	0.070	0.064	-0.081
	(0.018)	(0.023)	(0.021)
Living in semi-center	0.079	0.067	-0.112
	(0.019)	(0.024)	(0.022)
Log(Financial wealth)	0.178	0.088	-0.139
	(0.005)	(0.006)	(0.006)
Number of ATM in the province	1.442	1.978	-2.076
	(0.062)	(0.077)	(0.082)
R squared	0.116	0.163	0.137
Sample size	23,890	23,890	31,683

Note: The coefficients in columns (1) and (2) are estimated by an ordered probit model for the number of trips, coded in 7 groups (0 trips, less than 1 per month, 2, 3, 4, 5, 6, more than 7). The regression in column 1 is a two-limit Tobit for the fraction of income received in cash (ranging from 0 to 1). In columns (2) and (3) the sample excludes observations for 1989.

Table A1. Sample means of demographic variables used in the estimation: 1989-1995 SHIW

Variable	1989	1991	1993	1995
Less than elementary	0.08	0.08	0.10	0.09
Elementary	0.36	0.37	0.35	0.33
Junior high school	0.25	0.25	0.28	0.27
High school	0.22	0.22	0.21	0.24
College	0.08	0.07	0.06	0.06
Male head	0.81	0.80	0.73	0.72
Number of adults	2.31	2.33	2.31	2.31
Number of children	0.67	0.65	0.66	0.58
Age	52.05	53.28	53.06	54.07
N. of income recipients	1.72	1.74	1.76	1.79
Employed head	0.46	0.43	0.39	0.36
Self-employed head	0.17	0.16	0.14	0.14
Retired head	0.22	0.24	0.26	0.26
Living in Northern regions	0.50	0.47	0.49	0.49
Living in Central regions	0.19	0.19	0.19	0.18
Living in Southern regions	0.31	0.33	0.32	0.33
Living in rural areas	0.05	0.04	0.07	0.07
Living in the suburbs	0.39	0.41	0.36	0.32
Living in semi-center	0.30	0.27	0.31	0.32
Living in the center	0.25	0.27	0.26	0.29
Sample size	8,271	8,188	8,097	8,135
Sample size used in the estimation	7,973	8,127	7,663	8,100

Note: All averages are computed using sample weights and using the original sample size.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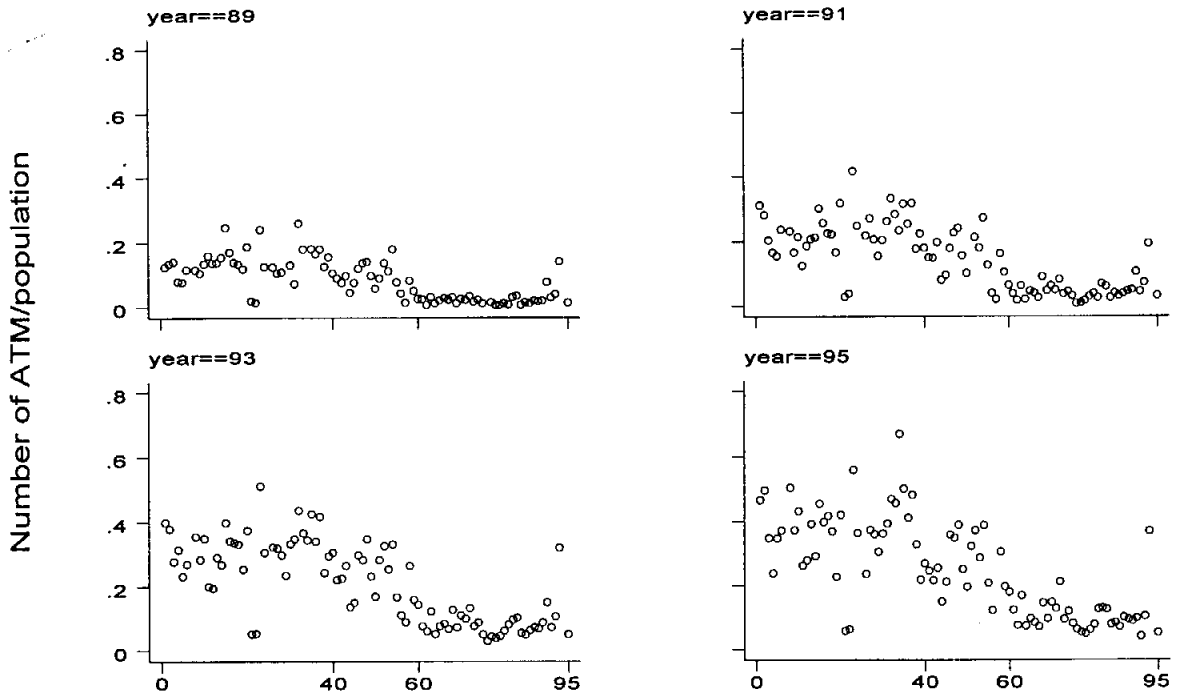
year==91
year==93
year==95
100
50
0
40
60
95
% of ATM uesers
Provincial code

Figure 1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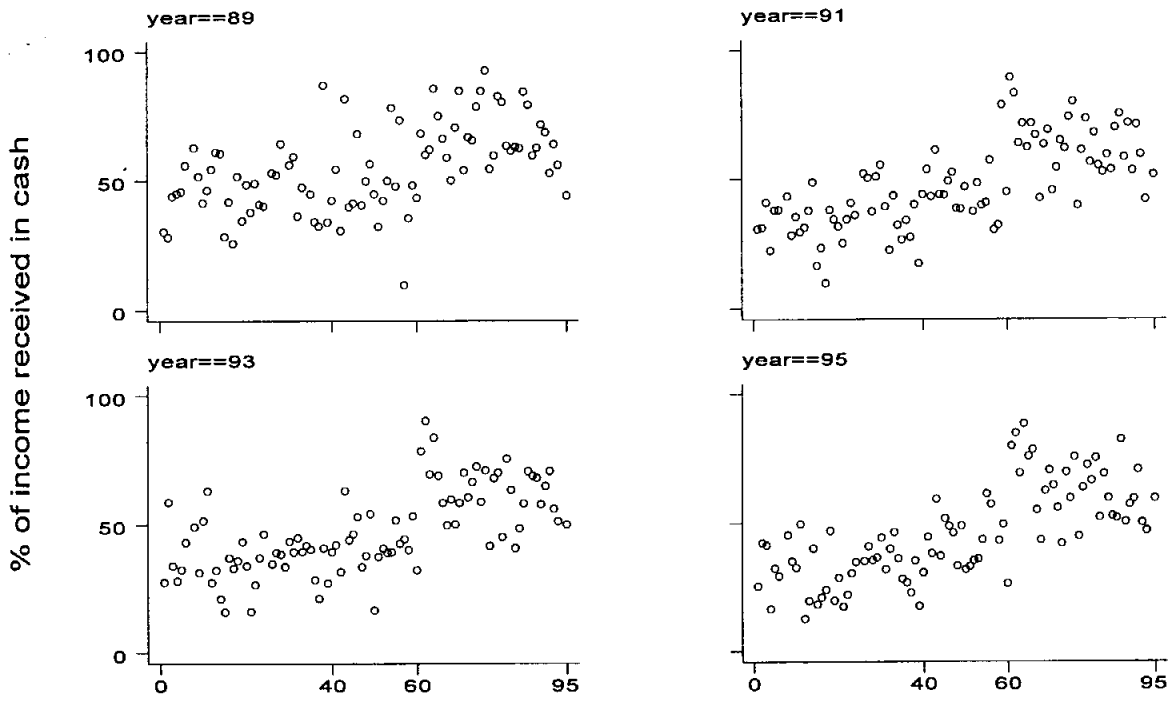
year==95
Number of ATM/population
0
.2
.4
.6
.8
0
40
60
95
Provincial code

Figure 2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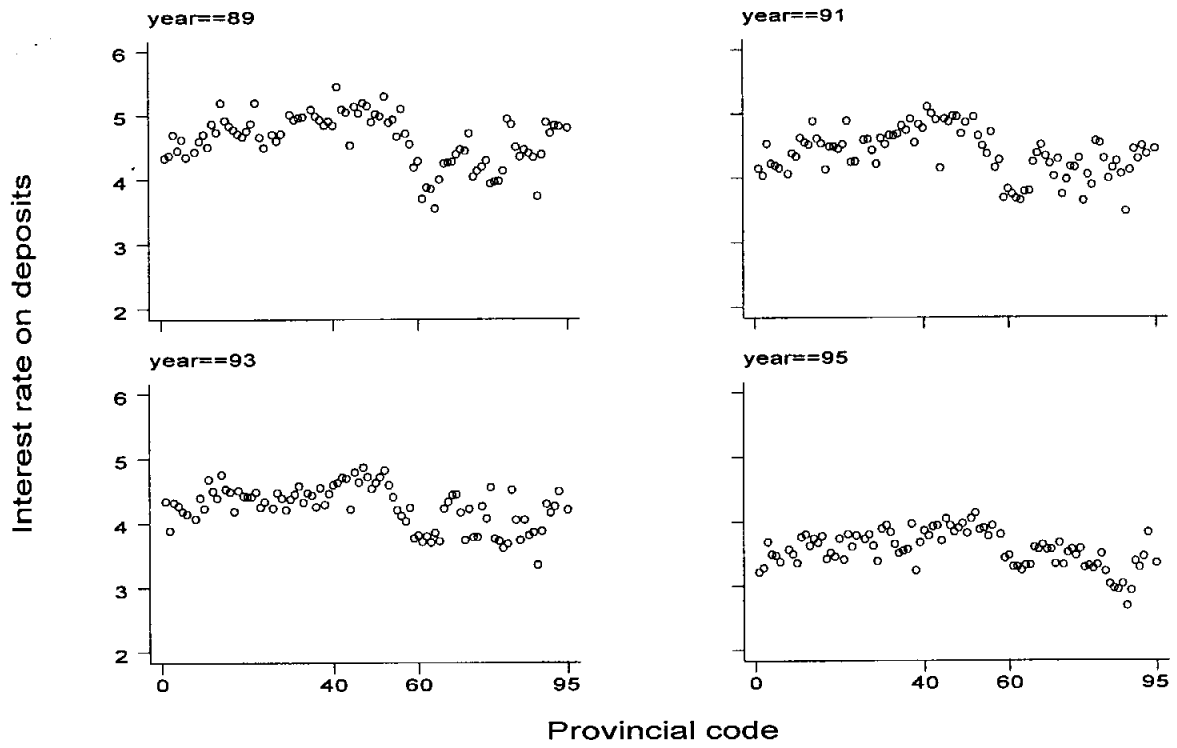
100
50
0
40
60
95
% of income received in cash
Provincial code

Figure 3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year==91
year==93
year==95
Interest rate on deposits
6
5
4
3
2
0
40
60
95
Provincial code

Figure 4

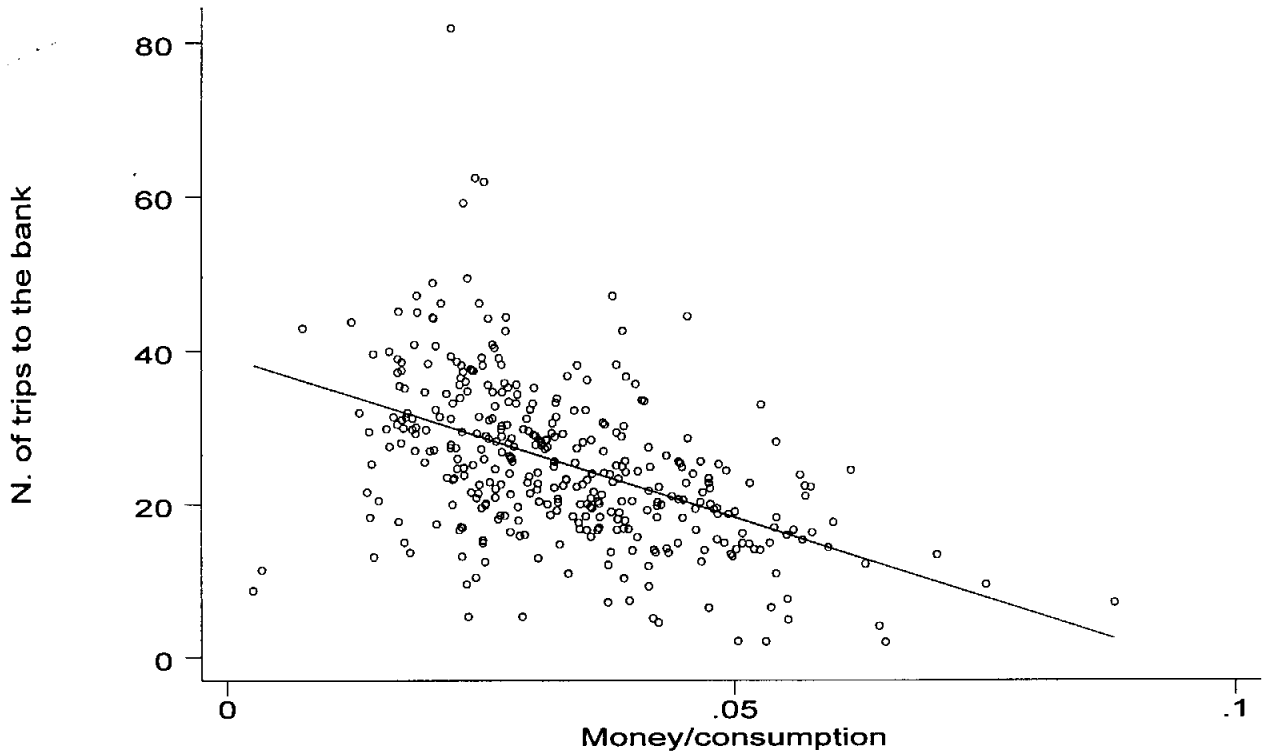

Figure 5