Multihoming in the Market for Payment Media: Evidence from Young Finnish Consumers

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Abstract

In the market for payment media, some consumers use only one medium when paying for their point-of-sale transactions, while others multihome and use many. As this pattern reflects the diffusion of new payment media, we take a look at the determinants of the adoption of new payment media through the window of multihoming. Using data on young Finnish consumers, we verify that a key determinant of multihoming behavior is consumer awareness. We show, however, that not controlling for the endogeneity of awareness can severely bias its effect downwards. Our IV/GMM -estimations show that the better informed use as much as 1.2 times more payment media than the less informed. Because many payment method innovations are typically first used simultaneously with the established methods, our results suggest that increasing consumer awareness could significantly speed up the adoption of new means of payment, such electronic money and mobile payments.

JEL: G200, E590
Keywords: Payment media, multihoming, consumer awareness, adoption of financial technology

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Abstract

In the market for payment media, some consumers use only one medium when paying for their point-of-sale transactions, while others multihome and use many. As this pattern reflects the diffusion of new payment media, we take a look at the determinants of the adoption of new payment media through the window of multihoming. Using data on young Finnish consumers, we verify that a key determinant of multihoming behavior is consumer awareness. We show, however, that not controlling for the endogeneity of awareness can severely bias its effect downwards. Our IV/GMM -estimations show that the better informed use as much as 1.2 times more payment media than the less informed. Because many payment method innovations are typically first used simultaneously with the established methods, our results suggest that increasing consumer awareness could significantly speed up the adoption of new means of payment, such electronic money and mobile payments.

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1 Introduction

Monetary history is full of examples where new payment media have taken off only slowly, if at all. It is not well understood what hampers the diffusion of these financial innovations, notably because of a lack of systematic evidence.[1] In particular, it can be hard to obtain consumer-level data on early adopters of emerging payment media. In this paper we take advantage of the exceptional feature of the payment media market that some consumers only use one medium, while others adopt many, i.e., "multihome".[2] Such multihoming essentially reflects the diffusion of new payment media, because even the most recent major innovations, coins, checks, paper money, and the payment card, have been used over an extensive period of time in chorus with the previously established payment media (Evans and Schmalensee, 1999). This novel insight gives us a possibility to view the determinants of the adoption of new payment media through the window of multihoming.

The known determinants of the adoption of new payment methods are natural. Monetary costs hinder diffusion (cf., e.g., Humphrey, Kim, and Vale 2001), the rate of adoption varies with consumer demographics (such as age, education and home-ownership status; see Carow and Staten 1999, Mantel 2000), and localized feedback loops between consumers and merchants matter (Rysman 2004).

[1] See Frame and White (2004) for a review of the scarce empirical literature on financial innovations and their diffusion. In many other dimensions, the literature on payment systems and methods is quite extensive, as can be seen from the excellent surveys by Hancock and Humphrey (1998) and Drehmann, Goodhart, and Krueger (2002).

[2] The way we use this term is closely related (but not identical) to its use in an emerging industrial economics literature on two-sided markets. In this literature, a consumer is said to be engaged in multihoming if she carries, say, two different *brands* of credit cards, with the two brands being close substitutes. As substitutability is a matter of degree, we use the term somewhat more liberally but in the very same sense.

There also is a received marketing tenet suggesting that providing information about a new product fosters its diffusion, especially if the adoption is held back by non-monetary costs, such as the costs arising from imperfect consumer information, and learning and searching costs. But, prior to our study, virtually no evidence exists on the effects of the non-monetary costs on the adoption of new payment media, nor whether and how much the adoption could be facilitated by information provision.

Our evidence from a random sample of young Finnish consumers suggests that the non-monetary costs are important and particularly that consumer awareness enhances multihoming. The economics of this positive relation is that consumer awareness reduces learning and searching costs as well as imperfect consumer information. It does so almost by definition. We estimate the *quantitative* importance of this effect.

Before we run into empirics and put consumer awareness into specific terms to quantify its effect, we formulate a theoretical model of multihoming. In our model consumers multihome, because it reduces the time cost of transactions. The negative relation arises because the more payment media a consumer carries, the easier her access to a modern economy's accounting network in different circumstances. Balancing the time cost of transactions against the monetary and non-monetary costs of adopting multiple payment media results in the optimal level of multihoming. The model also predicts that the optimal level of multihoming depends on consumer awareness, because the non-monetary costs are inversely related to it.

Although our model results in an estimating equation that is equivalent to a reduced form specification, the structural derivation of the model uncovers the components of the effect of consumer awareness that the reduced form estimate

mirrors. The theory also provides us with the conditional mean of a regression model, which is identical to the conditional mean of a Poisson (count) regression model with multiplicative unobserved heterogeneity. As we have a count variable as the dependent variable, we should model a count process, something that our conditional mean equation takes into account by design. It also turns out that unobserved heterogeneity cannot be overlooked. To tackle with the unobserved heterogeneity, we need instruments. Here again the model turns out to be helpful, suggesting theoretically motivated instruments.

As we will argue, multihoming is an increasingly relevant phenomenon in modern economies with advanced accounting networks and payment markets. We believe that Finland is a good approximation of such an economy, because the Finnish market for payment media is by international standards advanced and because Finns have for long relied on an access to electronic payment networks when paying point-of-sale (see Section 2 for a more detailed description of the Finnish market). We therefore test the predictions of our model of multihoming using Finnish data. We can also take advantage of some unique features of the survey data on young Finnish consumers available to us.

- The data contains direct measures of the point-of-sale paying habits of consumers. The measures allow us to generate a dependent variable at the level of individual consumers that distinguishes the point-of-sale paying from settling bills and the actual use of the payment media from having (an access to) them.
- As Guiso and Jappelli (2003) point out in their study of the consumer awareness and stock market participation, consumer awareness can take many guises and be an elusive concept, for it can be both about the existence and characteristics of payment media. We get a grip of it because the

data includes a series of questions capturing the consumers' exposure to the provision of information about financial services and payment media. The data also contains instruments, which allow us to control for the potential endogeneity of consumer awareness.

- Young consumers typically show a great rate of adoption of new payment media (Humphrey et al. 2001 and Stix 2003). We can evaluate the importance of both non-monetary and monetary costs for this segment of consumers in isolation.

Our data supports the notion of multihoming, as more than half of the young Finnish customers in our sample multihome. Not surprisingly, we find that the monetary costs of adoption are also important for the young. But consumer awareness turns out to be at least equally important determinant of multihoming. Endogeneity of consumer awareness cannot, however, be ignored, because we find that not controlling for the endogeneity can severely bias the effect of consumer awareness downwards. Our IV and GMM estimates indicate that the effect is quantitatively important: the better informed use 1.2 times more payment media than the less informed. Becoming informed thus leads to 20% increase in the expected number of payment media a person uses. We show that the effect of consumer awareness on multihoming is robust to introducing a rich set of control variables, such as consumer characteristics and variables describing the consumers' banking relationships. It also survives a number of other empirical checks.

While our analysis does not provide new insights on what drives the discrete choices between using "plastic or paper" and "debit or credit" (see, e.g., Zinman 2005, and Klee 2005), the key implication of our finding is that increasing consumer awareness can speed up the adoption of payment method innovations, such electronic money and mobile payments. Combined with theory (e.g., Rochet and

Tirole 2003), the finding also yields a variety of managerial implications for merchants and the issuers of payment media that will be elaborated in conclusions.

The remainder of the paper is organized as follows: In the next section, we describe the institutional environment and particularly some special characteristics of the Finnish market of payment media that make Finland a neat case for our study. In section 3 we consider the theoretical underpinnings of our study. The empirical implementation of the theoretical model is explained in section 4. In section 5 we describe our data and the construction of variables. We go trough the basic estimations, their results, and robustness tests in section 6. In section 7 we address the potential endogeneity of consumer awareness. The concluding section (section 8) includes a discussion of the implications of our findings for the adoption of new payment media.

2 Institutional Environment

2.1 The Finnish Market for Payment Media

The Finnish market for payment media has some distinctive properties that simplify the study of multihoming.[3] There are also some profound differences with the often-studied US market of payment media (see Ausubel 1991 and Humphrey, Pulley, and Vesala 2000 for a description of the US market).

The Finnish market for payment media is relatively advanced, for Finns have for sometime relied on accessing electronic payment networks when paying point-of-sale. A clear difference relative to the U.S. (and many other countries also) is that checks are no longer used in consumer trade *at all*, whereas debit

[3] Most of the industry details presented here are available at The Finnish Bankers' Association www-pages. For more information, see http://www.pankkiyhdistys.fi/english/index.html.

cards have been popular for some time now: In 2002, they accounted for 2/3 of the value of all card payments.[4]

In Finland, credit and debit cards appear to be closer substitutes than in the U.S.. This means that studying the discrete choice between "debit" and "credit" (that has recently been studied in the U.S.; see e.g., Zinman 2005), is less of interest to us. The claim that credit and debit cards are close substitutes can be backed from four angles:[5] First, Finns in general and young Finns in particular use their credit cards primarily for paying and *not for borrowing*: Our data (described more closely in section 5.1) tells us that in 2002, 37% of the young had an outstanding credit balance, but only for 5% it originated from payment card borrowing (for 4% from credit cards).[6] Instead of borrowing, the young have other, convenience related motivations to use a credit card, such as a Visa or a MasterCard. One of them is the desire to use it abroad in the point-of-sale transactions. Further, it is very typical for Finns to pay off their credit card balance in full by the payment due date. (By doing so they avoid paying interest on the balance they had). Second, the "rewards" benefits available for a credit card user, such as rebates or airlines miles, have played a small role. Third, while we do not have exact numbers for Finland, the benefit of "float" (i.e., interest-free loan) that a typical Finnish consumer (who always pays the balance in full) foregoes if she uses debit instead of credit, appears to be negligible (see also Zinman 2005, who computes the foregone float to be about 3$ for a "typical" U.S. customer).

[4] Various surveys show that between 1999 and 2003, the use of debit cards as the most common way of paying for daily consumer goods and services increased from 17% to 30%.

[5] The four margins in which credit and debit cards are close substitutes both in the U.S. and in Finland are acceptance, security, portability and time costs (see Zinman 2005 for a discussion from the U.S perspective)

The use of cash is decreasing rapidly. Between 1999 and 2003, the use of cash as a way of paying for daily consumer goods and services decreased by 18% (13 percentage points, to 58%). Although it still is relatively common in point-of-sale transactions, the ratio of currency in circulation to GDP, about 1.8% in 2002, is in Finland among the lowest in Europe. Moreover, a special feature of the Finnish market is that the use of cash is almost invariantly preceded by the use of an ATM: The entire currency in circulation (2,4 billion euros) goes through the ATMs seven times a year. There are two reasons for this: First, virtually everyone has a banking account where incomes are credited directly and an ATM (compatible) card. The use of cash without first accessing one's bank account via an ATM is a habit that is restricted to the senior citizens that have never learned to use ATMs. Second, the coverage of the ATM networks is rather extensive in Finland, and the networks of different banks allow for roaming.[7]

In Finland the market for payment media is concentrated, because the few main deposit banks that dominate the banking sector are the main issuers of payment media. Because the issuers of payment media are relatively homogenous the payment media, their pricing, and the ways of providing them with customers tend to be similar across the issuers, at least after controlling for the banking relationships of consumers.

Last but not least, the pricing of the payment media is also quite simple. At least one ATM or payment card is often automatically attached to a banking ac-

[6] For the rest, the loan was either a mortgage or a student loan. Borrowing via payment cards is directly related to age even within the young.

[7] The reason for the extensive ATM networks is that the Finnish banking sector was heavily regulated until the late 1980s. Because both deposit and loan interest rates were regulated, the banking groups competed by the scope of their service network. The last phase of the service competition was the introduction of ATMs. The deregulation and the subsequent banking crisis of the early 1990s actually first intensified the competition through ATM networks, because the banks replaced their branches by a set of ATMs to cut down costs.

count as a part of a banking service package. As explained by Koskinen (2001), the packages can include various payment media, whose pricing hence depends on the pricing of the banking service packages. Their pricing in turn is tied to the age of a consumer. It is typical that the basic packages are free of charge until the age of 26.

2.2 Point-of-sale Paying

We make two further observations on the institutional environment in which we embed our empirical analysis:

First, as also the studies by Humphrey, Pulley, and Vesala (1996, 2000) indicate, an increasing fraction of all point-of-sale purchases of goods and services are paid for by means of signals to an accounting network. The widespread use of the electronic payment media means that there is less need for transfers of a tangible medium of exchange. But more substantially, even when the tangible medium is transferred, it is often preceded by a connection to an ATM network. This appears to apply particularly well to Finland, where the entire currency in circulation goes through the ATMs several times a year and where getting "cash back" when paying by a card (say, at a retail store) is rare.[8] Because paying in cash practically translates into owning and repeatedly using an ATM card, use of cash at point-of-sale has an intimate relation to using an ATM card. We can therefore equate use of cash to using a "virtual payment card" (i.e., an ATM-card), which is used to debit an account. In a sense, an ATM-card is a payment card with improved security and privacy, but with larger costs of debiting a buyer's account, because all physical, monetary, and time costs are borne by the cardholder prior to

a transaction. Combined with the absence of checks, the foregoing suggests that "paper" need not be as different from "plastic" in Finland as it may be on some other counties (see Klee 2005 for a U.S. perspective).

Our second observation relates to the costs of transaction time. We hypothesize that adopting additional payment media is a means to reduce them. As Rochet and Tirole (2003) demonstrate, the two-sided feature of payment media market easily leads to a situation where some merchants do not accept some payment media that are accepted by other merchants. "Paper" (i.e., cash and an ATM card) may be of little use if one wishes to buy something on-line, make a phone order, rent a car, or book and pay a hotel reservation. Neither are credit/debit cards accepted universally, examples of such events being purchases at very small family shops, specialized retail stores and flea markets. Thus, the broader is the set of payment media a consumer carries, the easier is her access to the accounting network in various circumstances, since she can more flexibly initiate debits and credits to her wealth accounts for transaction purposes.

3 Multiple Payment Methods in a Shopping Time Model

In this section, we formulate a theoretical model of multihoming. We use the model to systematically develop our main hypothesis about the effect of consumer awareness on the adoption of payment media. The model formulation is borrowed from the literature on money demand, as there is no need to derive a new theory of payment media for our purposes. Our simple model results in an estimating equation that is equivalent to a reduced form specification. The model is, how-

[8] Indeed, Attanasio, Guiso, and Japelli (2002) find that the diffusion of ATM cards is the main factor explaining the shrinking currency holding.

ever, informative, for it both makes our assumptions transparent and puts structure into our empirics, in particular, into the search for instruments.

3.1 Main Assumptions

Our modeling set-up builds on two main assumptions: The first assumption is that a modern consumer's decision problem is about choosing the optimal number of payment media (that allows her to access an account at the electronic accounting network) *rather than* about (i) choosing the optimal currency holding or (ii) making a discrete choice of using a single medium (say, a card) from the set available payment media. This assumption means that the relevant set of payment media is relatively homogenous:[9] If checks are no longer used and if using cash invariable means using an ATM card, the relevant choice set for Finnish consumers reduces to the set of "available cards". Further, within this set, the choice between a credit and debit card is not to the same extent about choosing between borrowing and convenience use in Finland as it apparently is in the U.S. At least this is the situation that essentially prevailed in Finland under the period where our data comes from. As a result, consumers effectively choose an optimal number of various "cards" to economize the transaction time and associated costs.

An important implication of this assumption is that the marginal benefit (in terms of reduced shopping time) of adopting yet another payment card is decreasing (in a similar manner as the marginal benefit of larger real cash balances is).

[9] This implication may sound strong, for there is a large literature building on the various differences between the payment cards (see, e.g., Shy and Tarkka 2002, Zinman 2005, and the references therein). As a matter of fact, it has been argued that payment media can be hard to *rank* unambiguously, precisely because they differ in many dimensions (see, e.g., Santomero and Seater 1996): Some are associated with foregone interest, some involve longer processing costs, some provide more privacy, some protect better for fraud and others for accidental losses. If that is the case, it may be difficult to identify which media outperforms the others and in what dimensions. Here we do not explicitly model the trade-offs that emerge from such differences, nor do we study how they affect which payment media a consumer uses.

Although a complete model of multihoming would incorporate all differences between the different payment media, it should still involve a decreasing marginal benefit in the reduction of shopping time. The property should arise also if the payment cards are substitutes on average, but heterogeneous in how effectively they reduce shopping time for a particular consumer.

The second main assumption of ours is that consumers find the optimal number, i.e., the optimal level of multihoming, by weighting the time cost of transactions against the cost of adopting multiple payment media. We argue that this trade-off underlying the demand for payment media is deceptively similar to that behind the demand for money in the classic Baumol-Tobin model (Baumol 1952, and Tobin 1956). We therefore take the key ingredients for our model from the modern variants of the Baumol-Tobin model by McCallum and Goodfriend (1987), Santomero and Seater (1996), Mulligan and Sala-i-Martin (2000), and Attanasio et al. (2002).[10]

3.2 Model Formulation

Our two main assumptions suggest that multihoming reduces the time cost of transactions but at a decreasing rate. The following Baumol-Tobin type of technology determining transaction time captures formally this idea:

$$\tau = AT^{\gamma_1}\left(\frac{T}{n}\right)^{\gamma_2} \tag{1}$$

where A is a technology parameter, T is the amount of transactions to be conducted, and γ_1 and γ_2 are parameters, and n is the principal variable of the inter-

est, the number of payment cards adopted by a consumer, i.e., her level of multihoming. Building on this technology, our goal is to derive a model of the determination of *n* that guides our empirics.

Let ω denote the time cost of transactions (shadow value of time), and ψ the monetary and non-monetary cost of adopting a new payment medium, which is assumed to be fixed with respect to the number of adopted payment media. The consumer chooses *n* so as to minimize the sum of the costs of transaction time, $\omega\,\tau$, and the total adoption costs, ψn, subject to the transaction technology (1). Ignoring for brevity integer problems, demand for payment media is given by

$$n = T^{\frac{\gamma_1+\gamma_2}{1+\gamma_2}}\left(\frac{\omega A\gamma_2}{\psi}\right)^{\frac{1}{1+\gamma_2}}. \qquad (2a)$$

Equation (2a) shows how the optimal level of multihoming is directly related to the amount of transactions, *T*, and inversely related to the adoption cost, ψ. Our focus is on the adoption cost.

The models of technology adoption by consumers suggest that the non-monetary costs, e.g., searching and learning costs, primarily arise from imperfect consumer information. Because consumer awareness, denoted by *a* in what follows, reduces it and thus ψ almost by definition, we assume that $\psi = \psi(a)$ with $\psi'(a) < 0$. It then immediately follows from (2a) that $n'(a) > 0$, that is, our model predicts that the optimal level of multihoming is directly related to consumer awareness. This way of introducing awareness is admittedly ad hoc, but its empirical specification in the subsequent section allows for a richer interpretation, including an analysis of endogeneity of *a*.

[10] Santomero and Seater (1996), in particular, allow for several payment media. In their model obtaining a medium of exchange requires a separate 'trip to the bank' for each medium and, accordingly, consumers choose the number of banking trips separately for each payment medium. In

4 Empirical Model of Multihoming

4.1 Consumer Heterogeneity

In practise both the adoption cost, ψ, and the amount of transactions, *T*, consist of several factors and probably vary across consumers. To allow for this type of consumer heterogeneity we rewrite (2a) as

$$n_i = T_i^{\frac{\gamma_1+\gamma_2}{1+\gamma_2}} \left(\frac{\omega A \gamma_2}{\psi_i} \right)^{\frac{1}{1+\gamma_2}} \tag{2b}$$

for each consumer i = 1, 2, ..., N. We follow Mulligan and Sala-i-Martin (2000) and assume that ψ_i varies both with observable and unobservable characteristics of consumers. For example, income and financial wealth are observable in our data. Also many demographic and socio-economic characteristics such as gender, age and education, are observable to us. So is the awareness of consumer *i*, a_i.

The unobservable consumer heterogeneity is defined as

$$\upsilon_i \equiv \ln \psi_i - x'_i \delta + \alpha a_i , \tag{3}$$

where δ is a column vector, and x'_i is a row vector that includes a constant and the observable consumer characteristics except for awareness. The unobservable consumer-specific component defined by (3) is assumed to be independently and identically distributed, as well as independent of the amount of transactions, T_i, and the observable consumer characteristics, x_i and a_i, i.e., $E\left(\upsilon_i \middle| x_i, a_i, T_i\right) = 0$. In section 7 we show that this assumption can to some extent be relaxed.

After some manipulations, we can substitute (3) for (2b) to obtain

contrast, our model builds on the assumption that consumers directly choose the number of payment media instead of the number of banking trips associated with each medium.

$$n_i = \exp\left\{\frac{1}{1+\gamma_2}\left[\ln \omega A\gamma_2 + (\gamma_2+\gamma_2)\ln T_i + \alpha a_i - x'_i\,\delta - \upsilon_i\right]\right\} \qquad (4)$$

Because ω and T_i are unobservable, we still need to make two auxiliary assumptions to arrive at an estimable model.

First, as (4) already suggests, we assume that the time cost of transactions, ω, does not vary across consumers *conditional* on x_i. As a result, the first term, $\ln \omega A\gamma_2$, in the exponent function can be subsumed into x'_i.

Second, although we cannot directly measure T_i, we can observe consumers' income levels. An implication of the standard consumption function relation is that there is one-to-one mapping from a consumer's income to her consumption. We postulate that there is also one-to-one mapping from the consumption to T_i: the more one consumes, the more transactions need to be initiated. Such a relation is intuitive and, accordingly, it has been implicitly assumed in the previous literature, e.g., in Mulligan and Sala-i-Martin (2000) and Attasanio et al. (2002). It follows that a consumer's income and the amount of transactions she carries out have one-to-one relation. We capture the relation by assuming that T_i is a non-linear function of a consumer's income and her other characteristics, i.e., that

$$T_i = \exp\left(\theta_1 INC_i + \theta_2 INC_i^2 + \sum\nolimits_{j=3}\theta_j x_{ij}\right), \qquad (5)$$

where INC_i denotes consumer i's income level. The exponential specification in (5) is chosen, because T_i is a count variable. Under our specification, T_i could be the conditional mean of a Poisson density, and hence an outcome of a count process.[11] Specification (5) also ensures that the flow of transactions is positive.

After substituting (5) for (4) and using the first assumption, we have

$$n_i = \exp\left(\pi_0 a_i + \pi_1 INC_i + \pi_2 INC_i^2 + \sum_{j=3} \pi_j x_{ij}\right)\varepsilon_i, \qquad (6)$$

where $\varepsilon_i \equiv \exp\left(-\frac{\upsilon_i}{1+\gamma_2}\right)$ with $E(\varepsilon_i | T_i, a_i, x_i) = 1$, $\pi_0 \equiv \frac{\alpha}{1+\gamma_2}$ and, expect for π_0 and the constant, $\pi_j \equiv \frac{(\gamma_1+\gamma_2)\theta_j - \delta_j}{1+\gamma_2}$.

4.2 Estimation Issues

Equation (6) forms the gist of our empirical model of multihoming, as it provides us with the conditional mean of a regression model. We use three methods to estimate the model and particularly, π_0, the effect of consumer awareness on multihoming. As a benchmark we estimate a model with a linear mean function using OLS. The linear model is easy to justify even if the conditional mean function is given by (6), because in practice the two specifications produce qualitatively similar estimates.[12] Because $n_i > 0$, we can also resort to the widely-used log transformation of the dependent variable when estimating the parameters of the conditional mean equation (6). OLS estimation of the resulting transformed model provides us with a second set of results. Finally, we estimate the model using the Poisson quasi-likelihood method and the robust Huber-White variance-covariance matrix.

The Poisson quasi-likelihood method has two advantages: First, the conditional mean in (6) is conveniently identical to the conditional mean of a Poisson

[11] We could generalize this "conditional mean" to allow for multiplicative unobserved heterogeneity, provided that the multiplicative component is *iid* and independent of both the regressors and v_i. The quasi-likelihood methods for count data that we will use would be robust to this type of extension (see Wooldridge 1997 pp. 379-380.). For simplicity, we do not pursue this extension.

(count) regression model with multiplicative unobserved heterogeneity (see for example Wooldridge 1997, pp. 379-380 and Cameron and Trivedi 1998, pp. 97-98).[13] As will be explained in the next section, the level of multihoming – our dependent variable – is the number of different payment media a young consumer uses when paying for her purchases or consumption of services. An implication of such a dependent variable is that we would have to model a count process, something that our conditional mean equation takes into account by design.

The second advantage is that we know from the results for generalized count models that the consistency of estimation requires only a correct specification of the mean. Under the currently maintained assumption of exogenous consumer awareness, the Poisson quasi-maximum likelihood estimator will yield consistent estimates of the parameters of the conditional mean function, in particular, π_0. Because we have specified neither a variance function nor the probability density function for ε_i, the standard Huber-White sandwich estimator can be used to obtain consistent estimates of the variance-covariance matrix (Wooldridge 1997).[14]

Less conveniently, we cannot, as equation (6) shows, without additional assumptions identify the structural parameters γ_2 and α from the coefficient of a_i. Only the total effect of consumer awareness on multihoming can be quantified

[12] The reason for the similarity is that it can be shown using a first-order Taylor series expansion of the conditional mean around the sample mean of the dependent variable, $\overline{n}$, that linear mean slope coefficients are approximately $\overline{n}$ times exponential slope coefficients (Cameron and Trivedi 1998, p. 89).

[13] This generalized count regression has the property that the unobservables and observables are treated symmetrically.

[14] By specifying a mixing distribution for ε_i, we could derive the exact marginal distribution for the dependent variable. A two-parameter gamma distribution would result in a Poisson-gamma mixture, i.e., the familiar negative binomial model for counts (Cameron and Trivedi 1998, pp. 100-101). However, because a specific parametric distributional assumption for ε_i is at best a crude approximation, we follow a more general approach of using the Poisson quasi-maximum likelihood method and the Huber-White variance-covariance estimator. We return to this issue in the robustness tests in section 5.2.

from the data. Nonetheless, the structural derivation of the model uncovers the theoretical components of the total effect.

5 Data and Definition of Variables

5.1 Data

The Finnish Bankers' Association has commissioned a survey of young adults [in Finnish: "Nuorisotutkimus"] in 1996, 2000 and 2002. The primary aim of the surveys has been to collect data on the consumption habits of young Finns and their views about banking and financial products and services. The data for our analysis comes from the survey conducted between the 21st February and 5th March, 2002. The survey was based on a random sample of 1004 young adults aged between 15 and 28. We use the entire sample, which represents approximately 1/900 of the total population in the age group.

The data is rich in detail concerning the young adults' demographic and socio-economic characteristics, financial affairs, banking relationships, and information about banking products and financial affairs, including payment media. The data also includes information about the use of various payment media in retail transactions.

5.2 Dependent Variable

In this study the dependent variable, n_i, is the number of different payment media a young consumer uses when paying for her purchases or consumption of ser-

vices. The dependent variable summarizes the answers of the following three related questions in the survey:[15]

1) *What is the most typical way you pay for your purchases or consumption of services? i) cash, ii) debit card, iii) combined debit-credit card, iv) credit card, v) debit or credit card issued by a retailer, vi) Visa Electron, vii) stored value card , viii) GSM or WAP phone, ix) by other means, how? (specify)*;
2) *What about the second most typical way? Is it i) cash, ii) debit card, iii) combined debit-credit card, iv) credit card, v) debit or credit card issued by a retailer, vi) Visa Electron, vii) stored value card, viii) GSM or WAP phone, ix) by other means, how? (specify), x) there is no second way*;
3) *Do you still use another ways to pay for your purchases or consumption of services ? If yes, what are these? i) cash, ii) debit card, iii) combined debit-credit card, iv) credit card, v) debit or credit card issued by a retailer, vi) Visa Electron, vii) stored value card, viii) GSM or WAP phone, ix) by other means, how? (specify), x) there are no additional ways*.

Our method of counting of payment media has some useful properties. First, the three questions identify virtually all the payment media consumers could use when paying for consumption or services at the point-of-sale in Finland. Moreover, even if a payment medium was not properly identified, the respondents had three possibilities to identify such a medium by themselves. But no one did. Third, all the questions concern actually using a payment medium, not having an access to it. We therefore need not to worry about card owners who never use their cards even if they constituted a significant fraction of card ownership as, e.g., in Austria (see Stix 2003). Such phenomenon of "sleeping" cards can also exist in Finland where, as mentioned in section 2, almost every young has a banking account to

[15] Translation from Finnish by the authors.

which a payment card is automatically attached as a part of a (free) banking service package.

Yet another useful property of our data is that just before the questions of the use of payment media in retail transactions were presented, the respondents had been asked about their habits of paying for their bills. Our count variable should thus capture the young adults' payment habits in point-of-sale-transactions instead of their bill-paying habits.

5.3 Consumer Awareness

The previous literature unfortunately provides little help in choosing a proxy for consumer awareness, a_i. We measure it based on a series of questions included in the survey that concern the provision of information about payment media. We code an indicator variable that equals 1, if the respondent answered of having either received or been offered a *lot* of information about debit or credit cards, ways of paying bills, use of transaction accounts, or borrowing through credit cards; and zero otherwise.

The rationale for our definition of a_i is that a consumer's awareness of the existence and characteristics of payment media is likely to be directly related to the amount of information the consumer has been offered about them. The amount should, in turn, be directly related to the systematic and unsystematic forms of information provision by the various issuers of payment media. The currently maintained assumption of exogenous awareness requires that the exposure by consumer *i* to the information provision (as captured by a_i) is not related to ε_i (the unobservable consumer heterogeneity) after conditioning on the other observables (in x_i').

Although our measure of consumer awareness is certainly imperfect, we have several reasons to trust in it. First, in count models with an exponential mean function, the effect of an additive measurement error in a right-hand-side variable is qualitatively identical to that of unobserved heterogeneity (Cameron and Trivedi 1998, pp. 307-309). This property means that our results based on the Poisson quasi-maximum likelihood estimator are robust to such a measurement error, provided that the measurement error is uncorrelated with the regressors. Second, we show that our results hold in instrumental variable estimations that corrects for errors-in-variables when the measurement error and a regressor do correlate. Third, we also establish the robustness of our results with respect to an alternative proxy for consumer awareness. Finally, if our proxy failed to capture consumer awareness in a meaningful way, we should find no statistically significant effects.

5.4 Control Variables

The derivation of equation (6) suggests that the vector of observables, x_i', should include variables that reflect, ψ_i, the monetary and non-monetary costs of adopting new payment media. The vector should also include variables affecting the amount of transactions, T_i, because we have assumed in (5) that it is a function of a consumer's income and her other characteristics.

It is ultimately an empirical matter which variables affect the adoption costs and the amount of transactions. We therefore construct two different sets of control variables. The first set consists of demographic and socio-economic characteristics: sex (SEX = 1 if the respondent is female), age in years (AGE), age squared (AGESQ), employment status (EMP = if employed; UNEMP = if unemployed, the omitted category is for students), level of completed or on-going education

(HIGH = 1, if university, MEDIUM = 1 if high school or equivalent, the omitted category is for those with elementary school education), household type (NO-HOUSEH = 1, if lives with parents), type of family (CHILDREN = 1, if has at least one child), residential area (CITY = 1 if lives in a city with more than 30 000 inhabitants), geographic region of residence (WEST = 1, EAST = 1, NORTH = 1, if lives in these parts of Finland, the omitted category represents the respondents living in south), income (INCOME, in thousands of EUR), income squared (IN-COMESQ), the type of real wealth (RWEALTH = 1 if owns a real estate, a house or a condominium), financial wealth (FWEALTH = 1, if has savings in deposit or savings accounts, if owns stocks, shares of mutual funds, bonds, private pension insurance, or if has made other financial investments), and liquid wealth (LWEALTH = 1, if has savings in transaction accounts).

The demographic and education variables control for heterogeneity in adoption costs and consumption behavior, because they reflect preferences and ability. Dummies for the residential area and region capture the notion that payment media is a two-sided market and the adoption determinants considered by Attanasio et al. (2002), Stix (2003) and Rysman (2004), such as the number of ATM points in the area of residence and regional variation in the acceptance of payment media by retailers. They also capture other regional variation affecting multihoming. For example, the determinants of consumer awareness uncovered by Guiso and Jappelli (2003) include geographical variations in the intensity of social networks and learning as well as in the costs of spreading information about payment media. We also control for income and the type of wealth, because they affect consumption patterns and measure how relevant fixed monetary adoption costs are.

The second set of control variables comes from the regressors depicting consumers' relationship to their deposit banks: Identity of a consumer's main

bank (MBANK_*h* = 1, if principally uses the services of bank *h*, *h* = 1, 2, …, 6, the omitted category is for those who principally use the services of bank 7), use of other banks (NOSBANK = 1, if uses the services of other banks in addition to the main bank), choice of the main bank (BCHOICE = 1, if the main bank has been chosen by the respondent herself and not, e.g., by her parents or spouse), duration of the relationship with the main bank (BLENGHT = 1 if has been a customer of the current main bank since her birth), membership in the main bank's youth club (BCLUB = 1 if a member), and recent switch of main bank (SWBANK = 1 if has changed the main bank over the past 12 months).

Controlling for the banking relationships is quite natural because of the prominent role of the deposit banks in the Finnish market for payment media (see section 2). We trust that these regressors reflect heterogeneity in adoption costs: The MBANK_*h* -dummies and NOSBANK should capture, for example, differences in the pricing of various cards and marketing strategies across the banks. We can moreover conjecture that BCLUB proxy the initial level of consumer awareness about payment media, as a former member of a bank's youth club should be relatively well informed about banking products and services.

We introduce the two sets of controls sequentially into the model to ensure that our results are not driven by potential (unmodelled) endogeneity of some of the control variables in the second set of regressors. Variable SWBANK is for example potentially endogenous, because consumers could self-select, i.e., switch their main bank on the basis of anticipated demand for multiple payment media.[16]

[16] Besides the control variables described here we have tried several other groupings and sets. Our results are robust to such alternative specifications as also the robustness tests of the next section indicate.

6 Analysis

6.1 Descriptive Statistics

The summary statistics are presented in Table 1. They show that the respondents are on average 21 years old and have annual income of about 8100 EUR. A bit more than half of them are female, some 60% of them are students and around 28% have a university degree or are studying for one.

The table also indicates that multihoming is common in the market for payment media, but its scope is rather restricted. The dummy variable, DMHOME, which equals zero if the respondent singlehomes and unity if the respondent multihomes, indicates that 53% of the young Finns use more than one payment medium in their point-of-sale transactions.[17] The count variable, n_i, varies from 1 to 3 and has a mean of 1.6.[18] The average consumer awareness, a_i, is rather high, 0.7. Our measures thus indicate that consumer awareness is "more widespread" than multihoming. This is what we expect, for it would contradict the idea of awareness, if the opposite held.

[INSERT TABLE 1 ABOUT HERE]

Figure 1 displays the distribution of n_i conditional on a_i. The figure suggests that multihoming and consumer awareness are not independent, as consumer awareness clearly shifts the distribution of n_i to the right. As many as 65.4% of the uninformed consumers (with $a_i = 0$) use only one payment medium, while the

[17] While not shown in the table, an ATM card is the primary method for the young to debit their accounts. Approximately 3/4 of the respondents keeps cash as their most typical way of paying for their purchases or consumption of services. This fact violates none of our assumptions.

corresponding percentage for the informed is 39.1%. Put differently, 83% of the multihomers are better informed. To formally assess for the presence of dependence between multihoming and awareness, we compute Pearson's χ^2 -test. The test for independence obtains a value of 55.75 (*d.f.* = 2), which allows us to firmly reject the null hypothesis at the 1% significance level.

[INSERT FIGURE 1 ABOUT HERE]

6.2 Basic Estimations

In Panel A of Table 2 we present the results of the OLS, OLS with the log-transformed dependent variable ('log-OLS') and Poisson quasi-likelihood estimations when only the first set of control variables is included. Panel B reports the results when both sets of controls are used. The results show that the dummy for consumer awareness obtains a positive coefficient that is statistically significant at the 1% level, irrespective of the estimation method and the included set of control variables. This finding suggests that consumer awareness increases multihoming.

As to other determinants of multihoming, they are mostly in line with our expectations. Propensity to multihome is increasing in INCOME, but the positive relation begins to weaken after a threshold. Financial asset ownership also increases multihoming. If the findings are not entirely driven by different consumption patterns of the affluent, they indicate that also the young care about the monetary costs of adoption. Multihoming also depends on gender and education as the coefficients of SEX and HIGH suggests. Females, university students, and graduates use more payment media than their otherwise identical counterparts. From

[18] One respondent used four payment methods. We recoded her answer to equal three.

Panel B we can observe that membership in a bank's youth club turns out to be the only significant (at the 1% level) determinant of multihoming from the second set of control variables.

[INSERT TABLE 2 ABOUT HERE]

Although the effect of consumer awareness on multihoming is statistically significant, the results seemingly suggest that its economic meaning is smallish. According to the Poisson estimates of Panel A, the conditional mean is about $\exp(0.09) \approx 1.09$ times larger if $a_i = 1$ than if $a_i = 0$. Comparing consumer awareness with the other determinants of multihoming, however, shows that its effect is among the strongest. For example, the effect a_i is about twice that of SEX and that the conditional mean increases by the same proportional amount if INCOME increases by one standard deviation, i.e., if the respondents' annual income more than doubles. Moreover, our instrumental variable estimations, reported in section 7.4, suggest that the basic estimates are likely to be biased downwards.

6.3 Robustness Tests

To assess robustness of the documented effects we run a number of new regressions. In these robustness tests we use the two previously defined sets of control variables as the basic set of included regressors. For brevity, we only discuss the results of the robustness tests informally.

Robustness test 1: So far the level of multihoming has been represented by a count variable, which raises a concern that our results could be sensitive to the definition of the dependent variable. To address the concern, we transform the

count variable to a binary variable, called DMHOME in Table 1, by recoding 1 to 0 and values of 2 and more to 1. Although the transformation involves a loss of efficiency, it allows us to assess whether using the binary variable as the dependent variable changes our basic finding. It does not. Both the Logit and Probit estimations show that consumer awareness increases multihoming.

Robustness test 2: Another concern is the potential model specificity of our results. We derive the demand for multihoming from a rather specific theoretical model, which directly yields a count model. Alternatively, one could run reduced-form regressions, where multihoming is the dependent variable and consumer awareness is one explanatory variable among others. Because this approach would not necessarily result in a count model, we fit an ordered Logit and Probit models to the data. Our results are robust to using these alternative, order-based estimators.[19]

Robustness test 3: To address the problem of omitted variables, we construct a third set of control variables. The new set allows us to better control for heterogeneity that the amount of transactions, T_i, brings into the model. In particular, we are concerned about variation in the young Finns' consumption habits beyond what their basic demographic and socio-economic characteristics capture. The new set of regressors are as follows (the descriptive statistics are in the Appendix, Table A1): loan market status (BORROWS = 1 if currently has outstanding debt), use of the Internet (USEINT = 1 if uses the Internet regularly), and planned consumption (SPEND_c = 1, c = 1, 2, …, 6, in which c indexes planned near-term

[19] The results are also robust to using the standard negative binomial model. Imposing the nominal variance assumption of Gourieroux, Monfort, and Trognon (1984a,b) and using a two-step negative binomial quasi-maximum likelihood estimator would result in a more robust negative binomial model. It is, however, equally robust to the Poisson quasi-maximum likelihood that we use (Wooldridge 1997, pp. 381-382). Because no efficiency gain can be expected, the use of the two-step negative binomial quasi-maximum likelihood estimator is difficult to motivate here.

spending on education (c=1), housing (c=2), traveling (c=3), computers (c=4), sport or outdoor clothing and equipment (c=5), and other (c=6); the omitted seventh category is for the respondents without near-term spending plans).

Adding the new set of controls does not change our findings: In all estimations (OLS, log-OLS, and Poisson) the coefficient of consumer awareness remains positive and statistically significant at the 1% level.

Robustness test 4: Both theoretical and empirical research suggests that pricing of the payment media matters for the rate of adoption and multihoming (Santomero and Seater 1996, Humphrey et al. 2001, and Rochet and Tirole 2003). While we trust that the regressors reflecting consumers' banking relationships also capture differences in the pricing, a further robustness check is in order. As explained in section 2, it is typical that at the age of 26, the use of various banking service packages to which cards are often attached cease to be free of charge. Crossing this age may thus trigger search and reoptimization. We therefore include a dummy equalling one for those who are 26 or over, but the dummy does not get a significant coefficient.[20] The coefficient of consumer awareness changes only a little, if at all

Robustness test 5: Because our definition of consumer awareness could be driving the results, we use an alternative proxy for a_i. The alternative indicator variable equals 1 if the respondent, in addition to acknowledging that she had either received or had been offered a lot of information about debit or credit cards, ways of paying bills, use of transaction accounts, or borrowing using credit cards, indicated in another series of questions that she needed no further information

[20] It is still possible that in the anticipation of reoptimization, consumers start adjusting their demand for payment media before they reach the threshold age. But dummies allowing for this type of forward-looking behavior gain no significance.

about these products and services. The new proxy effectively captures consumers whose demand for information is "saturated". Using the new proxy reduces the estimated effect of consumer awareness. Nonetheless, the effect remains positive and significant at the 10% level. Moreover, when we use the new proxy in instrumental variable estimations, reported in the subsequent section, the coefficient becomes six times larger and is always significant at the 1% level. The increase suggests that measurement error may bias the effect of consumer awareness downwards when the alternative proxy is used.

7 Is Consumer Awareness Endogenous?

In this section we relax the assumption of exogenous consumer awareness by allowing for the possibility that $E(\varepsilon_i|a_i, x_i) \neq E(\varepsilon_i|x_i)$. Our empirical model of multihoming suggests that a_i can be endogenous if it is correlated with the unobserved components of the adoption cost ψ_i, i.e., with υ_i and thus ε_i. To identify sources of such correlation we have to explore the determinants of a_i .

7.1 Sources of Endogeneity

As we have defined it, consumer awareness reflects consumers' knowledge about the existence and characteristics of payment media. As Guiso and Japelli (2003) argue, the awareness reflecting existence can hardly be a choice variable of consumers: One can rarely choose to know something that is not known to exist. The awareness reflecting characteristics is about the pros and cons of the payment media consumers know to be available. Being knowledgeable can be a choice variable, but not necessarily. For example, this type of awareness is exogenous for a

consumer, if it primarily reflects how the issuers of the payment media inform her about their products' characteristics.

The foregoing discussion suggests two sources of endogeneity of a_i . First, if the awareness is not a consumer's choice variable, endogeneity can originate from the marketing strategies of the issuers of the payment media. Some consumers are more likely to be targets of informative advertising campaigns than others. Endogeneity arises if the propensity of being a target of such a campaign is related to υ_i . Second, if consumer awareness is a choice variable, endogeneity can originate from consumers' self-selection. Self-selection arises if a consumer chooses her level of awareness on the basis of the unobservable adoption cost determinants.

The above examples illustrate that a_i may correlate with υ_i and, thereby, with ε_i. However, signing the correlation *a priori* is difficult, as it can go either way. For example, we cannot identify who in our data are heirs of multihomers. They can be subjected to campaigns of the payment media issuers and simultaneously have a lower than average cost of adoption. This source of endogeneity would presumably bias the estimated effect of consumer awareness upwards. In contrast, a downward bias would probably follow, if the heirs simply receive payment media from their parents (and thus have lower than average cost of adoption) but are not directly offered information about them.

As the ability to pay abroad (see section 2) often prompts young Finns to acquire a payment card, travelling is another likely source of endogeneity where the bias can go either direction. On the one hand, frequent travellers are likely to be targets of the campaigns of the payment media issuers and their heavy users. An upward bias might therefore follow. On the other hand, many young Finns spend long periods abroad, e.g., as exchange students or working. Consequently,

they acquire cards but receive little information from their domestic issuers, suggesting a downward bias.

Self-selection can induce both negative and positive correlation, too. There are, for example, so called early adopters who are enthusiastic about new technologies. The early adopters choose to be (by choice) knowledgeable about the payment media and start to use them eagerly. This self-selection gives a rise to an upward bias. A downward bias would instead follow, if some consumers actively acquire information about the payment media, but do so because of having had for some (unobserved) reason only a limited access to them.[21]

Moving outside of our model of multihoming other sources of endogeneity can also be put forward. For example, endogeneity can arise from measurement error in a_i or unobserved heterogeneity not related to the costs of adoption.

7.2 Empirical Model of Multihoming with Endogenous Consumer Awareness

We specify a model of multihoming that allows for the endogeneity of a_i as

$$\begin{aligned} n_i &= \exp\left(\pi_0 a_i + \pi_1 INC_i + \pi_2 INC_i^2 + \sum\nolimits_{j=3} \pi_j x_{ij}\right)\varepsilon_i, \\ a_i^* &= z_i'\mu + x_i'\varphi + u_i, \\ a_i &= 1 \text{ if } a_i^* > 0, \\ a_i &= 0 \text{ otherwise,} \end{aligned} \tag{7}$$

where a_i* denotes unobserved consumer awareness, z_i´ is a row vector of observable determinants of the awareness other than those included in x_i´, and μ and φ are column vectors.

[21] Note, however, that our model includes two types of regional dummies that, as mentioned, control for geographical variation in the intensity of social interactions that is a determinant of consumer awareness about financial securities (Guiso and Japelli 2003).

A necessary condition for the system specified in (7) to be logically consistent is that the structural equation of a_i* is not a function of n_i (Blundell and Smith 1994 and Windmeijer and Santos Silva 1997). Because the idiosyncratic shocks can be correlated, endogeneity can arise even if multihoming does not have a direct effect on a_i.

The system specified in (7) allows for "an endogenous treatment effect" (Mullahy 1997 and Windmeijer and Santos Silva 1997). It can be estimated using the method of instrumental variables. Instrumental variables are by definition related to the outcome of interest only through the treatment of interest.

7.3 Instruments

There are two sets of variables that we trust are only related to n_i via a_i in our data. The first set consists of two indicators equalling 1, if the respondent had received or had been offered a lot of information about some banking products other than those related to paying and payment media. Thus, we code a variable INFO_F = 1, if the information was about housing loans, student loans, term deposits, or investing in stocks, mutual funds, etc., and INFO_M = 1, if the information was about using banking services by the Internet or by mobile phone.

The identification assumption underlying the instruments is derived from the marketing strategies of financial institutions that are often based on the advantages associated with the joint production and consumption of financial services (see, e.g., Berger, Humphrey, and Pulley 1996): If there are such advantages, it pays for banks to cross-sell financial products and services and pursue "one-stop banking". Cross-selling means that when consumers are informed about *a* banking product, they are *simultaneously* offered information about other financial services, such as payment media. Being knowledgeable about banking products other

than paying and payment media should, however, have no direct effect on multihoming. Receiving information, for example, about housing loans should have no direct relation to the unobserved costs of adopting payment media. Under this assumption, INFO_F and INFO_M are only related to n_i through a_i.

The second set of instrumental variables is build on the following three indicators: FIN_FO = 1, if the consumer responded that she follows regularly banking and financial news in media, FIN_IM = 1, if she found it important to be literate in banking and financial issues, and FIN_IN = 1, if she were interested to know more about banking and banking services.

These instruments allow us to control for endogeneity under two assumptions: First, a consumer's overall interest in financial and banking affairs determine her awareness about financial products and services, *including* payment media. Second, the overall interest has no *direct* impact on multihoming beyond that. In particular, if a_i takes a good grip of how consumer awareness about payment media affects multihoming, the three variables measuring overall interest should no longer be direct determinants of multihoming. If these claims are valid, {FIN_FO, FIN_IM, FIN_IN} are only related to multihoming through consumer awareness.

While we think that there are sound justifications for our instruments, others may be more agnostic. We therefore also report below two test statistics to illustrate the "validity" of the instruments. The first is an F-test statistic for "weak instruments" (Steiger and Stock 1997), which we implement by testing the joint significance of the instruments in the first stage. The second is a test for the significance of the instruments in the equation for n_i with a_i included. Anticipating, the results indeed indicate that the instruments explain consumer awareness about paying and payment media, but *not* multihoming.

7.4 Results of Instrumental Variable Estimations

For brevity, we only report in Table 3 the results of instrumental variable estimations with the short vector of explanatory variables. The set of instruments is {INFO_F, INFO_M} in Panel A and {INFO_F, INFO_M, FIN_FO, FIN_IM, FIN_IN} in Panel B. We report instrumental variable estimates for the linearized model in the first columns of the panels and for the log-transformed model in the second columns. In the third columns we present GMM estimates of the Poisson model with an endogenous dummy variable.[22] In other words, the results reported in Table 3 correspond to the results in Panel A of Table 2, but now the endogeneity of a_i is allowed for.

[INSERT TABLE 3 ABOUT HERE]

The results confirm our earlier findings: Consumer awareness is directly linked to multihoming. In fact, the estimated effect of a_i more than doubles from the previous estimations where its endogeneity was not accounted for. It is also statistically significant at better than the 1% level. The instrumental variable estimates suggest that the informed adopt about 1.2 times more payment media than the less informed. Becoming informed thus leads to 20% increase in the expected number of payment media a person uses.

[22] The GMM estimations of the Poisson model were implemented using a Gauss programme *ExpEnd*, written by Frank Windmeijer. The programme contains an estimation code for non-linear GMM estimation of exponential models with endogenous regressors (for details, see Windmeijer 2002). The reported numbers are based on the two-step estimates and multiplicative moment conditions (see Mullahy 1997, Windmeijer and Santos Silva 1997, Windmeijer 2002). Somewhat surprisingly, using additive moment conditions yield almost identical results.

Weak instruments do not bias our instrumental variable estimations. The F-test statistic for the joint significance of the instruments in the first stage has a *p*-value that is invariably below the 1% threshold. A corresponding joint test for the significance of the instruments in the equation for n_i with a_i included, indicates that the instruments do not explain multihoming. The two tests thus support the validity of the instruments.

We also consider the robustness of the instrumental variables estimations. First we repeat the instrumental variable estimations of Table 3 using the alternative proxy for consumer awareness described in section 6.3. The estimated effect increases and becomes statistically significant at the 5% level in each of the six estimations we run. Second, the results of the instrumental variable estimations do not change, when we use the complete set of control variables reported in Panel B of Table 2. For example, when the set of instruments is {INFO_F, INFO_M}, the coefficient of a_i is 0.163 and has a standard error of 0.064 in the log-transformed model. When the set of instruments is {INFO_F, INFO_M, INFO_F, INFO_M, FIN_FO, FIN_IM, FIN_IN}, the coefficient is 0.174 and the standard error 0.061. Finally, some may find the identification assumption underlying {FIN_FO, FIN_IM, FIN_IN} more convincing than that underlying {INFO_F, INFO_M}. Repeating the instrumental variable estimations of Panel B with a trimmed instrument set {FIN_FO, FIN_IM, FIN_IN} change none of our basic conclusions.

8 Conclusions

Some consumers use only one medium when paying for their point-of-sale transactions, while others use many. Explaining such multihoming behavior is the aim of this study.

We develop a theoretical model of multihoming and explore its predictions empirically using a random sample of young Finnish consumers. We find that in our sample more than half multihome and that consumer awareness is a major determinant of multihoming. Our instrumental variable and GMM estimates show that the endogeneity of consumer awareness is a real concern and can bias the effect of consumer awareness downwards. Once the endogeneity is controlled for, the *quantitative* effect of consumer awareness is not small: the better informed use 1.2 times more payment media than the less informed. Becoming informed thus leads to 20% increase in the expected number of payment media a person uses.

A starting point of our analysis is that monetary history is full of examples where new payment media have taken off only slowly, if at all. As we noted in the introduction, even the four major innovations in the way we pay, coins, checks, paper money, and the payment card, echo this view, as they were after their introduction first used in chorus with the then-established payment media. Our findings therefore have a clear-cut implication for the adoption of new payment methods, because they suggest that increasing consumer awareness could accelerate the adoption of new payment media, such as electronic money and mobile payments. Beyond this, the implications of our findings for the payment media industry are less clear-cut. Because consumer multihoming intensifies platform competition over merchants (Rochet and Tirole 2003), increasing consumer awareness is a two-edged sword for the payment media industry. On the one hand, it is advantageous for the merchants, but on the other hand, the issuers of payment media encounter a dilemma of prisoner type: Each issuer can have an incentive to increase consumer awareness of its own product, but the industry as a whole might be better off with less consumer multihoming.

Although the positive effect of consumer awareness on multihoming suggests that allocating more resources on marketing new payment media might increase their adoption rates, a caveat should be borne in mind. We are unfortunately unable to identify whether consumer awareness reflects the consumers' exposure to informative advertising or persuasive advertising, or something else (cf. Ackerberg 2001). We cannot therefore tell what kind of information provision or advertising would boost the demand for payment media. Isolating the mechanisms through which consumer awareness influences the adoption of new payment media is an area that clearly deserves further research.

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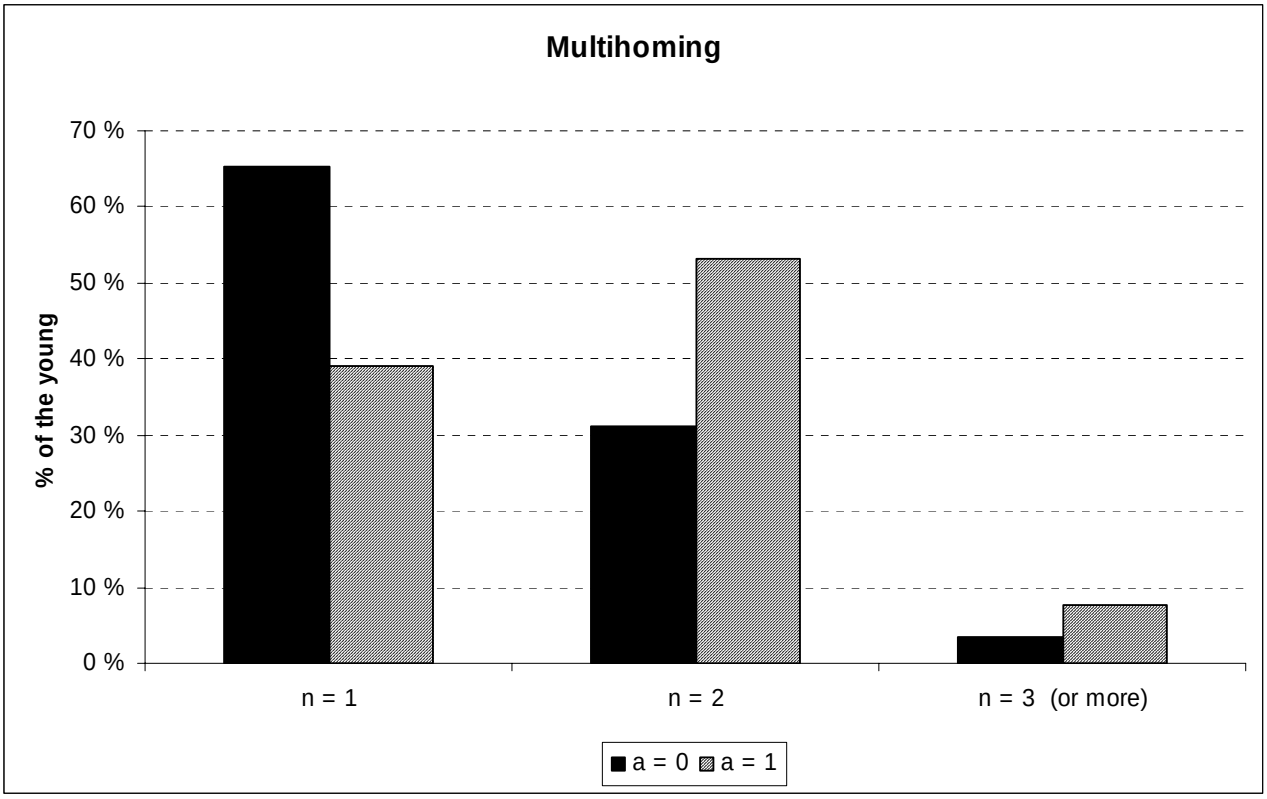
Table 1. Descriptive statistics

	Obs	Mean	Std. Dev.	Min	Max
n	946	1.59	0.61	1	3
DMHOME	946	0.53	0.50	0	1
a	946	0.70	0.46	0	1
INCOME	946	8.14	9.64	0	37.80
AGE	946	21.22	3.99	15	28
SEX	946	0.51	0.50	0	1
LIVCITY	946	0.48	0.50	0	1
WEST	946	0.38	0.48	0	1
EAST	946	0.12	0.33	0	1
NORTH	946	0.13	0.34	0	1
EMP	946	0.32	0.47	0	1
UNEMP	946	0.07	0.25	0	1
HIGH	946	0.28	0.45	0	1
MEDIUM	946	0.62	0.49	0	1
NOHOUSEH	946	0.44	0.50	0	1
CHILDREN	946	0.09	0.28	0	1
RWEALTH	946	0.14	0.35	0	1
FWEALTH	946	0.27	0.44	0	1
LWEALTH	946	0.25	0.44	0	1
MBANK_1	946	0.33	0.47	0	1
MBANK_2	946	0.39	0.49	0	1
MBANK_3	946	0.06	0.23	0	1
MBANK_4	946	0.15	0.36	0	1
MBANK_5	946	0.02	0.14	0	1
MBANK_6	946	0.03	0.17	0	1
NOSBANK	946	0.74	0.44	0	1
BCHOICE	931	0.36	0.48	0	1
BLENGTH	849	0.64	0.48	0	1
BCLUB	937	0.57	0.50	0	1
SWBANK	934	0.03	0.16	0	1

Note: Data source is “Nuorisotutkimus 2002” -survey of the Finnish Banker’s Association

Figure 1. Multihoming by the uninformed ($a = 0$) and the informed ($a = 1$)



Note: Data source is “Nuorisotutkimus 2002” -survey of the Finnish Banker’s Association

Table 2. Basic regression results

PANEL A	Dependent variable: n								
	OLS			Log-OLS			Poisson		
	Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.	
a	0.14	0.04	***	0.09	0.02	***	0.09	0.02	***
INCOME	0.02	6.2E-03	***	0.01	3.8E-03	***	0.01	3.9E-03	***
INCOMESQ	-3.5E-04	1.8E-04	*	-2.4E-04	1.1E-04	**	-2.2E-04	1.2E-04	*
AGE	0.11	0.07		0.07	0.04		0.11	0.04	**
AGESQ	-1.5E-03	1.6E-03		-9.2E-04	9.8E-04		-1.8E-03	9.5E-04	*
SEX	0.10	0.04	***	0.06	0.02	***	0.06	0.02	***
LIVCITY	0.05	0.04		0.04	0.02	*	0.03	0.02	
WEST	-0.05	0.04		-0.02	0.02		-0.03	0.03	
EAST	0.02	0.06		0.03	0.04		0.02	0.04	
NORTH	0.02	0.06		0.02	0.03		0.01	0.03	
EMP	0.01	0.06		0.01	0.04		5.7E-03	0.04	
UNEMP	-0.03	0.08		-7.9E-03	0.05		-0.02	0.05	
HIGH	0.26	0.09	***	0.17	0.06	***	0.17	0.06	***
MEDIUM	0.12	0.07		0.08	0.05	*	0.10	0.05	**
NOHOUSEH	-0.02	0.05		-0.01	0.03		-0.01	0.03	
CHILDREN	0.04	0.07		0.02	0.04		0.02	0.04	
RWEALTH	0.11	0.06		0.07	0.03	**	0.06	0.03	*
FWEALTH	0.13	0.04	***	0.08	0.02	***	0.08	0.02	***
LWEALTH	0.06	0.04		0.03	0.02		0.04	0.02	
Observations	946			946			946		
Log pseudo-likelihood	-			-			-1185.76		
Wald	20.71			22.09			558.59		
degr. of freedom	19, 926			19, 926			19		
significance	0.00			0.00			0.00		
R^2_{adj} (R^2_{pseudo} for Poisson)	0.28			0.30			0.03		

Note 1: *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level
Note 2: Poisson standard errors based on the robust Huber-White covariance matrix

PANEL B	Dependent variable: n					
	OLS		Log-OLS		Poisson	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
a	0.12	0.04 ***	0.08	0.03 ***	0.08	0.03 ***
INCOME	0.02	6.7E-03 ***	0.01	4.1E-03 ***	0.01	4.1E-03 ***
INCOMESQ	-4.5E-04	2.0E-04 **	-2.9E-04	1.2E-04 **	-2.8E-04	1.3E-04 **
AGE	0.02	0.08	0.01	0.05	0.05	0.05
AGESQ	1.9E-04	1.7E-03	2.2E-04	1.1E-03	-6.8E-04	1.0E-03
SEX	0.08	0.04 **	0.05	0.02 **	0.05	0.02 **
LIVCITY	0.07	0.04 *	0.06	0.03 **	0.04	0.02 *
WEST	-0.03	0.04	-0.01	0.03	-0.02	0.03
EAST	-2.7E-05	0.06	9.2E-03	0.04	1.8E-03	0.04
NORTH	0.02	0.06	0.03	0.04	0.01	0.04
EMP	0.02	0.06	0.02	0.04	9.8E-03	0.04
UNEMP	-0.02	0.08	4.0E-03	0.05	-0.01	0.05
HIGH	0.31	0.10 ***	0.20	0.06 ***	0.20	0.06 ***
MEDIUM	0.17	0.08 **	0.11	0.05 **	0.13	0.05 **
NOHOUSEH	-0.03	0.06	-0.02	0.04	-0.02	0.04
CHILDREN	0.06	0.07	0.03	0.05	0.03	0.04
RWEALTH	0.13	0.06 **	0.08	0.04 **	0.07	0.03 **
FWEALTH	0.09	0.04 **	0.05	0.03 **	0.05	0.03 **
LWEALTH	0.05	0.04	0.02	0.03	0.03	0.03
MBANK_1	0.21	0.20	0.12	0.13	0.14	0.12
MBANK_2	0.26	0.20	0.16	0.13	0.18	0.12
MBANK_3	0.38	0.21 *	0.23	0.13 *	0.25	0.12 **
MBANK_4	0.22	0.20	0.12	0.13	0.15	0.12
MBANK_5	0.39	0.23 *	0.20	0.15	0.25	0.14 *
MBANK_6	0.28	0.23	0.18	0.14	0.19	0.13
NOSBANK	-0.05	0.04	-0.03	0.03	-0.03	0.03
BCHOICE	0.11	0.05 **	0.07	0.03 **	0.07	0.03 **
BLENGTH	7.1E-03	0.05	0.01	0.03	3.6E-03	0.03
BCLUB	0.09	0.04 **	0.06	0.02 ***	0.06	0.02 ***
SWBANK	-0.09	0.12	-0.04	0.07	-0.06	0.05
Observations	840		840		840	
Log pseudo-likelihood	-		-		-1059.55	
Wald	11.48		12.20		488.70	
degr. of freedom	30, 809		30, 809		30	
significance	0.00		0.00		0.00	
R^2_{adj} (R^2_{pseudo} for Poisson)	0.27		0.29		0.03	

Note 1: *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level
Note 2: Poisson standard errors based on the robust Huber-White covariance matrix

Table 3. Instrumental variables regressions

PANEL A	Dependent variable: n								
	2SLS			Log-2SLS			GMM-Poisson		
	Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.	
a	0.29	0.09	***	0.18	0.06	***	0.18	0.05	***
INCOME	0.02	6.0E-03	***	0.01	3.8E-03	***	0.01	3.9E-03	**
INCOMESQ	-3.1E-04	1.8E-04	*	-2.1E-04	1.2E-04	*	-2.0E-04	1.0E-04	*
AGE	0.08	0.07		0.05	0.05		0.07	0.05	
AGESQ	-9.0E-04	1.6E-03		-5.4E-04	1.0E-04		-1.0E-03	1.0E-03	
SEX	0.10	0.04	***	0.07	0.02	***	0.07	0.02	***
LIVCITY	0.05	0.04		0.04	0.02	*	0.04	0.02	*
WEST	-0.04	0.04		-0.02	0.03		-0.02	0.03	
EAST	0.01	0.06		1.9E-02	0.04		0.02	0.04	
NORTH	0.03	0.06		0.03	0.04		0.02	0.03	
EMP	0.02	0.06		0.02	0.04		0.02	0.04	
UNEMP	-0.05	0.08		-1.7E-02	0.05		-0.02	0.05	
HIGH	0.25	0.09	***	0.17	0.06	***	0.18	0.06	***
MEDIUM	0.12	0.07	*	0.08	0.05	*	0.09	0.05	**
NOHOUSEH	-0.02	0.05		-0.01	0.03		-0.01	0.04	
CHILDREN	0.04	0.07		0.02	0.04		0.02	0.04	
RWEALTH	0.10	0.06	*	0.07	0.03	*	0.06	0.03	*
FWEALTH	0.12	0.04	***	0.07	0.02	***	0.08	0.03	***
LWEALTH	0.06	0.04		0.02	0.03		0.03	0.03	
Instruments:	INFO_F, INFO_M			INFO_F, INFO_M			INFO_F, INFO_M		
Observations	942			942			942		
Wald	19.99			21.28					
degr. of freedom	19 , 922			19 , 922					
significance	0.00			0.00					
Sargan (p-value)							0.88		

Note 1: *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level
Note 2: GMM-Poisson based on two-step estimates and multiplicative moment conditions

PANEL B	Dependent variable: n								
	2SLS			Log-2SLS			GMM-Poisson		
	Coef.	Std. Err.		Coef.	Std. Err.		Coef.	Std. Err.	
a	0.30	0.09	***	0.19	0.05	***	0.19	0.05	***
INCOME	0.02	6.2E-03	***	0.01	3.9E-03	***	0.01	3.9E-03	**
INCOMESQ	-3.1E-04	1.8E-04	*	-2.2E-04	1.1E-04	*	-2.0E-04	1.0E-04	
AGE	7.6E-02	0.07		4.7E-02	0.05		0.07	0.05	
AGESQ	-9.0E-03	1.6E-03		-5.0E-04	1.0E-03		-1.0E-03	1.0E-03	
SEX	0.10	0.04	***	0.07	0.02	***	0.07	0.02	***
LIVCITY	0.0529	0.04		0.04	0.02	*	0.04	0.02	*
WEST	-0.42	0.04		-0.02	0.03		-0.01	0.03	
EAST	0.01	0.06		1.9E-02	0.04		0.02	0.04	
NORTH	0.03	0.06		0.03	0.04		0.02	0.03	
EMP	0.02	0.06		0.02	0.04		0.01	0.04	
UNEMP	-0.05	0.08		-1.8E-02	0.05		-0.02	0.05	
HIGH	0.25	0.09	***	0.16	0.06	***	0.17	0.06	***
MEDIUM	0.12	0.07	*	0.08	0.05	*	0.09	0.05	**
NOHOUSEH	-0.02	0.05		-0.01	0.03		-0.01	0.04	
CHILDREN	0.04	0.07		0.02	0.04		0.02	0.04	
RWEALTH	0.01	0.06	*	0.07	0.03	*	0.06	0.03	*
FWEALTH	0.12	0.04	***	0.07	0.02	***	0.08	0.02	***
LWEALTH	0.06	0.04		0.02	0.03		0.03	0.03	
Instruments:	INFO_F, INFO_M, FIN_FO, FIN_IM, FIN_IN			INFO_F, INFO_M, FIN_FO, FIN_IM, FIN_IN			INFO_F, INFO_M, FIN_FO, FIN_IM, FIN_IN		
Observations	942			942			942		
Wald	20.01			21.30					
degr. of freedom	19, 922			19, 922					
significance	0.00			0.00					
Sargan (p-value)							0.12		

Note 1: *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level
Note 2: GMM-Poisson based on two-step estimates and multiplicative moment conditions