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The Effect of Transaction Pricing on the Adoption of Electronic Payments: A Cross-Country Comparison*

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Abstract

Pricing should speed up the substitution of low cost electronic payments for expensive paper-based transactions and cash. But by how much? Norway has explicitly priced individual payment transactions and rapidly shifted to electronic payments while the Netherlands has experienced the same shift without direct pricing. Controlling for differences between countries, we estimate the incremental effect of pricing on the shift to electronic payments. If users strongly value the improved convenience or security of electronic payments, pricing–viewed negatively by most consumers–may not be necessary to ensure rapid adoption of electronic payments.
(92 words)

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1 Introduction

The production of electronic payments by banks typically cost from one-third to one-half as much as its paper-based equivalent or cash (c.f., Humphrey, Willesson, Bergendahl, and Lindblom, 2005). As well, merchants' cost of accepting electronic payments over giro networks and at the point of sale are also lower (credit cards excepted). Since the resource cost of a country's payments system may account for 2% to 3% of its GDP, it is clear that shifting from paper to electronic payments can confer social benefits. Importantly, the discounted value of these benefits will be larger the more rapidly this shift occurs.

There is overwhelming evidence that consumers respond to price incentives but almost no evidence of what this response may be in the payments area. Although consumers are used to responding to price incentives, they tend not to welcome the opportunity to trade off perceived payment preferences with relative prices when their payment use has commonly been viewed as being "free."[1] While businesses typically pay directly for the payment services they use via explicit transaction fees or compensating balances, consumers have traditionally paid implicitly through lost float or lower (or no) interest on transaction balances. In addition, due to competitive reasons, banks fear a loss of deposit market share if they move first (and are perhaps the only one) to explicitly price consumer payment transactions while anti-trust authorities would be suspicious of industry efforts to coordinate such pricing.

One country–Norway–has overcome these difficulties by coordinating only the timing of when direct pricing of consumer payments would start–not the level of prices to be charged which could in fact be zero. The quid pro quo was an elimination of banks' practice of recouping payment costs through payment float–debiting consumer accounts prior to a value date for bill payments or delaying funds availability for credits to accounts–which made it appear that payment use was "free." The goal was to make payment costs more explicit so consumers could match better the benefits and costs of different payment instruments, a response expected to lower the social cost of their payment system.[2]

Our main purpose is to determine the effect of differential transaction-based pricing of payment instruments on the adoption rate of electronic payments. This is done by comparing the shift to electronic payments in two countries–one that has pricing (Norway) and one that does not (Netherlands). Transaction-based prices are key since they affect consumers' decisions about payment use whereas fixed fees are sunk costs ex post that do not vary with usage and thus have limited behavioral effects. The implied discounted social benefit that follows from a possibly more rapid substitution of low cost for high cost payment instruments is also estimated. Data on payment instrument use for many developed countries is available annually in various Bank for International Settlements and European Central Bank documents, as well as from payment statistics by national central banks. As these time series rarely exceed 15 years, a parsimonious model specification is necessary. A comparable time series of actual payment instrument prices on a broad range of payment instruments is available only for Norway. We contrast the rapid adoption of electronic payments in Norway over 1990-2004 with the experience of the Netherlands which also rapidly adopted electronic

[1] Surveys indicate that customers are sensitive to price increases of payment instruments and react accordingly by switching to cheaper ones, see Humphrey, Kim and Vale (2001).

[2] Pricing in Norway was implemented by banks individually and encouraged by the central bank. The fact that the larger banks were first to introduce explicit pricing made it easier for the other banks to follow after a lag. Bank efforts to improve the payment system have also occurred in Canada (to eliminate the float incentive to use checks), Germany (to truncate checks and collect them electronically), and the Netherlands (shifting from paper-based credit transfers to "straight-through-processed" direct debits).

payments but did not impose per transaction prices on consumers. By applying a system estimation to our model we are able to improve on the degrees of freedom and increase the efficiency of our estimators.

If the incremental effect of direct pricing is large, holding constant other within and cross-country influences affecting the adoption of electronic payments, then the potential social benefit can also be large. This would suggest that antitrust concerns raised by possible bank coordination of the implementation of pricing (but not any coordination of the level of prices being charged) could be offset by subsequent social benefits. It would also suggest, in a revealed preference context, that consumers generally place a relatively low value on the greater convenience and security offered by electronic payments since, otherwise, pricing would not have a large separate effect on adoption rates. A final consideration, but one not discussed here, is the loss of seigniorage revenues to the government to the degree that electronic payments replace cash at the point of sale.

In what follows, we show in Section 2 how the composition of payments has evolved in Norway and the Netherlands along with the levels of relative prices in Norway. Transaction prices for consumers are zero in the Netherlands.[3] Our focus is on the substitution of debit cards for cash (or cash and checks) at the point of sale along with the substitution of (remote) electronic giro payments for paper-initiated giro transactions.[4] In Section 3, we specify a parsimonious point of sale "country difference" model to separate the effect of pricing debit card use and ATM cash withdrawals from differences in terminal availability and real personal consumption in our two countries. A similar model relies primarily on prices for the substitution of electronic versus paper-initiated giro payments (since terminal availability is not a constraint). By using two countries we seek to effectively "hold constant" non-price attributes that can influence payment use in addition to pricing when the analysis is applied to only a single country. Our set of four equations is estimated in Section 4 in a seemingly unrelated regression framework to improve efficiency and the effect of prices on payment composition, including the implied price elasticities, are presented. Different models are estimated to judge the robustness of the price effect under alternative specifications, such as different lagged relationships, first differences, and error correction. The social benefit of pricing is illustrated in Section 5 using bank cost data and fitted logistic S-curves to payment use data for Norway and the Netherlands. A summary of our results and the public policy issues they raise are discussed in Section 6.

2 Payment Composition, Pricing, and Other Influences on Payment Instrument Use

2.1 Payment Composition

Both Norway and the Netherlands experienced a relatively rapid change in their payment composition for point-of-sale and bill payment transactions over 1990-2004. Point-of-sale instruments are now almost solely debit cards and cash but in the early 1990s checks were also important. As seen in Table 1, the number of debit card transactions per person per

[3] Some fixed fees do exist in the Netherlands. Debit card users pay a flat annual average fee of 6 euros and Internet banking has usually a one-time startup fee of around 15 euros.

[4] While check and credit card transactions are included in the analysis, check transactions are significant only in the early 1990s while there are few credit card payments in either country over the whole period.

Table 1: Payment Instrument Use Per Person in Norway and the Netherlands (1990-2004)

	1990	1993	1996	1999	2002	2004	Growth Rate
Debit Card transactions							
Norway	5	16	36	71	113	146	25%
Netherlands	1	4	24	44	66	77	33%
ATM Cash Withdrawals							
Norway	14	17	22	24	23	22	3%
Netherlands	8	20	26	28	30	28	9%
Electronic Giro (credit transfers + direct debits)							
Norway	15	18	29	46	65	78	12%
Netherlands	44	54	70	93	116	124	7%
Paper Giro (credit transfers)							
Norway	53	44	52	38	24	18	-7%
Netherlands	34	32	33	27	21	18	-5%

Source: www.dnb.nl, DNB statistics, www.norgesbank.nl, Norges Bank Annual Report on Payment Systems.

year in Norway rose from 5 to 146 over our 15-year period, growing 25% per year.[5] The Netherlands started from a smaller base of 1 transaction per person per year but rose to 77, a 33% annual growth.[6] Part of this difference is due to the fact that Norway started 1990 with far more debit card terminals in place than the Netherlands and so was at a higher point of usage on their logistic growth curve. In 2004, the average amount of a debit card transaction was about €55 in Norway and €44 in the Netherlands.

No time-series data exists on the number of cash transactions, although a few (markedly) different estimates exist for some countries at different points in time. These estimates differ primarily because of the difficulty of estimating very small value cash transactions in which coins are often used and for which stored value cards–which are just starting to gain some acceptance–are the only real substitute.[7] We use the number of cash withdrawals at ATMs as our indicator of cash use in transactions. Since average ATM withdrawals corrected for price changes are fairly stable over time for both countries, our indicator–although not

[5] Oil company terminals and cards were introduced in the 1980s as a substitute for cash at gas stations. Although these terminals also accepted bank debit cards, oil company cards could not be used elsewhere and were not priced. The Norwegian payment statistics do not include oil company transactions as debit card purchases (Norges Bank, 2000, p. 33) and neither do we. Oil company terminals are included in our series of debit card terminals, however, since they accept debit cards for payment.

[6] Checks written per person in Norway went from 12 per person annually in 1990 to less than 1 in 2004. In the Netherlands they went from 17 to zero. Credit card transactions per person in both countries were less than 1 in 1990 and only 3 per person (Netherlands) to 5 (Norway) in 2004 (or about 3% of card use in each country). The dominance of debit cards over credit cards is probably due to the fact that banks–not the credit card companies–through a joint venture were the first to introduce EFTPOS directly from deposit accounts and have POS terminals connected to the bank network installed in shops. The banks' purpose was to replace checks with electronic cards at the point of sale but this also permitted a substitution away from cash. Interestingly, Zinman (2004) develops a model of implicit costs to explain why debit cards are replacing credit cards in the U.S.

[7] Brits and Winder (2005) provide an estimate of cash use in the Netherlands in 2002. Cash accounted for 85% of POS transactions and 56% of sales while debit cards comprised 13% of transactions and 40% of sales. The average value of a cash transaction was around 10 euros but over 47 euros for debit cards in 2002.

perfect–seems to be in reasonable correspondence with actual cash use.[8] While each cash withdrawal (€138 on average in Norway and €107 in the Netherlands in 2004) funds multiple actual cash transactions, the act of withdrawing cash is priced in Norway while its use at the point of sale is not. Thus we compare debit card and cash use at the point where both are actually priced and consumer choice is exercised.[9]

In both Norway and the Netherlands, debit card use expanded at a rapid rate while growth of ATM cash withdrawals was much smaller. As shown below, the average price of an ATM withdrawal rose relative to a debit card transaction in Norway but these two prices were both zero in the Netherlands. If relative price was the only influence on relative use, we would expect a slower growth for ATM withdrawals in Norway (where the ATM price was, after 1996, higher than debit cards) than in the Netherlands (where there is no difference in relative prices). We see indications of this for ATMs in Table 1 (as growth in Norway is slower than in the Netherlands) but we do not see it for debit card use (where the reverse holds).

In order to reflect the substantially lower cost associated with electronic bill payments, employee disbursements, and interbusiness transactions over giro networks, the price of an electronic giro payment in Norway was less than a paper-initiated giro transaction (either delivered in the mail or passed over the counter at a bank or postal office). Since giro prices were zero in the Netherlands, one would expect to see a more rapid growth of electronic giro transactions and slower growth (or greater reduction) of paper giro transactions in Norway than in the Netherlands. Both of these expectations are realized in Table 1. Per person use of electronic giro payments in Norway rose from 15 to 78 over 1990-2004 (growing 12% a year) while only rising from 44 to 124 over the same period in the Netherlands (growing 7% annually).[10] At the same time, paper giro use fell in both countries but from a higher level and at a greater rate in Norway. Indeed, by 2004 individuals in both countries initiated only 18 paper giro transactions per year.

2.2 Payment Prices in Norway

The average–and sometimes weighted average–per transaction prices being charged for different payment instruments in Norway are illustrated in Table 2. Since there are no per transaction fees in the Netherlands, the relative prices that Norwegian consumers face also reflect the difference in prices faced between Norway and the Netherlands. This is the price effect we wish to separate from other influences on payment choice in these two countries.[11]

The weighted average per transaction price of a cash withdrawal in Norway was, until

[8] In 2004 prices, the average real ATM withdrawal in Norway rose gradually from 127 euros in 1991 to 138 euros in 2004, while in the Netherlands it rose from 94 euros in 1991 to 107 euros in 2004. These figures imply annual real growth rates of roughly 0.6 percent and 0.9 percent for Norway, respectively, the Netherlands.

[9] In reality, consumer payment choice is more complex. First, for an ATM there is the choice of whether to withdraw or not, then second, at the point-of-sale whether to use "free" cash or a priced debit card. We leave this "two-stage decision" issue aside in our analysis. Our view is that the use of cash at the point-of-sale will be influenced by the cost of consumers' replenishing their inventory of cash via an ATM (or other sources).

[10] By 2004, direct debits accounted for 10% of electronic giro payments in Norway but 56% in the Netherlands. This is the main reason why electronic giro payments per person in the Netherlands are so much higher than in Norway.

[11] Consumers in the Netherlands do face a fixed annual fee for the use of a debit card but, as the fee is fixed, the consumer "sees" a zero price per additional transaction and responds accordingly. However, below transaction amounts of 10-12 euros, Dutch debit card users are sometimes confronted in some retail locations with a charge of about 15 eurocents.

Table 2: Average Per Transaction Prices for Different Payment Instruments in Norway

Prices in Euros	1990	1993	1996	1999	2002	2004	Growth Rate
Debit Card Price							
Norway	.18	.23	.25	.26	.28	.26	2%
ATM Cash Withdrawal Price							
Norway	.05	.18	.24	.29	.39	.40	14%
Relative Price: Debit Card/ATM Cash Withdrawal							
	3.60	1.28	1.04	.90	.72	.65	-11%
Electronic Giro Price							
Norway	.10	.18	.22	.23	.31	.27	7%
Paper Giro Price							
Norway	.35	.62	1.18	1.86	2.65	2.76	15%
Relative Price: Electronic Giro/Paper Giro							
	.29	.29	.20	.12	.11	.09	-8%

Source: www.dnb.nl, DNB statistics, www.norgesbank.nl, Norges Bank Annual Report on Payment Systems.

1996, less than that for debit cards.[12] This was because a cash withdrawal at one's own bank was free during business hours and prices applied only to withdrawals after business hours or at another bank's ATM. While debit cards started out in 1990 with a price that was more than three times higher than the weighted average of different ATM prices (Row 3, Table 2), it ended up being only 65% of the cash withdrawal price in 2004. Thus only after 1996 did the absolute price of a debit card favor its use over cash when EFTPOS terminals were available. But even before 1996, there was an indirect inducement to use debit cards in Norway when it became possible in late 1992 to obtain "cash-back" from a debit card transaction at the point of sale.[13] This avoided the extra cost and inconvenience of having to use an ATM to withdraw cash since small amounts of cash could be obtained at no additional cost when making purchases at the local market.

There was a stronger relative price inducement to use an electronic rather than a paper-initiated giro transaction for consumer bill payments. In 1990, the price of an electronic giro transaction was only 29% as high as a paper giro payment but by 2004 this had fallen to only 9% of the paper price. In the beginning, electronic giro payments were initiated via telephone but this was later overtaken by the spread of Internet banking. This applies to credit transfers where the consumer retains control in initiating a payment, as opposed to a direct debit where the receiver of the credit initiates the debit to the consumer's account under a prearranged contractual agreement. In addition, it is noted that billers often give a

[12] This observation only holds on a per-transaction basis. On average one ATM withdrawal could fund roughly 2 to 3 debit card transactions. However, since this difference in "transaction domain" between both instruments is relatively stable over time, it should only affect the intercept in our model in logs.

[13] Although cash-back transactions and cash at the counter at one's own bank are also sources for obtaining cash for free in Norway–and implicitly lower the effective price for obtaining cash compared to our use of the weighted average of free and priced ATM access–these data are available only for recent years and therefore could not be included in the analysis.

slight discount to customers that pay by direct debit, thus creating a price advantage over an electronic giro. Due to lack of data, this relative price discount could not be taken into consideration here.

It is important to note that the prices charged in Norway do not cover the full bank cost of making a payment (c.f., Flatraaker and Robinson, 1995; Gresvik and Øwre, 2003). In 1988, transaction prices covered only around 25% of the banks' payment cost but this coverage had risen to around 70% in 2001.[14]

2.3 Terminal Availability and Levels of Consumption

While relative prices provide an inducement to use electronic payments at the point of sale, this can be accomplished only if a merchant has an EFTPOS terminal that can be used. This observation points to the two-sided nature of the payment market which influences the adoption rate of new payment instruments. In particular, the market for electronic payment services is considered a two-sided market in the sense that both consumers and merchants are needed simultaneously to demand and "consume" card payments. Suppliers of payment card services (or so-called "platforms") can effectively cross-subsidize between merchants and consumers through differential pricing to stimulate this demand. In two-sided markets, typically only one side is charged on a transaction basis while the other side obtains the service (almost) for free in order to generate greater demand.[15] Indeed, merchants value a wide diffusion of payment cards among consumers while consumers benefit from high terminal density at retail locations that accept their cards. In our analysis, payment card and ATM terminal density are included to take this two-sided effect into account in explaining relative payment card usage.

Table 3 shows the number of EFTPOS terminals in place in Norway and the Netherlands over 1990-2004 per one million of population (which controls for differences in population size).[16] As shown in the first two rows, Norway had almost twice as many debit card terminals as the Netherlands in 2004 and this difference was far more extreme in earlier periods. While the growth of EFTPOS terminals has been more than twice as rapid in the Netherlands, it still has a long way to go to provide the same density of terminal access as Norway. By this measure alone, it really would not be possible–regardless of any price incentive–for consumers in the Netherlands to use debit cards with the same intensity per person as they do in Norway. As noted earlier, there is no price incentive to use debit cards in the Netherlands so there are two reasons–no price incentive and fewer EFTPOS terminals per person–to expect that the Netherlands would use debit cards less intensively than in Norway. Even so, as shown below, it is difficult to separate the effect of prices from terminal availability on debit card and ATM use.

The same "separation problem" exists for cash withdrawals at ATMs. Norway prices ATM withdrawals while the Netherlands does not and for the entire period Norway also provided a greater density of ATMs to withdraw cash from (Row 3, Table 3). Separating the

[14] The relationship between fees and underlying costs is different in Sweden with surplus bank revenues from card transactions cross-subsidizing the expense of providing cash, distorting resource allocation (Sveriges Riksbank, 2004).

[15] In Norway, the consumer side is directly charged for its use of payment instruments while in the Netherlands the retailer side of the market pays per transaction. Bolt and Tieman (2004) provide an explanation for these widely observed completely skewed pricing strategies in two-sided markets. See Rochet and Tirole (2003) for a rigorous analysis of two-sided markets and competition.

[16] In 2004, the population in the Netherlands was 16.3 million; in Norway it was 4.6 million.

Table 3: Terminal Availability, Real Consumption, and Demographic Influences on Payment Instrument Use

	1990	1993	1996	1999	2002	2004	Growth Rate
Debit Card EFTPOS Terminals (per mil population)							
Norway	2,487	6,324	8,932	13,214	17,723	21,091	15%
Netherlands	148	1,600	6,170	9,176	10,941	11,967	34%
ATM Terminals (per mil population)							
Norway	419	396	426	451	484	473	0.8%
Netherlands	180	291	395	421	465	468	6.6%
Real Per Capita Personal Consumption (in 1000)							
Norway	11.9	12.1	13.9	15.1	17.8	16.7	2.3%
Netherlands	9.2	9.3	9.9	10.9	11.4	11.3	1.4%
Share of Young Adults in Population							
Norway	8.0	7.8	7.2	6.4	6.0	6.0	-1.9%
Netherlands	8.5	8.2	7.0	6.1	6.0	6.0	-2.3%

Source: www.dnb.nl, DNB statistics,National Accounts, Dutch CBS, www.norgesbank.nl, Norges Bank Annual Report on Payment Systems, IFS.

price effect from the terminal effect for ATM cash withdrawals may be somewhat easier here since by 2004 both countries had almost the same ATM density but withdrawals were priced only in Norway and, compared to the Netherlands after 1993, per person use in Norway was correspondingly less (Row 3, Table 1).[17]

Inferences on the relative importance of pricing may be more accurate if two other possible, but small, influences on payment choice are considered. One concerns differences in the level of real per capita personal consumption between the two countries, since higher levels of real consumption tend to be associated with larger numbers of transactions.[18] A second influence concerns the possibility that changes in the number of young adults in both countries may affect differences in new payment adoption rates. Consumer surveys indicate that young adults and higher income individuals adopt new payment arrangements more rapidly than others even without pricing. But direct pricing could well affect the adoption rates of those with greater habit persistence, a lower opportunity cost, or who do not value much the added convenience or security that electronic payments can offer.

The level and variation of both per capita consumption and the share of young adults in the population over time are illustrated in the bottom half of Table 3. Real per capita consumption in Norway was 29% greater than that in the Netherlands in 1990 but rose to be

[17] As Norway is roughly nine times larger than the Netherlands, differences in population density may compromise the usefulness of our availability measure of ATM and EFTPOS terminals. However, both countries are highly urbanized which is probably the most important driver for installing terminals. In Norway, the five largest cities account for about 25% of total population but for only 1% of total geographic area (see Norway Statistics, www.ssb.no). Less extreme, in the Netherlands, the 10 largest cities make up roughly 20% of Dutch population with 3.5% of the area (see CBS statistics, www.cbs.nl.). Since this difference in densities is effectively a constant over 15 years, in our log-difference equation its impact would affect only the intercept and not the slope parameter, which is our terminal elasticity.

[18] All monetary values for Norway (prices as well as real consumption) have been translated from Norwegian kroner into euros using a purchasing power parity exchange rate. Also, real per capita consumption in Norway includes oil revenues only indirectly as some of this revenue is used to finance government expenditures which likely reduces taxes from what they would otherwise be, permitting real consumption to be larger.

48% higher in 2004. This difference should be associated with a rising number of all types of transactions in Norway relative to the Netherlands. There are smaller differences between these two countries in the shares of young adults–new entrants into the labor force aged 20 to 24. Indeed, these shares are falling in both countries.[19]

3 A Country-Difference Model of Payment Choice

3.1 A Country-Difference Model

Differences between Norway and the Netherlands are used to try to explain per capita use of debit cards, ATM cash withdrawals, and electronic and paper giro payments. As outlined above, the main influences on payment use and composition are differences in the number of EFTPOS and ATM terminals per million population, the prices being charged in Norway (positive) and the Netherlands (zero), and differences in the level of real per capita consumption. Our time period is short (only 15 years) as time-series data on payment instrument use has only recently been deemed important enough to be routinely collected at the country level by government agencies. While some time-series on some payment types do exist for longer periods in some countries, this information is not comprehensive nor are payment instrument prices available since very few types of payment services are directly priced. Norway is the exception that allows us to undertake this analysis. These data constraints impose a parsimonious specification on our explanatory four-equation model:

$$\begin{aligned} CARD_t = \ & \alpha_1 + \alpha_2 CARDTERMINAL_{t-1} + \alpha_3 CARDPRICE_t \\ & + 1/2(\alpha_{22} CARDTERMINAL^2_{t-1} + \alpha_{33} CARDPRICE^2_t) \\ & + \alpha_{23} CARDTERMINAL_{t-1} * CARDPRICE_t \\ & + \alpha_4 CONSUMPTION_t + \varepsilon_{1t} \end{aligned} \tag{1}$$

$$\begin{aligned} ATM_t = \ & \beta_1 + \beta_2 ATMTERMINAL_{t-1} + \beta_3 CARDPRICE_t \\ & + 1/2(\beta_{22} ATMTERMINAL^2_{t-1} + \beta_{33} CARDPRICE^2_t) \\ & + \beta_{23} ATMTERMINAL_{t-1} * CARDPRICE_t \\ & + \beta_4 CONSUMPTION_t + \varepsilon_{2t} \end{aligned} \tag{2}$$

$$\begin{aligned} EGIRO_t = \ & \gamma_1 + \gamma_2 EGIROPRICE_t + 1/2(\gamma_{22} EGIROPRICE^2_t) \\ & + \gamma_3 CONSUMPTION_t + \varepsilon_{3t} \end{aligned} \tag{3}$$

$$\begin{aligned} PGIRO_t = \ & \delta_1 + \delta_2 EGIROPRICE_t + 1/2(\delta_{22} EGIROPRICE^2_t) \\ & + \delta_3 CONSUMPTION_t + \varepsilon_{4t}. \end{aligned} \tag{4}$$

In the variable definitions, NOR indicates Norway and NL indicates Netherlands and differences between these countries are expressed in index form:[20]

[19] Demographic variables are typically extremely smooth series. In implementation, these variables created convergence problems in our system estimations and were deleted.

[20] In many cases, the log of the absolute difference in our variables between countries was negative (or changed from positive to negative) so all variables are expressed as the log of the ratio or index of the difference between countries.

$CARD$	=	ln (NOR debit card use/NL debit card use), on a per person basis;
$CARDTERMINAL$	=	ln (NOR card terminals/NL card terminals), per million population;
$CARDPRICE$	=	ln (NOR card price/NOR ATM price);
$CONSUMPTION$	=	ln (NOR personal consumption/NL personal consumption, real per capita;
ATM	=	ln (NOR ATM cash withdrawals/NL ATM cash withdrawals), per person;
$ATMTERMINAL$	=	ln (NOR ATM terminals/NL ATM terminals), per million population;
$EGIRO$	=	ln (NOR electronic giro use/NL electronic giro use), per person;
$EGIROPRICE$	=	ln (NOR electronic giro price/NOR paper giro price);
$PGIRO$	=	ln (NOR paper giro use/NL paper giro use), per person.

Since debit card and ATM terminals have to be in place before consumers can use them, and even when in place typically have a lag before they are used at a significant level, these two terminal variables are lagged by one year in the model to give a closer correspondence between the exogenous availability of new terminals and their possible effect on use. Prices, of course, also have to be known before they can affect payment choice. The lag here is likely much shorter and prices are specified as exogenous and contemporaneous.[21]

Looking at the data, it appears that the two countries differ in when they introduced electronic payment instruments. In the Netherlands, usage of the electronic giro was on a higher level than in Norway in 1990 whereas Norway had a higher density of ATM and EFTPOS terminals. This "starting value" problem is taken into account in our logarithmic specification through the intercept which is not restricted to a value of 1 (which would imply equal starting values for 1990).

3.2 Illustrating the Determinants of Payment Composition

While our model looks different from the usual demand equation specification used to estimate price effects on payment instrument use in a single country (c.f., Humphrey, Kim, and Vale, 2001), the same variables–quantity of use, levels of own price, substitute price, and income (via consumption)–are included in the analysis. Ideally, we would like to run an experiment where there are no price inducements to affect consumer choice of payment instruments in a country, observe the rate of adoption of electronic payments based solely on non-price considerations along with terminal availability (if required), and then re-run the experiment adding price inducements in order to separate price from non-price effects. This would address the omitted variable problem of unknown non-price attributes of different payment instruments.[22] Our use of two countries–one with pricing, one without–addresses the non-price attribute omitted variable problem if country differences in non-price attributes are relatively small, as seems likely. In any case, we also estimate the effect of pricing in one

[21] The effects of different lag arrangements on the results are noted in Section 4.

[22] For example, if an electronic payment instrument offers significant convenience or security benefits compared to its paper-based alternative, then pricing the paper instrument higher than its electronic alternative would likely generate a larger price response than if such non-price attributes did not exist.

country (Norway) below but are aware that these results may incorporate unknown non-price attributes.

The observed relationships underlying our four-equation model are illustrated in the two figures below. In Figure 1, the price of debit cards in Norway is steadily falling relative to the weighted average price actually incurred for an ATM cash withdrawal over 1990-2004 (line with circles). Although the relative price of debit cards was falling, the absolute price was higher than a weighted average of ATM cash withdrawal prices up until 1996 (Table 2). Thus it is not surprising that relative debit card use in Norway compared to the Netherlands was falling (as seen in the top line with boxes) up until 1997. After 1996-97, the absolute price of debit cards in Norway was less than an ATM cash withdrawal and debit card use in Norway expanded slightly faster than in the Netherlands (which did not have this price inducement).[23] While a falling relative price is expected to promote use, this apparently occurred only when the price of a debit card transaction was absolutely less than an ATM withdrawal. Overall, the pattern of debit card and ATM prices in Norway reduced debit card use relative to the Netherlands up to 1996 and expanded it slightly afterward (shown as a slight rise in the top line with boxes after 1996). Thus we should not expect a strong price elasticity response for debit card use. And, indeed, the response we obtain is weak.

The situation for ATMs is essentially the reverse. The average ATM price is lower than that for debit cards in Norway over 1990-1996 so ATM use in Norway may be expected to exceed that in the Netherlands where these prices are the same (both at zero). But ATM use in Norway expands at a slower rate than in the Netherlands up until 1995 (as the bottom line with boxes falls over this period). After 1998 when the debit card price is absolutely lower than the ATM price, Norwegian ATM use falls slightly relative to the Netherlands. Consumer choice seems to be affected by absolute prices as well as changes in relative prices.

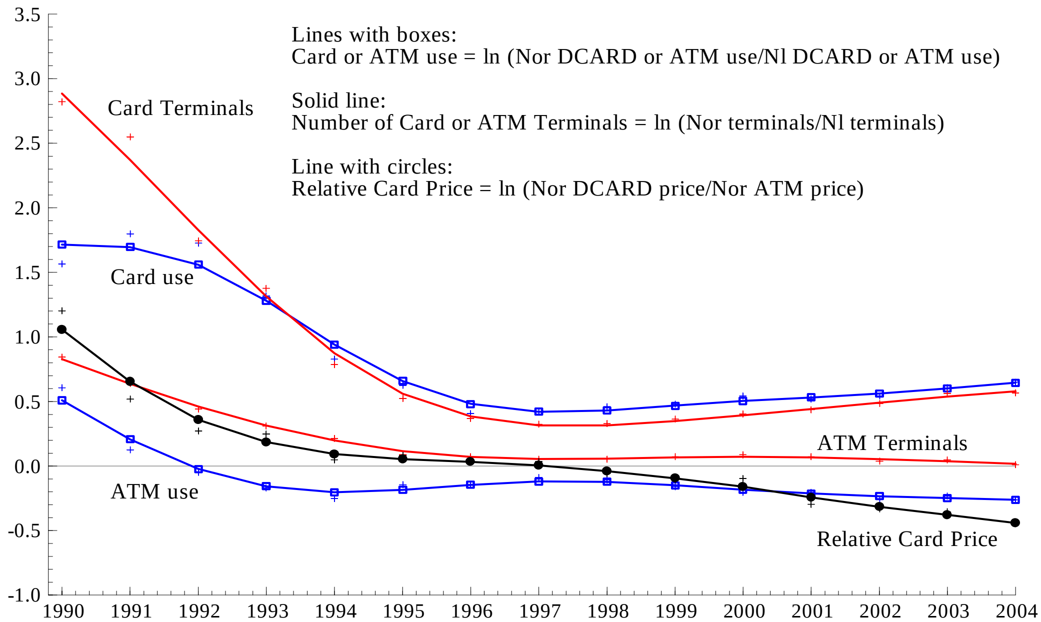
For debit cards as well as ATMs, use seems to closely follow the availability of terminals needed for these transactions. This implies a positive relationship. As shown below, however, ATM terminal availability appears to have gotten ahead of terminal use in both countries toward the end of our period, leading to a negative relationship where terminals expand but use falls.

The price-use relationship for electronic and paper giro transactions seems clearer, perhaps because there are no "terminal constraints" and likely weaker non-price attributes to potentially confound the effect of prices on relative giro use.[24] In Figure 2, the price of an electronic giro transaction in Norway falls relative to paper only after 1993 (line with circles). Importantly, and unlike the debit card to ATM price relationship, the electronic giro price is always absolutely lower than the paper price in Norway. Thus use of electronic giro payments in Norway is seen to rise relative to that in the Netherlands over the whole period (bottom line with boxes) while the relative use of paper giros falls–although only slightly–after 1995 (top line with boxes). The relationships illustrated in Figure 2 indicate that the relative level of payment prices, as well as the change in relative prices over time, is important in determining relative payment use for giro payments. The same holds for debit card and ATM use in Figure 1.

[23] This is where the ratio of the debit card to ATM price equaled one so the log of this value (the line with circles) was at zero in the figure. The curves in all figures are cubic splines of plotted actual observations.

[24] While an Internet connection is needed for consumers to make an electronic credit transfer, this is not needed for a direct debit. As well, the number of Internet connections far exceeds the number of Internet banking users so an Internet connection does not act as a binding "access constraint" in the same manner as a debit card or ATM terminal. Obviously, the same holds for telephone connections and telephone giros.

Figure 1: Debit Card Use, Prices, and Terminal Availability



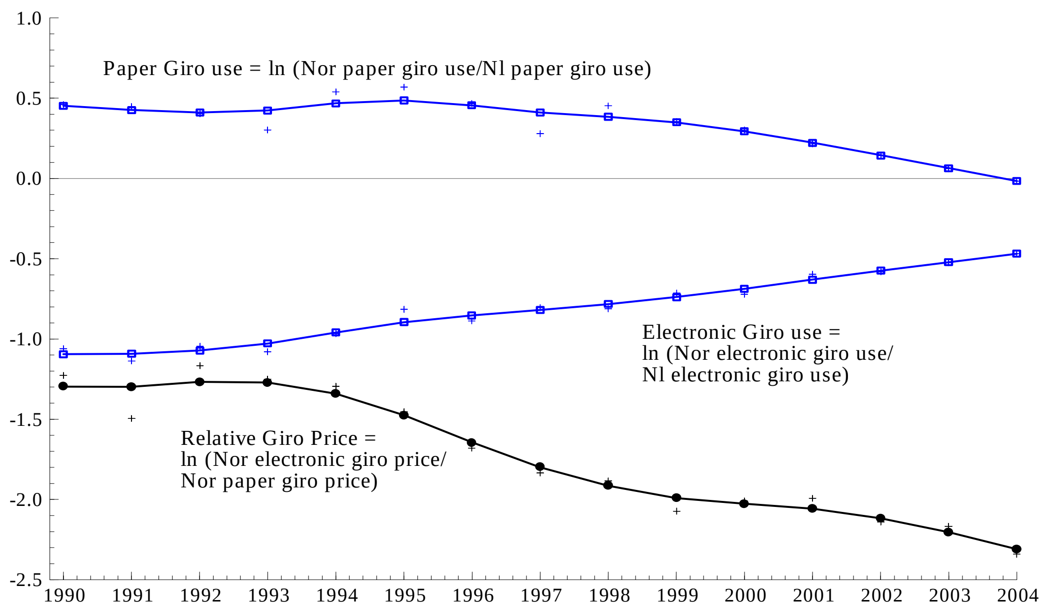
4 Estimation Results and the Effect of Price on Payment Instrument Use

The system of equations (1) to (4) was estimated in a seemingly unrelated regression framework to allow for the possible correlation between errors in locally identifying debit card use with those for ATM cash withdrawals and similarly for electronic and paper giro use. The estimated parameters and their associated t-statistics are shown in the Data Appendix. With 15 observations per equation, there are 38 degrees of freedom (d.f. = 4*15 - 22). As expected from viewing Figures 1 and 2, the explanatory power of the model was high (the respective R^2s were .98, .99, .87, and .80 from the system estimation). While the variables are not I(0) and only infrequently bivariately cointegrated, the Durbin-Watson statistics suggest no serious positive autocorrelation of residuals (the D-W values were, respectively, 2.12, 2.80, 1.86, and 2.03). This is confirmed by analyzing the estimation results using first differenced data as well as an error correction specification. In addition, the relationships shown in the figures appear to be reasonable and expected from theory so the degree of spurious correlation, if any, is likely to be small. We feel that these findings support the results of our preferred model using levels data. Naturally, given the small sample size, any strict interpretation of the estimated elasticities needs to be accompanied by sufficient caution.

4.1 The Effect of Price on Payment Use

The derivatives of equations (1) to (4) with respect first to relative prices and then with respect to lagged terminal availability are shown in Column 1 of Table 4 (and they are all significantly different from zero). A 10% reduction in the price of debit cards relative to an

Figure 2: Electronic and Paper Giro Use and Prices



ATM cash withdrawal is associated with a 2.2% rise in the relative use of cards in Norway compared to the Netherlands (which has a zero explicit price for both cards and ATMs). At the same time, a 10% increase in debit card terminals in Norway relative to the Netherlands is associated with a 5.3% rise in debit card use in Norway relative to the Netherlands. As seen in the table, lagging both terminals and prices by one period doubles the strength of the price response (from -.22 to -.48) but does not alter the terminal elasticity. Assuming no lags, however, increases considerably the apparent responsiveness of debit card use to changes in terminal availability–making it almost one-to-one in percentage terms–but the trade-off is to generate a price elasticity insignificantly different from zero.

Over 1990-2004, the price of ATMs in Norway rose relative to debit cards. The price elasticity suggests that a 10% rise in the relative price of ATMs is associated with a 2.3% decrease in relative use.[25] Numerically, this is very similar to the result for the debit card equation where a 10% reduction in the relative price of debit cards gives a 2.2% rise in relative use.[26] The ATM terminal elasticity, however, has an unexpected sign and is negative at its mean. When evaluated yearly, the terminal elasticity is positive over 1990-1994 but the negative relationship for the remaining years dominates, giving a negative mean. Looking more closely at ATM use and terminal availability (Tables 1 and 3) suggests that the source of the negative elasticity is that per person ATM use in Norway reaches a peak in 1998 and then falls while ATM availability in Norway reaches a peak five years later in 2003. Similarly, ATM use in the Netherlands peaks in 2001 but terminals continue to expand. The apparent

[25] Since the price ratio used in the ATM equation is the same as that used in the debit card equation–ln (Norway debit card price/Norway ATM price)–the negative debit card price elasticity would become a positive elasticity in the ATM equation.

[26] The ATM price effect is larger when both terminals and prices are lagged in the model.

Table 4: Price and Terminal Elasticities Under Different Model Specifications

	Lagged Terminals	Lagged Terminals and Prices	No Lags	Separate Prices Own	Separate Prices Substitute
Debit Card					
Price Effect	-.22*	-.48*	-.06	-.19	-.03
Terminal Effect	.53*	.57*	.94*	.49*	
ATM Cash Withdrawal					
Price Effect	.23*	.31*	.29*	-.85*	.69*
Terminal Effect	-.16*	-.49*	-.35*	-.35*	
Electronic Giro					
Price Effect	-.46*	-.53*	-.44	.21*	.10*
Paper Giro					
Price Effect	.27*	.25*	.33*	-.03	.03

Starred (*) values indicate a P-value smaller than .01 in a two-tailed t test.

explanation for the negative ATM terminal elasticity is that ATM use has reached saturation (due in part to the price disincentive) while terminals are still being added, giving the result that terminals are expanding while use is falling.

The estimated price effects for electronic and paper giro payments conform to expectations since, when the relative price of electronic giro transactions falls 10%, relative use of this instrument in Norway rises 4.6% compared to the Netherlands. Similarly, a 10% increase in the relative price of paper giro payments is associated with a 2.7% reduction in relative use between the two countries.[27] Our preferred model in equations (1) to (4) was respecified so that direct debits, which comprise 10% of electronic giro payments in Norway but 56% in the Netherlands, were deleted from the electronic giro use and price data. This had almost no effect on the results shown in Column 1 of Table 4. Equations (1) to (4) were respecified again to include checks with ATMs so that both can substitute with debit cards. Checks were important in the early 1990s, had a high price, and their use effectively fell to zero by 2004. Nothing of substance was changed except that the debit card price elasticity lost significance.

Real per capita personal consumption was markedly higher in Norway and growing faster than in the Netherlands. We expected that this would have a significantly positive effect on expanding relative electronic payment use in Norway. However, as seen in the Data Appendix where the parameter results are shown, the effect of real per capita personal consumption on payment use was insignificant in all four equations.

Just as an exercise, equations (1) to (4) were simplified by deleting the squared terminal, squared price, and terminal-price interaction variables. Then the remaining price ratio in each equation (e.g., debit card price/ATM price and electronic giro price/paper giro price) was reexpressed as the log of separate own and substitute price variables for each equation. The resulting own and substitute price elasticities, along with the reestimated terminal effect, are shown in the last two columns of Table 4. Our preferred model (in Column 1) is specified in ratio form, due to our limited sample, but it is of interest to see the implied own and cross-

[27] Since the same price ratio is used in both the electronic and paper giro equations–ln (Norway electronic giro price/Norway paper giro price), the negative electronic giro price elasticity would become a positive elasticity in the paper giro equation.

price elasticities that result from estimating each price elasticity separately. All but one own price elasticity is negative and three of the four cross-price elasticities are positive (as would be expected for a substitute payment instrument). However, considering that only one negative own elasticity and two positive cross elasticities were significant, it seems that the price effects are not very strong.

An earlier study of the effects of payment instrument pricing in Norway over 1989-1995 found significant and inelastic own price elasticities for debit cards (-.35) and ATM cash withdrawals (-.55) along with significant substitution between debit cards and ATMs which ranged from -.11 to -.46 (see Humphrey, Kim, and Vale, 2001). Although this study did not control for terminal availability as we do, the results obtained do not greatly differ from ours. In both studies, own price elasticities are all inelastic and debit cards significantly substitute for ATM cash withdrawals with an elasticity less than .50.

4.2 An Error Correction Specification

Although our model is specified in log-differences between Norway and the Netherlands, the variables used in our system estimation are non-stationary. As the estimation results may be biased and could reflect spurious correlations, our model was reestimated in first difference and error-correction forms. The model in levels, in first differences, or in error correction form are all nested within an "autoregressive distributed lag" framework. The imposed restrictions in this framework are linear and easily tested.

To illustrate, consider the following extension of equation (1), written in an autoregressive distributed lag regression format by adding lagged endogenous and exogenous variables:[28]

$$\begin{aligned} CARD_t = {} & \alpha + \gamma CARD_{t-1} + \delta_1 CARDPRICE_t + \delta_2 CARDPRICE_{t-1} \\ & + \beta_1 CARDTERMINAL_{t-1} + \beta_2 CARDTERMINAL_{t-2} + u_t. \end{aligned} \tag{5}$$

The simultaneous restrictions $\gamma = \beta_2 = \delta_2 = 0$ bring us back to a model specified in (current) levels only. Without affecting its ability to explain the data or changing the least squares estimates of the parameters of interest, (5) may be rewritten as:

$$\begin{aligned} \Delta CARD_t = {} & \alpha + (\gamma - 1) CARD_{t-1} + \beta_1 \Delta CARDTERMINAL_{t-1} \\ & + (\beta_1 + \beta_2) CARDTERMINAL_{t-2} + \delta_1 \Delta CARDPRICE_t \\ & + (\delta_1 + \delta_2) CARDPRICE_{t-1} + u_t. \end{aligned} \tag{6}$$

Imposing the simultaneous restrictions $\gamma = 1$, $\beta_1 + \beta_2 = 0$, and $\delta_1 + \delta_2 = 0$ generates a model specification in first differences that can be tested using a Wald test.

Alternatively, (5) may be rewritten in error correction form:

$$\begin{aligned} \Delta CARD_t = {} & \alpha + \beta_1 \Delta CARDTERMINAL_{t-1} + \delta_1 \Delta CARDPRICE_t \\ & + (\gamma - 1)(CARD_{t-1} - \lambda_1 CARDTERMINAL_{t-2} \\ & - \lambda_2 CARDPRICE_{t-1}) + u_t, \end{aligned} \tag{7}$$

[28] Note that compared to equation (1), the squared variables, interaction terms, and consumption have been excluded. These additional variables could be included without affecting our illustration.

where $\lambda_1 = \frac{\beta_1+\beta_2}{\gamma-1}$ and $\lambda_2 = \frac{\delta_1+\delta_2}{\gamma-1}$.

If the parameter $\gamma_1 - 1$ is negative and significantly different from zero, the model in error correction format cannot be rejected. In (7) we have an equilibrium relationship:

$$\Delta CARD_t = \alpha + \beta_1 \Delta CARDTERMINAL_{t-1} + \delta_1 \Delta CARDPRICE_t + u_t,$$

and an equilibrium error,

$$CARD_{t-1} - \lambda_1 CARDTERMINAL_{t-2} - \lambda_2 CARDPRICE_{t-1},$$

that measures the extent to which the long-run relationship between the variables $CARD_{t-1}$, $CARDTERMINAL_{t-2}$ and $CARDPRICE_{t-1}$ is not satisfied. Consequently, the feedback parameter $\gamma - 1$ can be interpreted as the proportion of the resulting disequilibrium that is reflected in the movement of $CARD_t$ in one period. If specified in logarithms, the parameters λ_1 and λ_2 yield estimates of long-run elasticities that would be equivalent to the price and terminal elasticities we derived from equations (1) to (4) if our model in levels is appropriate. Interestingly, error correction models are also appropriate when the variables are non-stationary and are particularly attractive when the dependent variable is I(1). Generally, the significance of the parameter $\gamma - 1$ indicates the existence of a long-run equilibrium and the cointegration of the non-stationary variables.[29] This would allow direct estimation of our preferred model in levels.

The error correction results of all four equations are shown in Table 5 along with the price and terminal elasticities for our preferred model from Table 1 using levels data along with new elasticities using only first differenced data. In a first difference framework both terminal elasticities have the expected sign and are significant, but this is at the expense of poor results for the price elasticities. In the error correction form, the debit card price elasticity is no longer significant but the other price elasticities have the expected sign and are significant (even with a reduction in degrees of freedom), although in two cases the feedback parameter was not significant at the 5% level. Given our data limitations, the results weakly suggest that the price elasticities using levels data in equations (1) to (4)–our preferred model–are robust and can be relied upon as long-run estimates.

4.3 Estimation of Electronic for Paper Substitution in Norway

The effect of pricing on payment instrument use is also estimated for Norway alone. This approach should give similar results to our country difference model if non-price characteristics that affect payment use in a country are not too strong. The specification is linear and simpler than our country difference model (due to degrees of freedom considerations) and all the data are for Norway:

$$\begin{aligned} CARDATM_t = \alpha_1 + \alpha_2 CARDATMTERMINAL_{t-1} \\ + \alpha_3 CARDATMPRICE_t + \alpha_4 CONSUMPTION_t + \varepsilon_{1t} \end{aligned} \tag{8}$$

$$ELEPAPER_t = \beta_1 + \beta_2 ELEPAPERPRICE_t + \beta_3 CONSUMPTION_t + \epsilon_{2t} \tag{9}$$

[29] As a stability condition, the feedback parameter $\gamma - 1$ needs to be between zero and -1.

Table 5: Price and Terminal Elasticities: Data in Levels and First Differences

	Levels Data	1st Differenced Data	1st Differenced & Levels Data in an Error Correction Model
Debit Card			
Price Effect	-.22*	.47	3.25
Terminal Effect	.53*	.75*	.82
Feedback Parameter			-.066
ATM Cash Withdrawal			
Price Effect	.23*	.06	.32*
Terminal Effect	-.16*	.47*	-.39*
Feedback Parameter			-.826*
Electronic Giro			
Price Effect	-.46*	.37*	-.60*
Feedback Parameter			-.240
Paper Giro			
Price Effect	.27*	.11	.49*
Feedback Parameter			-.448*

Starred (*) values indicate a P-value smaller than .01 in a two-tailed t test.
Debit cards and ATMs formed one system estimation while electronic and paper giros formed another in the first differenced and error correction models.

where:

$CARDATM$	=	ln (debit card use/ATM use), on a per person basis;
$CARDATMTERMINAL$	=	ln (card terminals/ATM terminals), per million population;
$CARDATMPRICE$	=	ln (debit card price/ATM price);
$CONSUMPTION$	=	ln (personal consumption), real per capita;
$ELEPAPER$	=	ln (electronic giro use/paper giro use), per person;
$ELEPAPERPRICE$	=	ln (electronic giro price/paper giro price).

Equations (8) and (9) were estimated in a systems equation framework (with 23 degrees of freedom, d.f. = 2*15 - 7). As shown in Table 6, the elasticity of substitution between debit cards and cash was -.20 using levels data and -.31 in first differences. A 10% rise in the relative price of an ATM cash withdrawal (which reduces the ratio of debit card to ATM prices) is associated with a small (2.0% or 3.1%) rise in the ratio of debit card to ATM use. If this parameter was -1.0, then the expenditure shares of debit cards and ATMs would be unchanged since a 10% relative rise in the ATM price would be exactly offset by a 10% decrease in relative ATM use. Since the parameter is less than one (in absolute value), the expenditure share of ATMs rises as the price-induced substitution is less responsive than in (say) a traditional Cobb-Douglas framework where the elasticity of input substitution to a price change is 1.0. The elasticity of terminal availability on debit card and ATM use is .54 which indicates that a 10% relative rise in debit card terminals leads to a 5.4% relative rise in debit card use.

Table 6: Price and Terminal Substitution for Norway

Debit Card/ATM substitution:		
	Levels Data	1st Differenced Data
Price Effect	-.20*	-.31*
Terminal Effect	.54*	.06
Electronic/Paper Giro Substitution:		
Price Effect	.54*	.13

Starred (*) values indicate a P-value smaller than .01 in a two-tailed t test.

The substitution elasticity between electronic and paper giro transactions had the wrong sign (at .54) and was significant using levels data in a system estimation. Use of first differenced data did not alter this sign but dropping real personal consumption from (8) and (9), which had a large and significant effect, did (giving a significant -1.98 value for electronic/paper giro substitution).

4.4 Conclusions Regarding the Effect of Pricing on Payment Use

Three conclusions can be drawn from our price elasticity results so far. First, in Table 4 and in our alternative specification here, the effect of terminal availability on relative debit card and ATM use exceeds that for pricing since the terminal elasticities are larger. This implies that convenience, safety, and other non-price attributes of different payment instruments are themselves an important inducement to change payment use, as long as terminals are available, than is price. Even so, pricing does have a significant effect in influencing payment choice but not as much as we had expected. A second conclusion, which follows in part from the first, is that changes in relative prices (or terminals) both have a smaller than proportional effect on relative use. In this sense, both effects are relatively inelastic. Third, the similarity of the price elasticity results from our country difference model with those for debit card/ATM substitution in Norway alone suggests that the omitted variable of unspecified non-price payment instrument attributes is not strong enough to markedly distort price elasticity results derived from a single-country estimation.

Although approximate, our overall conclusion is that while terminal availability appears to have a stronger effect on relative payment instrument use than does direct per transaction pricing, the shift to electronic payments could be speeded up when pricing is combined with terminal availability.[30] If both prices and terminals are expanded at similar percentage rates then the adoption of electronic payments could have been speeded up by perhaps 40% compared to not having per transaction pricing.[31] As seen in Tables 2 and 3, however, debit card terminals changed at a much greater rate than did the price of ATMs or the relative prices of cards to ATMs, indicating that in this instance a potential speedup of 40% is too high and was not realized.

More precisely, for Norway the average annual growth in debit card terminal density equaled +15%, whereas the growth in card price relative to ATMs was -11%. Given the estimated elasticities in Table 4, this would predict a relative rise of debit card use over ATMs

[30] Dutch survey results confirm the relative importance of terminal availability for payment instrument usage and stress also the non-price attributes of payment instruments (e.g. , in the adoption of stored-value cards, see Jonker, 2005).

[31] This estimate is derived from the ratio of the price elasticity in our preferred model (-22%) in Column 1 of Table 4 to the terminal elasticity (53%), which equals .42.

of $15 \times 0.53\% + 11 \times 0.22\% = 10.4\%$ from the terminal and price effects alone. Without any price inducements this increase in usage would be $15 \times 0.53\% = 8.0\%$, suggesting that the substitution process has been speeded up by approximately $2.4/10.4 = 23\%$, although the realized contribution of pricing to debit card adoption was 2.4% a year.[32] Electronic giro payments do not have a terminal constraint and the influence of consumption growth on payment use is not significant so only the effect of pricing is measured. The growth of electronic giro relative to paper giro prices was -8% while the price elasticity in Table 4 was .46, suggesting that the realized contribution of pricing to the adoption of electronic giro payments was $8 \times 0.46\% = 3.7\%$ annually. Thus in terms of both the size of the estimated price elasticities and their realized impact on adoption rates, the effect of pricing on the shift to electronic payments is greater for giro transactions than for debit cards. The fact that terminal elasticities are an important component of the substitution process for cards suggests that non-priced attributes–such as convenience and security–play a greater role for cards versus cash than for electronic versus paper giro transactions.

5 Illustrating the Social Benefit of Electronic Payments

Logistic or "S-curves" have been successfully used to approximate the adoption and dispersion of new products and technology, such as the adoption of the telephone, the television, the Internet, and the use of robots in manufacturing. This procedure is applied here to electronic payments since, during our 15-year period, the shares of debit cards (in total debit card and ATM transactions) and electronic giros (in electronic plus paper giro payments) made the transition from rising at an increasing rate to rising at a decreasing rate (c.f., Table 7).[33]

Over 1990-2004, the average change in debit card shares at 4 percentage points per year in both countries suggests that per transaction pricing of debit card and ATM transactions in Norway did not appear to speed up the adoption of cards. If it had, we would expect to see a larger average share change for Norway than for the Netherlands (rather than the reverse seen in Table 7). This result is essentially consistent with the low estimated price elasticities for debit cards compared to electronic giros seen in Tables 4 and 5.[34]

The smaller change in electronic giro shares for the Netherlands compared to Norway implies that pricing giro transactions has speeded up the transition to electronics. For giro transactions, the relative price of paper giros was rising but, in addition, the electronic price was absolutely lower than the paper price. Although the relative price of ATM transactions was also rising over our sample period, the debit card price was absolutely higher than the ATM price for the beginning one-third of our sample. While economists maintain that only changes in relative prices matter, common sense suggests that consumers are also influenced by absolute prices. Our data show a falling relative price of debit cards over the whole period but, if the debit card price had remained above the weighted average of an ATM transaction for the entire period as well, it is very unlikely that many consumers would have chosen to use a debit card unless the non-price attributes were very strong.

[32] The same calculation using price (-.20) and terminal (.54) elasticities for Norway alone from Table 6 gives a 20% speedup for debit card use (with a contribution of 2.2% annually).

[33] The coverage of an inflection point for electronic giros in the Netherlands is weak, however.

[34] Indeed, replacing the dependent variables in equations (1) to (4) with the index of shares, rather than the index of per person use, reverses the sign for the debit card price elasticity and gives an insignificant paper giro price effect. With the index of shares–ln [(Norway share electronic/share paper)/(Netherlands share electronic/share paper)] the price effects are weaker than those we identified earlier.

Table 7: Debit Card and Electronic Giro Payment Shares in Norway and the Netherlands

	Debit Card		Electronic Giro	
	Norway	Netherlands	Norway	Netherlands
1990	.27	.12	.22	.56
1995	.58	.39	.34	.67
2000	.78	.63	.60	.80
2004	.87	.73	.82	.87
Percentage point change in share per year:				
	4	4.1	4	2.1

Payment shares are debit card use/(debit card + ATM use) and electronic giro use/(electronic + paper giro use).

Since inflection points are covered in the data series, logistic S-curves were estimated and are shown in Figures 3 and 4.[35] The S-curves are from: $\ln(S_t/(1-S_t) = a + bT + \epsilon_t$ where S_t = the share of electronic payments in total electronic and paper transactions, T = time, and b is the slope of the S-curve. This form imposes symmetry around the inflection point in the data and assumes that electronic payments will, at some point in time, completely replace their paper-based alternative. This is more likely for electronic versus paper giro transactions than it is for debit cards and cash, unless stored-value cards become popular and replace cash use.[36] The fit to the observed data can be assessed by the extent to which the data points over 1990-2004 deviate from the solid curves in the figures.[37] All the other data points in the figures are predicted shares from a fitted logistic curve.

An alternative way to judge the effect of pricing payment services is to compare the slopes of the estimated S-curves. For debit cards in Figure 3, $b = .197$ for Norway while $b = .249$ and is higher for the Netherlands, suggesting a more rapid adoption rate. While this difference is statistically significant at the .05 (but not .01) level, it is not very important economically (as seen visually from the figure and noted in Table 7 where the yearly average change in shares is shown). For electronic giro transactions in Figure 4, the difference in slopes is greater (b =.202 for Norway, b = .126 for the Netherlands) and this difference is significant at the .01 level, as can be inferred simply by looking at the graph.[38] From a public policy perspective, this suggests that consumer valuation of the convenience, security, and other non-price benefits of debit card use is important and that pricing–given the relative prices being charged–has likely had only a relatively small incremental impact on the trade-off between debit card use versus obtaining cash from an ATM. In contrast, pricing appears to make a significant difference in the adoption rate of electronic giro transactions. This is consistent with the larger price elasticities usually estimated for electronic giros compared to

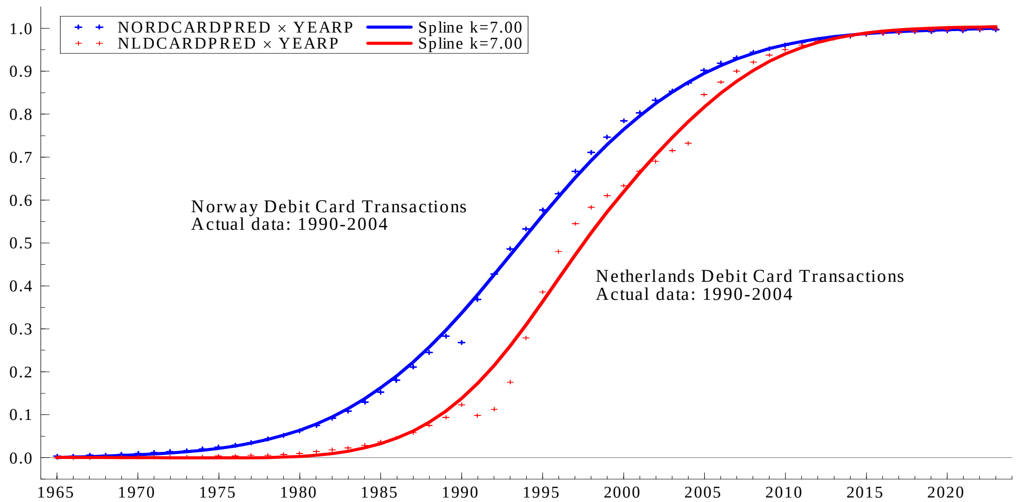
[35] Comparing S-curves for Norway and the Netherlands illustrates the "starting value" problem again, which we also encountered in estimating the model.

[36] A non-linear, symmetric, logistic curve specification exists that can impose an upper limit (say $S_t^* = .90$) to the replacement of ATM cash withdrawals by debit cards using $\ln S_t = S_t^*/(1+c\exp(-bT))+\epsilon_t$. Unfortunately, we were unable to obtain convergence when this model was estimated.

[37] The adjusted R^2s ranged from .91 to .99. Meade and Islam (1995) have shown that the standard logistic curve we use (along with another simple specification) outperforms more complicated models. This is largely because allowing for non-linearity and/or asymmetry around the inflection point asks too much of the limited data typically available.

[38] Assuming the two S-curves are independent, since they refer to different countries, the means test for Figure 3 was: $t = (.249 - .197)/\sqrt{(.021)^2 + (.006)^2} = 2.38$ and was $t = (.202 - .126)/\sqrt{(.010)^2 + (.006)^2} = 6.52$ for Figure 4.

Figure 3: Debit Card Transaction Shares for Norway and the Netherlands



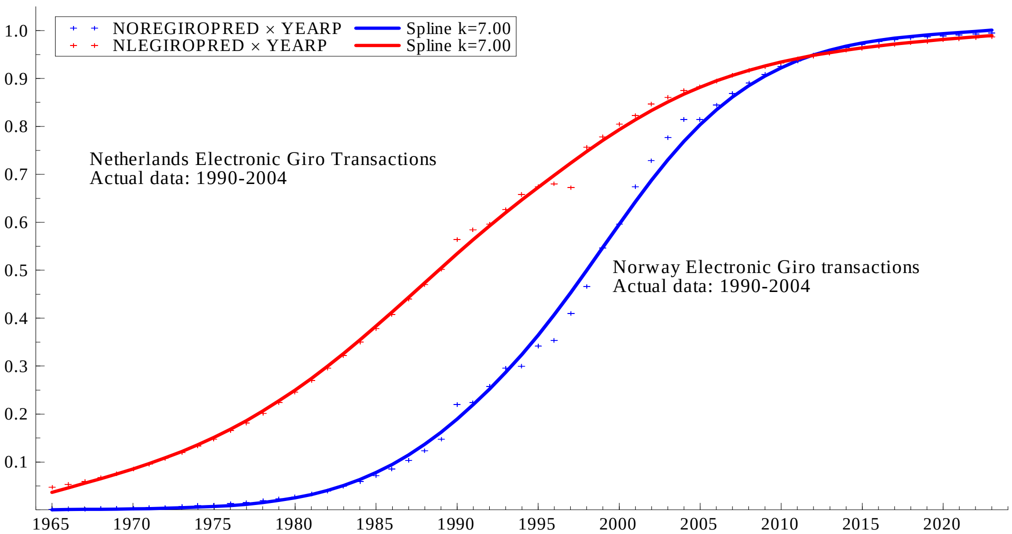
debit cards.

The discounted social benefit of electronic payments can be approximated by considering the difference in the bank cost of producing electronic versus paper payments (Row 1 of Table 8) and the speed by which a country shifts to electronic payments (determined, as an approximation, from Figures 3 and 4).[39] The per transaction bank cost figures used here are for Norway but are very similar to those for the Netherlands. As the time taken to shift from paper to electronics differed across countries and payment instruments, we computed benefits using a common number of years (40). We started when the share of electronics was .10 and ended when it reached .90, to eliminate the slow start and finish evident in the fitted S-curves which are farther from our observation set. Once a .90 share was attained, the undiscounted nominal benefits remained at that level until the end of the 40-year period. Benefits are computed using the level of payments in 1999, noted in the footnote to the table, since we do not have information on what that level was before 1990 nor after 2004. The annual per person benefits were discounted at 3% and sums of the per person discounted (and undiscounted) benefits are shown in Table 8. Shifting to debit cards from ATMs apparently saves €945 per person in Norway and €769 in the Netherlands while the shift to electronic from paper giro payments saves €814 and €881 per person, respectively, in the two countries. Factoring in the savings from eliminating checks adds €461 and €676 in savings per person in Norway and the Netherlands, discounted over the same 40-year period.[40] Overall, the

[39] Savings in merchant costs are typically unknown but, if estimated, should be included (taking care not to double count certain expenses, such as including bank fees in merchant costs). Some merchant cost savings information does exist for point-of-sale transactions in the Netherlands but no information exists for merchant savings for giro payments (Brits and Winder, 2005).

[40] Bank check costs per transaction were 2.70 euros while debit card expenses were .30 euros. This gives a

Figure 4: Electronic Giro Transaction Shares for Norway and the Netherlands



apparent discounted savings in bank costs per person from electronic payments is €2,220 in Norway and €2,326 in the Netherlands. If the switch to electronic payments took place immediately rather than over a 40-year horizon, the total savings would be €0.7 billion for all of Norway (.35% of GDP in 2004) and €2.9 billion for all of the Netherlands (.61% of GDP).[41]

6 Summary and Conclusions

Electronic payment instruments (credit cards excepted) are considerably cheaper than their paper-based alternatives, including cash. Banks and merchants are interested in shifting users to electronic payments to save costs, as are some government policy makers who seek

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net savings of 2.40 euros for each of the 11.8 (Norway) and 17.3 (Netherlands) checks written per person in 1990 that were fully replaced by debit cards by 2004. Had the net savings per check been the same as the cost difference between debit cards and ATMs (1.01 euros - .30 euros = .71 euros), then the values shown in Table 8 would already include the check savings. Since the check savings are larger, the additional savings from checks for each year is 2.40 euros - .71 euros = 1.69 euros times the per person check numbers above times 40 years and then discounted at 3%. This gives the discounted sums reported for checks in the text.

[41] Multiplying the estimated cost difference for debit cards and ATMs in Norway and the Netherlands (.71 euros) by the number of total debit card and ATM transactions per person in 1999 (95 and 72, respectively) and then by the population of each country (4.6 and 16.3 million, respectively) gives the cost savings estimate if debit cards immediately replaced ATMs. The cost difference for debit cards and checks is 2.40 euros and the respective number of transactions in 1990 was 11.8 and 17.3 checks per person. The cost difference of electronic versus paper giro payments was .69 euros while the respective number of transactions was 84 and 120 per person in 1999. These values, plus GDP, were used to compute the estimated savings in the text. Including merchant cost savings would raise these values.

Table 8: Estimated Per Person Benefit from Electronic Payments (all values are in euros)

	Debit Card vs. ATM		Electronic vs. Paper Giro	
	Norway	Netherlands	Norway	Netherlands
Cost Difference	1.01 - .30	1.01 - .30	1.39 - .70	1.39 - .70
Undiscounted	1,907	1,533	1,644	1,835
Discounted	945	769	814	881

Per person debit card + ATM transactions in 1999 were 95 per year in Norway and 72 in the Netherlands while electronic + paper giro transactions were, respectively, 84 and 120.

to improve the cost efficiency of their nation's payment system. Historically, banks have recouped their payment costs through: (1) interest earned on payment float (from delaying availability of funds credited to accounts and debiting accounts prior to bill payment value dates); (2) maintaining a spread between market rates and the rate paid on deposits; and (3) charging flat monthly fees or imposing balance requirements. In contrast to business users, consumers face very few payment services that are priced on a per transaction basis and so have little incentive to choose the lowest cost instrument either at the point of sale or for bill payments.

Banks are well aware that transaction pricing can speed up the shift to electronic payments but are reluctant to lose deposit market share by being the first (and perhaps only) bank to implement explicit prices differentiated according to underlying costs. While this problem is mitigated if most (or all) banks implement pricing at about the same time, antitrust authorities are unlikely to view such coordination as being in the public interest unless the social benefits from pricing are significant and the quid pro quo is a compensating reduction in payment float, a higher interest rate paid on deposits, or a reduction in flat fees or balance requirements. Indeed, float reduction was the trade-off when banks coordinated the timing of when they would implement pricing in Norway (there was no coordination in the prices to be charged and initially some were zero).

In this paper we use the experience of Norway (which priced its payment services) and the Netherlands (which did not) over 1990-2004 to try to determine what the incremental effect of transaction pricing may be on the adoption of debit cards versus withdrawing cash from an ATM and on the adoption of electronic giro transactions (credit transfers and direct debits) over paper giros. Specifically, we compare payment instrument use per person in Norway in response to the prices being charged, the availability of terminals, and the level of real consumption with the experience of the Netherlands which also adopted electronic payments but did not price. Our four-equation country difference model spanned 15 years–the limit of the available data–and during this time the share of electronic payments rose by some 60 percentage points, from around the mid-twenties to the mid-eighties which in most cases easily covered the inflection point where the share of electronic payments switches from rising at an increasing rate to rising at a decreasing rate. Our model is estimated in a systems equation framework using levels data and robustness is illustrated by estimating models in a first difference and error correction framework. Price and terminal elasticities derived from these models form the basis for our conclusions and indicate the incremental effect of pricing on the adoption rate of electronic payments. We also attempt to estimate the social benefit of shifting to electronic payments and offer guidance on how pricing may best be implemented.

The effects of pricing differ depending on which instruments are being considered. Overall, pricing has a smaller effect on shifting consumers from ATM cash withdrawals to debit card use than it does in shifting use from paper to electronic giro transactions. The reason for this difference seems to be that there are non-price benefits associated with debit card use (convenience, security) that consumers value such that the availability of terminals needed for debit card transactions has a stronger effect on debit card use than prices, as evidenced by the fact that the debit card price elasticity is smaller than the terminal elasticity. Debit cards also substitute for costly checks and the high price on these instruments in Norway was associated with their virtual elimination, although the same thing happened in the Netherlands which did not price. While terminal availability appears to have a stronger effect on debit card use than does pricing, the shift to cards can be speeded up when pricing is combined with terminal availability. Using our estimated elasticities and the actual changes in prices and terminals, the predicted relative rise of debit card use over ATMs was 8.0% from terminal effects alone but rose to 10.4% with pricing, an increase of around 20%.

The effect of pricing on electronic giro use was greater than it was for debit cards since the electronic giro price elasticity is larger and the percent change in price experienced was greater. Reasons for this difference are the above-mentioned non-price convenience and security attributes of debit cards along with the fact that for one-third of our time period the absolute price of a debit card transaction was higher than the weighted average price of an ATM cash withdrawal. In contrast, the price of an electronic giro was always absolutely lower than the paper giro price. Even though the relative prices of debit cards and electronic giros were both falling over the entire period, the higher absolute price of a debit card transaction versus an ATM would be expected to dull the overall price response being measured for the entire period since there is no strong reason to believe that the price response is symmetric (and symmetry was not imposed in our model) since the non-price attributes of debit cards and ATMs are different. Thus if pricing is implemented, it will likely be more successful if the absolute price of the less expensive instrument is always absolutely lower per transaction than the price of the more expensive instrument.[42]

In terms of cost savings, the shift from ATM cash withdrawals and checks to debit cards plus the savings from shifting from paper to electronic giro transactions–if it happened without a lag–may save €0.7 billion in bank costs for Norway (.35% of GDP in 2004) and €2.9 billion for the Netherlands (.61% of GDP).[43] Merchant cost savings, for which little information exists, would increase these savings estimates as would viewing the discounted bank cost savings over a 40-year transition period (and is noted in the text). As both of these countries are well on their way to realizing the full potential gains from electronic payments, the issue of pricing or not pricing is a policy topic for developed countries that are not as far along in the substitution process or for most developing countries that are just in the initial stages of thinking about how to improve the efficiency of their payments system. The social benefits of electronic payments are quite large and may convince antitrust authorities to allow the coordination of the timing of the implementation of pricing (but not of course the prices to be charged) to speed up this transition if banks wished to adopt explicit pricing. And with interest rate margins falling, worsening the recoupment of bank payment costs, this wish may soon become a reality.

[42] This was not done in Norway, perhaps because dispensing cash via an ATM was already less expensive than dispensing it through a branch office (assuming the rise in dispensing frequency at an ATM does not rise enough to offset this advantage).

[43] The savings are absolutely higher for the Netherlands primarily because its population (16.3 million) is much larger than that of Norway (4.6 million), but GDP per capita is lower.

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8 Data Appendix.

Parameter estimates and t-statistics are shown below for the system estimation of equations (1) to (4). Standard errors were computed from a heteroscedastic-consistent matrix (Robust-White).[44]

Variable	Parameter	Estimation	T-statistic
Constant	α_1	.497961	2.77398
DIFDCARDTML	α_2	.373649	2.55827
DIFDCARDPRICE	α_3	.055702	.180209
DIFDCARDTML2	α_{22}	.167924	1.24453
DIFDCARDPRICE2	α_{33}	.870318	1.21951
DCARDTMLPRICE	α_{23}	-.308628	-.922949
DIFPCONS	α_4	-.571509	-1.13726
Constant	β_1	.035974	.554554
DIFATMTML	β_2	-1.67562	-8.56053
DIFDCARDPRICE	β_3	1.00388	5.85276
DIFATMTML2	β_{22}	5.93594	7.78129
DIFDCARDPRICE2	β_{33}	2.33231	3.40630
ATMTMLPRICE	β_{23}	-3.15162	-4.50450
DIFPCONS	β_4	-.138567	-.766170
Constant	γ_1	-.519080	-1.21248
DIFEGIROPRICE	γ_2	1.06886	2.15115
DIFEGIROPRICE2	γ_{22}	.881313	3.06231
DIFPCONS	γ_3	.544589	1.13520
Constant	δ_1	-.606181	-1.20153
DIFEGIROPRICE	δ_2	-1.69478	-2.90182
DIFEGIROPRICE2	δ_{22}	-1.13584	-3.30711
DIFPCONS	δ_3	-.678980	-1.34759

Debit Card equation (1): $R^2 = .978$, Durbin-Watson = 2.12
ATM Cash Withdrawal equation (2): $R^2 = .987$, Durbin-Watson = 2.80
Electronic Giro equation (3): $R^2 = .872$, Durbin-Watson = 1.86
Paper Giro equation (4): $R^2 = .802$, Durbin-Watson = 2.03

Data description and sources:

The Netherlands:
Source: DNB Statistics (www.dnb.nl), CBS Statistics (www.cbs.nl) and National Accounts statistics.

[44] Our data computations follow a translog type of approach where squared values of variables are computed as $(\ln X)^2$ rather than $\ln (X^2)$ and interaction variables are $(\ln X)(\ln Y)$ rather than $\ln (XY)$. Consequently, first differences are computed as $(\ln X)_t^2 - (\ln X)_{t-1}^2$ rather than $\ln (X^2)_t - \ln (X^2)_{t-1}$ and interaction variables are $(\ln X)(\ln Y)_t - (\ln X)(\ln Y)_{t-1}$ rather than $\ln (XY)_t - \ln (XY)_{t-1}$. The two approaches give similar but not identical results.

Debit card transactions include goods purchased with domestic debit cards; credit card usage (of about 3% of total card usage) is not included. Debit card terminals are EFTPOS terminals at the point-of-sale in retail locations. ATM cash withdrawal transactions include only withdrawals with domestic debit cards. ATM terminals are owned by Dutch commercial banks. Paper-based giro transactions include ordinary credit transfers ("mail giro") and inpayment transfers ("accept-giro"). Electronic giro transactions include credit transfers, standing order credit transfers and direct debits.

Consumption is derived from national accounts data on final private consumption expenditures, per capita, and corrected for inflation using CPI data. Demographic data are constructed using data from the Dutch Central Bureau of Statistics.

Norway:
Source: Norges Bank (www.norgesbank.no), Norges Bank Annual Report on Payment Systems (2004, 2000, 1997), Statistics Norway (www.ssb.no), and International Finance Statistics database.

Debit card transactions include goods purchased with Norwegian payment cards in Norway and abroad but does not include use of oil company cards (see footnote 4 in the text). Debit card terminals are EFTPOS terminals that also include terminals owned by oil companies (since all debit cards can be used). ATM cash withdrawal transactions include withdrawals from commercial banks and savings banks. These banks own the ATM terminals. Debit card price relates to the bank per transaction price for payment cards using an EFTPOS terminal. ATM withdrawal price is a weighted price for a cash withdrawal, based on observed prices and volume weights corresponding to withdrawals at a bank's own ATM terminals during opening hours and outside of opening hours, and other banks' ATM terminals during opening hours and outside of opening hours. Paper-based giro transactions include mail giro, giro for cash payments, account debits, and money orders. Electronic giro transactions include company terminal giros, giro via Internet or telephone, credit transfers, and direct debits. Paper-based giro price is a weighted price per transaction using observed prices and volume weights corresponding to mail giro, giro for cash payments, account debits, and money orders. Electronic giro price is a weighted price per transaction using observed prices and volume weights for terminal giro, Internet giro, telephone giro, and direct debits.

Consumption is derived from IFS data on final private consumption expenditures, per capita, and corrected for inflation using CPI data. All nominal values and prices are converted into euros using a purchasing power parity exchange rate published by Norges Bank. Demographic data are constructed using data from Statistics Norway.

Some missing values at the beginning of the sample were estimated by applying simple extrapolation procedures.