Transaction Pricing and the Adoption of Electronic Payments: A Cross-Country Comparison*

Wilko Bolt,[a] David Humphrey,[b] and Roland Uittenbogaard[a]
[a]De Nederlandsche Bank
[b]Florida State University

After safety, the efficiency of a nation's payment system is a primary concern of central banks. Since electronic payments are typically cheaper than paper-based or cash payments, pricing these transactions should speed up the shift to electronics. But by how much? Norway explicitly priced point-of-sale and bill-payment transactions and rapidly shifted to electronic payments, while the Netherlands experienced a similar shift without pricing. Controlling for terminal availability and differences between countries, direct pricing accelerated the shift to electronics by about 20 percent. The quid pro quo was the elimination of bank-float revenues.

JEL Codes: D12, G21.

1. Introduction

The average bank cost of an electronic payment is one-third to one-half that of its paper-based equivalent or cash (cf. Humphrey et al. 2006). A merchant's average cost of accepting a bill payment electronically over a giro network or at the point of sale (POS) is also lower (credit cards excepted). Since the resource cost of a country's payment system may account for 1–2 percent of its GDP, it is clear

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that shifting from paper to electronic payments can confer social benefits. Importantly, the discounted value of these cost benefits will be larger the more rapidly this shift occurs. Additional effects also exist and are of concern to central banks since the replacement of cash by electronic payments can alter the monetary aggregates (Duca and VanHoose 2004), reduce government seigniorage revenues (Humphrey, Kaloudis, and Øwre 2004), and make tax evasion and illegal transactions more difficult to hide.

There is overwhelming evidence that consumers respond to price incentives but very little evidence on how strong 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." While businesses often 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. However, consumer surveys indicate that certain implicit costs (e.g., availability, convenience, and security) can affect payment choice (Borzekowski and Kiser 2006; Klee 2006), and models have been developed to discriminate between pecuniary and behavioral reasons for credit card versus debit card use (Zinman 2005). These and other motivations for choosing different payment instruments were outlined in a recent survey, but their relative importance has not been determined (Scholnick et al. 2007). As per-transaction pricing of consumer payments is rare in Europe and the United States, these analyses cannot address what the impact of explicit pricing would be. Such pricing is rare since, reportedly, banks fear a loss of deposit market share if they are the first (and only) bank to implement it, while antitrust authorities would be suspicious of industry efforts to coordinate the implementation of per-transaction prices to minimize changes in relative market shares.

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 a phasing out 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" because the monetary cost to users was indirect and implicit. 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 (Enge and Øwre 2006).

Our 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 transaction pricing (Norway) and one that does not (the Netherlands). Transaction-based prices are key since they directly affect consumers' decisions about payment use, whereas implicit prices and fixed fees can have limited behavioral effects since these costs do not vary with usage and, when imposed, are typically stable over time. Nonprice effects—such as availability, convenience, and security—also influence payment use, and our attempt to control for these effects utilizes a two-country model.

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

If the incremental effect of direct pricing is large, holding constant other intracountry and cross-country influences affecting the adoption of electronic payments, then the potential social benefit can also be large. This suggests that antitrust concerns raised by possible bank coordination of the implementation of prices (but not the level) could be offset by subsequent social benefits. We find that while pricing has speeded up the shift to electronic payments, the shift was only about 20 percent faster in Norway with pricing than in the Netherlands without pricing. Our analysis extends earlier work on payment pricing (Humphrey, Kim, and Vale 2001) by separating terminal-availability influences from price effects for point-of-sale transactions and by doubling the time period covered to capture more price variation. Newly available data also allows us to analyze the paper/electronic trade-off for giro-based bill payments as well as issues associated with nonstationarity in aggregate trended payment data. Finally, we control for unspecified and hard-to-measure nonprice influences to obtain potentially more accurate price elasticities.

In what follows, section 2 illustrates how the composition of payments has evolved in Norway and the Netherlands along with the levels of relative paper and electronic prices in Norway. Explicit transaction prices for consumers are zero in the Netherlands. 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 electronic giro payments for paper-initiated giro transactions.

In section 3, a parsimonious "country-difference" model is specified to separate the effect of pricing on point-of-sale debit card use and ATM (automated teller machine) 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 (Internet connections far exceed giro use and are not a constraint, and, in any case, an electronic or paper giro can be initiated by phone or in person). No good data exists on payment use prior to the start of pricing (1986) in Norway, so nonprice attributes of different payment instruments can affect measured price elasticities if standard analysis is applied using only one country (as was the case in Humphrey, Kim, and Vale 2001). The Netherlands, which did not price, is used to "hold constant" nonprice attributes of the different payment instruments to obtain potentially more accurate price effects. Put differently, we seek to "subtract" the shift to electronic payments that presumedly would have occurred without pricing—due to nonprice attributes, terminal availability, and per-person consumption levels—from the shift that is observed with pricing plus these three influences on use.

Our set of four equations is estimated in section 4 in a seemingly unrelated regression framework to improve efficiency. The effects of prices on payment composition, including the implied price elasticities, are presented here. 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. A summary of our results is contained in section 5, along with an estimate of the bank cost savings associated with the shift to electronic payments.

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.[1] As seen in table 1, the number of debit card transactions per person per year in Norway rose from 5 to 146 over our fifteen-year period, growing 25 percent per year.[2] The Netherlands started from a smaller base of one transaction per person per year but rose to seventy-seven, a 33 percent annual growth.[3]

[1] Unlike in the United States, credit card use is low in Europe (and miniscule in the two countries we examine).

[2] 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, 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.

[3] Checks written per person in Norway went from twelve per person annually in 1990 to less than one in 2004. In the Netherlands, they went from seventeen to zero. Credit card transactions per person in both countries were less than one in 1990 and only three per person (the Netherlands) to five (Norway) in 2004 (or about 3 percent 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 (electronic funds transfer at point of sale) directly from deposit accounts and have POS terminals connected to the bank network installed in shops. The banks' purpose was to replace checks and cash with cheaper electronic cards at the point of sale.

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

Part of this difference is due to the fact that Norway started 1990 with 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 country has time-series data 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 so far have very limited acceptance—are the only real substitute.[4] We use the number of cash withdrawals at ATMs as

[4]Brits and Winder (2005) provide an estimate of cash use in the Netherlands in 2002. Cash accounted for 85 percent of POS transactions and 56 percent of

our indicator of cash use in transactions.[5] This quantity measure seems appropriate since the average real value of an ATM withdrawal rose by less than 1 percent annually in both countries.[6] 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.[7]

Analysis of the U.S. market suggests that the price depositors pay when withdrawing cash from a foreign ATM (an ATM owned by a different bank) affects ATM deployment decisions (to earn revenue) and tends to tie depositors to banks with larger ATM networks (Hannan 2005; Knittel and Stango 2004). These effects are not important in the Netherlands, as consumers are not charged for ATM usage from any bank, and they play a minor role in Norway where there is only a foreign ATM fee set by the depositor's bank but no surcharge by the ATM owner. Thus, the contemporaneous determination of ATM price and terminal deployment is weak, and, in any event, we lag terminal availability in our model specification to mitigate this possible endogeneity problem.

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sales value, while debit cards accounted for 13 percent of transactions and 40 percent of sales. The average value of a cash transaction was around €10 but over €47 for debit cards in 2002.

[5]Only recent time-series data exist on the number or value of cash withdrawals over the counter at financial institutions or through "cash-back" opportunities at supermarkets. ATM cash withdrawals are the only consistent data that exist for our time period.

[6]In 2004 prices, the average real ATM withdrawal in Norway rose gradually from €127 in 1991 to €138 in 2004, while in the Netherlands it rose from €94 in 1991 to €107 in 2004. These figures imply annual real-growth rates of roughly 0.6 percent and 0.9 percent for, respectively, Norway and the Netherlands. There is thus little reason to specify both the number and the value of ATM cash withdrawals.

[7]In reality, consumer payment choice is more complex. First, at an ATM there is the choice of whether to withdraw or not; then second, at the point of sale, there is the choice of 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).

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 (and in table 2), 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 transaction growth in Norway is slower than in the Netherlands), but we do not see it for debit card use (where relative prices would favor more rapid growth in Norway over the Netherlands).

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 transactions to 78 over 1990–2004 (growing 12 percent a year) while only rising from 44 transactions to 124 over the same period in the Netherlands (growing 7 percent annually).[8] 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

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

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

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.[9]

[9]Consumers in the Netherlands do face a fixed annual fee for maintaining an account (about €6) that allows the holder to use a debit card and the bank's ATM network to withdraw cash, while Internet banking typically has a one-time startup fee (around €15). Because these fees are fixed, consumers "see" a zero price per additional transaction and respond accordingly. If the fixed fees, which did not vary much over time, were added as additional variables in our (double log) model, basically only the intercept and not the price elasticities would be affected. Additionally, while the average value of a debit card transaction was between €40 and €50, about 3 percent of all Dutch debit card transactions

The weighted-average per-transaction price of a cash withdrawal in Norway was in 1996, and earlier, less than that for debit cards.[10] 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 (table 2, row 3), it ended up being only 65 percent 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.[11] 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.[12] 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 percent as high as a paper giro payment, but by 2004

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were subject to a merchant surcharge of about 15 eurocents (De Nederlandsche Bank 2004) when the transaction value was less than €10–€12. Some merchants wished to discourage use of debit cards for low-value transactions since accepting cash is cheaper due to bank fees paid by merchants for debit card transactions.

[10]This observation only holds on a per-transaction basis. On average, one ATM withdrawal could fund roughly two to three 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.

[11]The relative debit card/ATM price changes shown reflect banks' initial efforts to induce depositors to shift cash withdrawals from branch offices to cheaper ATMs and then later from cash use to even cheaper debit card transactions.

[12]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 directly included in the analysis. The alternative of including a cash-back dummy, since it was collinear with the debit card price variable already in the model, yielded anomalous results, suggesting that these two effects cannot be reliably separated. Thus, the debit card price elasticity reported below is best considered as a combination of price and cash-back effects in Norway.

this had fallen to only 9 percent 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. Billers often give a slight discount to customers who pay by direct debit, thus creating a slight price advantage over a credit transfer. However, regardless of which party initiates the payment, both are counted as a single electronic giro transaction.

It is important to note that the prices charged in Norway do not cover the full bank cost of making a payment (cf. Flatraaker and Robinson 1995; Gresvik and Øwre 2003). In 1988, transaction prices covered only around 25 percent of the banks' payment cost, but this coverage had risen to around 70 percent in 2001.[13] As well, in both countries banks initially made some effort to inform customers of the advantages of using lower-cost electronic payments whether or not the transactions were directly priced (but we cannot explicitly account for this in our model).

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 per-transaction basis, while the

[13]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, with more detail in Guibourg and Segendorff 2007).

other side obtains the service (almost) for free in order to generate greater demand.[14] 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

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 1,000)							
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: DNB statistics, www.dnb.nl; National Accounts; Dutch CBS; Norges Bank Annual Report on Payment Systems, www.norgesbank.nl; IFS.

[14]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.

population (which controls for differences in population size).[15] 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 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 (table 3, row 3). Separating the 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 (table 1, row 3).[16]

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

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

[16] 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 percent of total population but only 1 percent of total geographic area (see Norway statistics, www.ssb.no). Less extreme, in the Netherlands, the ten largest cities make up roughly 20 percent of Dutch population, with 3.5 percent of the geographic area (see CBS statistics, www.cbs.nl). Since this difference in densities is effectively a constant over fifteen years, in our log-difference equation its impact would affect only the intercept and not the slope parameter, which is our terminal elasticity.

per capita personal consumption between the two countries, since higher levels of real consumption tend to be associated with larger numbers of transactions.[17] 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, those with a lower opportunity cost, or those 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 percent greater than that in the Netherlands in 1990 but rose to be 48 percent 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 twenty to twenty-four. Indeed, these shares are falling in both countries.[18]

3. A Country-Difference Model of Payment Choice

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.

[17] 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 otherwise would be, permitting real consumption to be larger.

[18] Demographic variables are typically extremely smooth series. In implementation, this created convergence problems in our system estimation and the population share variable was excluded.

Our time period is short (only fifteen years), as time-series data on payment instrument use have only recently been deemed important enough to be routinely collected at the country level by government agencies. While some time-series data 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:

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

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

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

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

In the variable definitions below, NOR indicates Norway and NL indicates the Netherlands. Differences between these countries are expressed in index form:[19]

[19]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.[20] Note that in the absence of Dutch prices for payment instruments, we implicitly take the relative price for the Netherlands as being constant, which will then only affect the intercept in our model.

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

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

is not restricted to a value of 1 (which would imply equal starting values for 1990).

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

The system of equations (1)–(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. With fifteen observations per equation, there are thirty-eight degrees of freedom (d.f. $= 4 * 15 - 22$). As shown in the appendix, the explanatory power of the model was high (the respective adjusted R^2s were .96, .98, .84, and .75 from the system estimation). As the variables are not I(0) and thus our levels estimation may be unbalanced, yielding spurious results, we first checked for the presence of any residual autocorrelation. Fortunately, system residual portmanteau (Ljung-Box) Q-test statistics (adjusted for small sample) indicate that the autocorrelations of the residuals are not statistically significant. As well, the Durbin-Watson values are fairly reasonable for our four levels equations (respectively, 2.12, 2.80, 1.86, and 2.03). These autocorrelation tests suggest that the variables of our four equations are likely to be cointegrated.

To formally test for cointegration, we applied augmented Dickey-Fuller (ADF) tests to the residuals of the levels equations (1)–(4), using critical values computed by Phillips and Ouliaris (1990). The test statistics show that we reject the null of no cointegration at the 5 percent level for the ATM and the electronic giro equation, and at a 10 percent level for the debit card and paper giro equation (see the last column in table 5, discussed later).[21] The signs of the estimated parameters appear to be reasonable and expected from theory, so the degree of spurious correlation, if any, is likely to be small. Moreover, as shown in the next subsection, the residuals of our levels equations—measuring the deviations of a "long-run"

[21]By definition, cointegration requires that the variables be integrated of the same order. Keeping in mind our small sample, applying ADF tests—using MacKinnon (1996) critical values—indicated that for fourteen out of seventeen variables, the null of a unit root is not rejected.

Table 4. Price and Terminal Elasticities Under Different Model Specifications

	Lagged Terminals	Lagged Terminals and Prices	No Lags	Separate Prices	
				Own	Substitute
Debit Card					
Price Effect	−.22**	−.48**	−.06	−.19	−.03
Terminal Effect	.53**	.57**	.94**	.49**	
ATM Cash Withdrawal					
Price Effect	.23**	.31**	.29**	−.86**	.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

Note: Starred (**,*) values indicate significance levels of 1 percent and 5 percent, respectively.

relationship—significantly affect the short-run dynamics of the variables. Hence, we feel that these findings support the results of our preferred model using levels data.[22]

The derivatives of equations (1)–(4), first with respect to relative prices and then with respect to lagged terminal availability, are shown in column 1 of table 4 (with parameters and other statistics shown in the appendix). A 10 percent reduction in the price of debit cards relative to an ATM cash withdrawal is associated with a 2.2 percent rise in the relative use of cards in Norway compared

[22]Naturally, given the small sample size, unit-root and cointegration tests have reduced power, and strict interpretation of the estimated elasticities should be made with caution.

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

	Levels Data	Error Cor. Residuals	Error Cor. 1st Diff. & Levels[a]	1st Diff. Data[a]	ADF Test
Debit Card					−3.82° [b]
Price Effect	−.22**		3.25	.47	
Terminal Effect	.53**		.82	.75**	
Feedback Parameter		−0.93*	−.07		
ATM Cash Withdrawal					−5.55*
Price Effect	.23**		.32*	.06	
Terminal Effect	−.16**		−.39**	.47**	
Feedback Parameter		−0.84*	−.83**		
Electronic Giro					−4.50*
Price Effect	−.46**		−.60**	.37**	
Feedback Parameter		−0.71*	−.24		
Paper Giro					−3.66°
Price Effect	.27**		.49**	.11	
Feedback Parameter		−0.85*	−.45*		

Note: Starred (**,*) values indicate significance levels of 1 percent and 5 percent, respectively; circled (°) values indicate a 10 percent level.
[a]Debit cards and ATMs formed one system estimation, while electronic and paper giros formed another in the first-differenced and error-correction models.
[b]Test based on one significant explanatory variable.

with the Netherlands (which has a zero explicit price for both cards and ATMs). At the same time, a 10 percent increase in debit card terminals in Norway relative to the Netherlands is associated with a 5.3 percent 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 that it generates a price elasticity insignificantly different from zero.

Over 1990–2004, the price of ATMs in Norway rose relative to that of debit cards. The price elasticity suggests that a 10 percent rise in the relative price of ATMs is associated with a 2.3 percent decrease in relative use.[23] Numerically, this is very similar to the result for the debit card equation, where a 10 percent reduction in the relative price of debit cards gives a 2.2 percent rise in relative use.[24] The ATM terminal elasticity, however, has an unexpected sign and is negative at its mean. When evaluated yearly, the terminal elasticity is positive over 1990–94, but the negative relationship for the remaining years dominates, giving a negative mean. Looking more closely at ATM use and terminal availability by year (not shown) 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 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 (allowing banks to substitute ATMs for expensive branches, which fell absolutely in the two countries), 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 percent, relative use of this instrument in Norway rises 4.6 percent compared with the Netherlands. Similarly, a 10 percent increase in the relative price of paper giro

[23]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.

[24]The ATM price effect is larger when both terminals and prices are lagged in the model. Using bank-level data for Spain, Scholnick et al. (2007) also find that debit cards substitute for ATM cash withdrawals.

payments is associated with a 2.7 percent reduction in relative use between the two countries.[25] Once an individual switched to making an electronic giro payment, almost all of their giro transactions were electronic, and electronic payment volume grew by inducing more and more individuals to switch. In contrast, the substitution of debit cards for ATMs was twofold since it involved individuals shifting a progressively larger share of their point-of-sale transactions from cash to cards over time as more terminals became available and relative prices changed as well as inducing more and more individuals to adopt and use cards.

To illustrate the robustness of our results, our preferred model in equations (1)–(4) was respecified so that direct debits, which comprise 10 percent of electronic giro payments in Norway but 56 percent in the Netherlands, were deleted from the electronic giro use (basically leaving only credit transfers). This had almost no effect on the price results shown in column 1 of table 4. Equations (1)–(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.[26]

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, the effect of real per capita personal consumption on payment use was insignificant in all four equations.

Just as an exercise, equations (1)–(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

[25]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.

[26]The price and terminal elasticities were only slightly changed if, instead of estimating equations (1)–(4) as a single system, system estimation was applied to (1) and (2) and then separately to (3) and (4).

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-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.

4.1 Cointegration and Error Correction

In the previous section we formally tested whether the variables of our levels equations were cointegrated. These tests indicated that the residuals were stationary and that we could reject the null hypothesis of no cointegration. To assess how deviations from the long-run equilibrium—as captured by the movements of the residuals—affect the short-run dynamics of the variables, we also estimated an error-correction (system) model. Since the models in levels, in first differences, or in error-correction form are all nested within an "autoregressive distributed lag" framework, it allows us to test which model fits the data best.

To illustrate, consider the following extension of equation (1), written in an autoregressive distributed lag regression format by adding lagged endogenous and exogenous variables:[27]

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

Without affecting its ability to explain the data or changing the least-squares estimates of the parameters of interest, (5) may be

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

rewritten in error-correction form:

$$\begin{aligned}\Delta CARD_t = \alpha + \beta_1 \Delta CARDTERMINAL_{t-1} + \delta_1 \Delta CARDPRICE_t \\ + (\gamma - 1)(CARD_{t-1} - \alpha_{22} CARDTERMINAL_{t-2} \\ - \alpha_{33} CARDPRICE_{t-1}) + u_t,\end{aligned} \tag{6}$$

where $\alpha_{22} = \frac{\beta_1+\beta_2}{\gamma-1}$ and $\alpha_{33} = \frac{\delta_1+\delta_2}{\gamma-1}$ denote the long-run elasticities (equivalent to the elasticities in levels equation (1)). In (6) we have an equilibrium relationship describing the short-run dynamics,

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

and an equilibrium error,

$$CARD_{t-1} - \alpha_{22} CARDTERMINAL_{t-2} - \alpha_{33} CARDPRICE_{t-1},$$

which measures the deviation from the long-run relationship between the variables $CARD_{t-1}$, $CARDTERMINAL_{t-2}$, and $CARDPRICE_{t-1}$. 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 the parameter $\gamma_1 - 1$ is negative and significantly different from zero, the model in error-correction format cannot be rejected.[28] In this case, long-run equilibrium deviations have a significant impact on the short-run dynamics, which disqualifies the model in first differences. On the other hand, insignificance of the adjustment parameter would favor a first-difference model and implies a "disconnect" between the short run and long run. This disconnect would then cast doubt as well on the empirical relevance of the long-run relationship (even when the variables are cointegrated).

Because our variables in levels are cointegrated, direct estimation of equations (1)–(4) yields "super-consistent" estimators of the (cointegrating) long-run elasticities. Under cointegration, the residuals from the levels equations can be used to estimate the

[28] As a stability condition, the feedback parameter $\gamma - 1$ needs to be between 0 and –1.

error-correction model. Alternatively, one can estimate equation (6) directly, using first differences and lagged level variables, but this will reduce our already limited degrees of freedom even further. The error-correction estimation results of all four equations are shown in table 5, along with the price and terminal elasticities for our preferred levels model from table 4.

The second column shows the adjustment parameters using the stationary residuals of the levels equations (1)–(4). All parameters have the right sign and magnitude, and are significant at the 5 percent level, indicating that the short-run dynamics is indeed significantly influenced by deviations from the long-run relationship.[29] The first-difference results are shown in column 4 of table 5, but the model is rejected. While the terminal elasticities have the expected sign and are significant, this is at the expense of weak results for the price elasticities. Compared with using residuals in the error-correction estimation, we obtain weaker results when we apply direct estimation of the error-correction equations (see column 3). Here 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 percent level.

Given our data limitations, the outcomes of the cointegration tests, and the performance of the error-correction model using stationary residuals, these results weakly suggest that the (cointegrating) price elasticities using levels data in equations (1)–(4)—our preferred model—are robust and can be relied upon as long-run estimates.

4.2 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

[29]The residual properties of the error-correction estimation using residuals are fairly reasonable with (adjusted) Ljung-Box stats: Q(1) = 24.1 (p = 0.09), Q(2) = 43.1 (p = 0.09), Q(3) = 62.8 (p = 0.07), and Q(10) = 163.5 (p = 0.41).

to our country-difference model if nonprice characteristics that affect payment use in a country are weak. The specification is linear and simpler than our country-difference model (due to degrees-of-freedom considerations), and all the data are for Norway:

$$\begin{aligned} CARDATM_t = {} & \alpha_1 + \alpha_2 CARDATMTERMINAL_{t-1} \\ & + \alpha_3 CARDATMPRICE_t + \alpha_4 CONSUMPTION_t \\ & + \varepsilon_{1t} \end{aligned} \tag{7}$$

$$\begin{aligned} ELEPAPER_t = {} & \beta_1 + \beta_2 ELEPAPERPRICE_t + \beta_3 CONSUMPTION_t \\ & + \epsilon_{2t}, \end{aligned} \tag{8}$$

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 (7) and (8) 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 percent 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 percent or 3.1 percent) 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 percent

Table 6. Price and Terminal Substitution for Norway

	Levels Data	First-Differenced Data
Debit Card/ATM Substitution		
Price Effect	$-.20^{*}$	$-.31^{**}$
Terminal Effect	$.54^{**}$	.06
Electronic/Paper Giro Substitution		
Price Effect	$.54^{**}$	.13

Note: Starred (**,*) values indicate significance levels of 1 percent and 5 percent, respectively.

relative rise in the ATM price would be exactly offset by a 10 percent decrease in relative ATM use. Since the parameter is less than 1 (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 percent relative rise in debit card terminals leads to a 5.4 percent relative rise in debit card use.

The substitution elasticity between electronic and paper giro transactions initially 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 (7) and (8), which had a large and significant effect, did (giving a significant –1.98 value for electronic/paper giro substitution). Overall, the card/ATM price and terminal elasticity results were similar between our two-country and single-country applications. This occurs because terminal availability appears to be a good instrument for the combined effect of non-price influences. In contrast, for giro transactions where such a proxy is not available, the two-country giro price elasticity indicated a much smaller degree of price substitution than the single-country specification, suggesting that nonprice effects in a single-country model overstate the bill-payment price elasticity.

4.3 The Effect of Pricing on Payment Use

Our overall conclusion is that the availability of card terminals is a good proxy for the net effect of nonprice influences (such as convenience) on card use. And although nonprice influences on card use appear to have a stronger effect than does per-transaction pricing, the shift to electronic payments is speeded up when pricing is present.[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 percent compared with 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 percent is too high and was not realized.

More precisely, for Norway, the average annual growth in debit card terminal density equaled +15 percent, whereas the growth in card price relative to ATMs was −11 percent. Given the estimated elasticities in column 1 of table 4, this would predict a relative rise of debit card use over ATMs 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 percent 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 in the single-country case, while nonprice influences are incorporated in the two-country estimate. The growth of electronic giro relative to paper giro prices

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[30]Dutch survey results confirm the relative importance of terminal availability for payment instrument usage and stress also the nonprice attributes of payment instruments (see Jonker 2007).

[31]This estimate is derived from the ratio of the price elasticity in our preferred model (–22 percent) in column 1 of table 4 to the terminal elasticity (53 percent), which equals .42.

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

was −8 percent, 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.

5. 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 policymakers who seek to improve the cost efficiency of their nation's payments system. Historically, banks have recouped their payment costs through (i) interest earned on payment float (from delaying availability of funds credited to accounts and debiting accounts prior to bill-payment value dates), (ii) maintaining a spread between market rates and the rate paid on deposits, and (iii) 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 price 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 they 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).

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) versus paper giros. Specifically, we compare per-person payment instrument use 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 fifteen 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. The similarity of our card/ATM price and terminal elasticity results between our two-country and single-country applications suggests that terminal availability is itself a good proxy for hard-to-specify/hard-to-measure nonprice attributes of card use at the point of sale. In contrast, for giro bill-payment transactions where such a proxy was not available, the two-country giro price elasticity indicated a much smaller degree of price substitution than the single-country specification. This indicates that unspecified nonprice effects in a single-country framework can overstate the "true" giro price elasticity value.

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 consumers value the nonprice benefits associated with debit card use (convenience, security) 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 has a stronger effect on debit card use than does pricing, the shift to cards can be speeded up when explicit 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 percent from terminal effects alone but rose to 10.4 percent with pricing, an increase of over 20 percent.

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 nonprice convenience and security attributes of debit cards, which promoted use, along with the fact that for one-third of our time period the absolute price of a debit card transaction was actually 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 transaction would be expected to dull the overall price response being measured for the entire period, as there is no strong reason to believe that the price response is symmetric (and symmetry was not imposed in our model) since the nonprice 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 than the price of the more expensive instrument.[33] Also, 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

[33]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).

role for cards versus cash than for electronic versus paper giro transactions.

Given the large resource cost of a country's payments system, it is obvious that shifting from paper to electronic payments can confer social benefits. Although not shown here, we estimated that 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 percent of GDP in 2004) and €2.9 billion for the Netherlands (.61 percent of GDP).[34] On a discounted basis over time, shifting from 90 percent paper-based instruments and cash to 90 percent electronic and card instruments could save about €2,300 per person in each country.[35] Merchant cost savings, for which little information exists, would increase these savings estimates.

As both Norway and the Netherlands are on their way to realizing the full potential gains from electronic payments, the issue of pricing or not pricing is seemingly more a policy topic for developed countries that are not as far along in the substitution process or for most developing countries that are 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. But pricing could become a reality even in countries that have largely shifted to electronic payments since, with low or falling interest rate margins, this would facilitate the recoupment of bank payment costs compared to continued reliance on indirect methods (large loan-deposit interest rate spread, delayed funds availability, minimum balance requirements, or monthly fixed fees).

[34]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.

[35]More information on the cost-savings estimate derived from payment-cost data and fitted logistic S-curves of a changing share of payment use is contained in a working paper (Bolt, Humphrey, and Uittenbogaard 2005).

Appendix

Parameter values and other statistics are reported below for equations (1)–(4) and generated the price and terminal elasticities shown in column 1 of table 4. Standard errors were computed from a heteroskedastic-consistent matrix (Robust-White). The nonlinear estimation procedure was LSQ in TSP (version 5.0). More information on data sources can be found in Bolt, Humphrey, and Uittenbogaard (2005).

Variable	Parameter	Estimation	T-statistic
Constant	α_1	.497961	2.773980
DIFDCARDTML	α_2	.373649	2.558270
DIFDCARDPRICE	α_3	.055702	.180209
DIFDCARDTML2	α_{22}	.167924	1.244530
DIFDCARDPRICE2	α_{33}	.870318	1.219510
DCARDTMLPRICE	α_{23}	−.308628	−.922949
DIFPCONS	α_4	−.571509	−1.137260
Constant	β_1	.035974	.554554
DIFATMTML	β_2	−1.675620	−8.560530
DIFDCARDPRICE	β_3	1.003880	5.852760
DIFATMTML2	β_{22}	5.935940	7.781290
DIFDCARDPRICE2	β_{33}	2.332310	3.406300
ATMTMLPRICE	β_{23}	−3.151620	−4.504500
DIFPCONS	β_4	−.138567	−.766170
Constant	γ_1	−.519080	−1.212480
DIFEGIROPRICE	γ_2	1.068860	2.151150
DIFEGIROPRICE2	γ_{22}	.881313	3.062310
DIFPCONS	γ_3	.544589	1.135200
Constant	δ_1	−.606181	−1.201530
DIFEGIROPRICE	δ_2	−1.694780	−2.901820
DIFEGIROPRICE2	δ_{22}	−1.135840	−3.307110
DIFPCONS	δ_3	−.678980	−1.347590

Debit card equation (1):

adj. $R^2 = .960$, S.E. of regression = 0.010, D-W = 2.12.

ATM cash withdrawal equation (2):

adj. $R^2 = .975$, S.E. of regression = 0.035, D-W = 2.80.

Electronic giro equation (3):

adj. $R^2 = .836$, S.E. of regression = 0.087, D-W = 1.86.

Paper giro equation (4):

adj. $R^2 = .746$, S.E. of regression = 0.087, D-W = 2.03.

System residual portmanteau (adjusted) test for autocorrelations:

Q(1) = 20.92 (p = 0.18), Q(2) = 33.41 (p = 0.40), Q(5) = 79.45 (p = 0.50), Q(10) = 163.44 (p = 0.41).

Log-likelihood: 99.73; Number of observations: 60.

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